Theoretical Astronomy in the Early Modern Ottoman Empire:

ʿAlī al-Qūshjī's *Al-Risāla al-Fatḥiyya*

by

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August 2019

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctoral of Philosophy

To Serap

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ABSTRACT

This dissertation aims to demonstrate the importance of *Al-Risāla al-Fatḥiyya* (*The Treatise of Conquest*) in the history of theoretical astronomy (*ʿilm al-hayʾa*) in Islamic societies, especially in the Ottoman context. It was written by ʿAlī al-Qūshjī (d. 879/1474), one of the eminent scholars of his period, and dedicated to the Ottoman Sultan Meḥmed II to honor his victory over the Āq Qoyūnlū ruler Uzun Ḥasan in the Otlukbeli War in 878/1473. Originally from Samarqand, Qūshjī was trained by leading Timurid scholars, and became a prominent member of the Samarqand observatory and madrasa, two prestigious institutions built by Ulugh Beg, the then governor of Transoxiana. During this period, Qūshjī also contributed to the preparation of *Zīj-i Ulugh Beg*, one of the most important astronomical tables produced in the pre-modern world. Towards the end of his life, upon the invitation of the Sultan, Qūshjī emigrated to Istanbul, where he died after a short sojourn.

The literature on the history of Islamic astronomy and Ottoman science has assumed the significance of Qūshjī's scientific activities and works, but only a small amount of research has dealt with them. Although the *Fatḥiyya* was one of Qūshjī's last works, which he continued to revise until his death, modern literature has made little effort to situate it within its historical, local, and scientific contexts. This situation stems, in part, from the lack of a critical edition of this work. As a contribution to studies on Qūshjī and the *Fatḥiyya*, this dissertation deals with them in two main parts. Part 1 includes three chapters. Chapter 1 offers a literature review of Qūshjī studies that deals not only with astronomy but, more generally, with his scholarly output that has attracted attention in modern scholarship. Chapter 2 addresses Qūshjī's intellectual biography, introducing his educational background and scholarly activities with reference to the intellectual, political, and social dynamics of the localities in which he flourished. Chapter 3 attempts to scrutinize the *Fatḥiyya* with respect to the historical, local, and scientific contexts within which it was written. It also analyses the evolution of the *Fatḥiyya*, especially in regard to Qūshjī's other *hayʾa* work, *Risālah dar hayʾah*, that was written earlier in Persian. Additionally, this chapter investigates how Qūshjī was engaged with earlier authoritative *hayʾa* works in his *Fatḥiyya* project. Part 2 includes four chapters: a description of the manuscripts and editorial procedures; an Arabic edition of the *Fatḥiyya;* an English translation; and a commentary on the *Fatḥiyya*.

RÉSUMÉ

Cette thèse vise à démontrer l'importance de la *Risāla al-Fatḥiyya* (*Le Traité de la conquête*) dans l'histoire de l'astronomie théorique (*ʿilm al-hayʾa*) au sein des sociétés islamiques, plus particulièrement dans le contexte ottoman. Il a été rédigé par ʿAlī al-Qūshjī (d. 879/1474), l'un des éminents érudits de cette époque, et dédié au sultan ottoman Meḥmed II afin de célébrer sa victoire sur Uzun Ḥasan, souverain des Āq Qoyūnlū, lors de la bataille d'Otlukbeli en 878/1473. Originaire de Samarcande, Qūshjī reçut son éducation de grands érudits timurides et devint un membre réputé de l'observatoire et de la madrasa de Samarcande, deux institutions prestigieuses construites par Ulugh Beg, à l'époque, gouverneur de Transoxiane. Pendant cette période, Qūshjī participa également à l'élaboration du *Zīj-i Ulugh Beg* (*les Tables sultaniennes*), l'une des plus importantes tables astronomiques produites dans le monde prémoderne. Vers la fin de sa vie, sur l'invitation du Sultan, Qūshjī émigra à Istanbul où il mourut après un court séjour.

La recherche portant sur l'histoire de l'astronomie islamique et les sciences ottomanes reconnaît l'importance des activités et œuvres scientifiques de Qūshjī, mais seulement un petit nombre d'études y ont été consacrées. Bien que le *Fatḥiyya* soit l'une des dernières œuvres de Qūshjī, qu'il continua de réviser jusqu'à sa mort, la littérature contemporaine a déployé peu d'efforts pour la situer au sein de son contexte historique, local et scientifique. Cette situation résulte, en partie, de l'absence d'édition critique de cette œuvre. À titre de contribution à la recherche sur Qūshjī et le *Fatḥiyya*, cette thèse traitera de ceux-ci en deux parties principales. La première partie inclut trois chapitres. Le premier chapitre propose une revue de la littérature consacrée à Qūshjī, portant non seulement sur l'astronomie, mais également, plus généralement, sur sa production savante qui fit l'objet de l'attention de la recherche contemporaine. Le deuxième chapitre aborde la biographie intellectuelle de Qūshjī, introduisant sa formation scolaire et ses activités scientifiques en référant aux dynamiques intellectuelles, politiques et sociales des lieux dans lesquels il se forma. Le troisième chapitre vise à étudier dans le détail le *Fatḥiyya* quant aux contextes historiques, locaux et scientifiques dans lesquels il a été composé. Ce chapitre analyse également l'évolution du *Fatḥiyya*, plus particulièrement par rapport à une autre œuvre de Qūshjī relative à la *hayʾa*, *Risālah dar hayʾah*, composée antérieurement en Persan. En outre, ce chapitre examine la manière avec laquelle Qūshjī, au sein de son projet du *Fatḥiyya*, se rapporte à des œuvres antérieures de *hayʾa* faisant autorité. La deuxième partie inclut quatre chapitres : une description des manuscrits et des procédures éditoriales; une édition du *Fatḥiyya* en arabe; une traduction en anglais; un commentaire du *Fatḥiyya*.

ACKNOWLEDGMENTS

First and foremost, I am indebted to my supervisor, F. Jamil Ragep for his invaluable guidance and support which helped me throughout my graduate study. I render my warmest thanks to him whose erudition and intellectual rigour provided me with a better understanding of the history of science and Islamic astronomy. I am grateful to Robert Wisnovsky who offered me valuable insights in the domain of Islamic philosophy, and Miquel Forcada of University of Barcelona, the internal and external examiners of my dissertation respectively, for their helpful feedback and recommendations. I would like to thank the other members of the thesis committee, Aslıhan Gürbüzel to whom I am also grateful for our discussions on Ottoman intellectual history, Eran Tal, and Jonathan Wild, for showing their interest in my dissertation. I also thank Rula Jurdi Abisaab for her valuable guidance in the domain of Islamic intellectual history, when I was preparing for one of my comprehensive examinations under her direction. I thank Khalid Medani and Sarah Lessard for dealing with the final administrative process to help me in submitting my dissertation. I would also like to thank Anne Farray, Adina Sigartua, and Zeitun Manjothi for their administrative help during my graduate study.

I want to express my gratitude to Sally P. Ragep for her insightful scholarship on the education of astronomy in Islamic context, and also for warmly welcoming, with F. Jamil Ragep, me and my family in various gatherings. My warmest thanks go to İhsan Fazlıoğlu of Istanbul Medeniyet University who was always generous to share with me his inspiring thoughts on Ottoman science, and helped me in locating valuable sources related to my dissertation. I received support in various ways from scholars including, in alphabetical order, Atilla Arkan, Zeynep Arkan, Mürteza Bedir, Ali Demirci, Feza Günergun, Bilal Kuşpınar, Turgay Şafak, Recep Şentürk, Erol Özvar, Maşuk Yamaç, Sara Nur Yıldız, and Tuncay Zorlu. I am grateful to all of them.

I was lucky to have friends in Montreal, Istanbul and elsewhere who helped me in various ways during my graduate study. If I were to mention some of them, I would thank, in alphabetical order, Berat Açıl, Mehmet Alıcı, Yasin Apaydın, Mehmet Arıkan, Hassan Arif, Ekrem Arslan, Taha Yasin Arslan, Ali Aslan, Fariduddin Attar, Mehmet Bulğen, Deniz Özlem Çevik, Naser Dumairieh, Furkan Ercan, Ziya Erdinç, Osama Eshera, Pauline Froissart, Halil İbrahim İskender, Yusuf Ziya Karabıçak, Hasan Karataş, Nilüfer Kaval Koss, M. Tahir Kılavuz, M. Fatih Kılıç, Necmettin Kızılkaya, M. Ali Koca, M. Akif Koç, Sajjad Nikfahm-Khubravan, A. Taha Orhan, Hüseyin Örs, David Pantalony, Atilla Polat, M. Habib Saçmalı, Fateme Savadi, San Soyer, A. Tunç Şen, Cahid Şenel, Kübra Şenel, M. Selman Tosun, İbrahim Halil Üçer, and Brian Wright.

I received financial support from various institutions during my research. I would like to thank McGill University for granting me various fellowships and awards including McGill-Ingenium Fellowship in the History of Science, Medicine, and Technology, and Wilfred Cantwell Smith Fellowship in Islamic Studies. I am also grateful to Canada Research Chair in the History of Science in Islamic Societies for providing me with several fellowships, stipends, and opportunities to work as a student researcher in the Islamic Scientific Manuscripts Initiative (ISMI) initiatied by McGill University and Max Planck

Institute for the History of Science in Berlin. In addition, I would like to thank ISTEV, Ihsan, Meridyen, Nesil, and Petrol Foundations for providing research scholarships. In terms of intellectual and financial support, however, I must single out Istanbul Foundation for Research and Education (ISAR), which has always been an inspiring environment for the seeking of knowledge, along with wonderful scholars, researchers, and friends. I am grateful to all of them. I am also thankful to the staff at such libraries as McGill University's Islamic Studies Library, Süleymaniye Manuscripts Library, Beyazıt Manuscripts Library, Topkapı Museum Manuscripts Library, and Center for Islamic Studies Library in Istanbul (ISAM) for their help in reaching primary and secondary sources during my research.

I do not have words to describe my gratitude for my family. My mother Şerife, my brothers Furkan, Gökhan and his family Tubanur and Salih Eren, as well as my parents-in-law Yaşar and Hatice were always supportive even when we were away from them. I also want to express my respect to the memories of my late father Yakup and late brother Serkan.

My heartfelt thanks go to my kids Yusuf and Gülru who have always been a blessed joy. When they grow up, I hope they will excuse me for times in which I was busy with someone called Qūshjī, instead of playing with them. Finally, I cannot express how grateful and thankful I am to the love of my life, my wife Serap, for her unconditional affection, support, and encouragement. I was very lucky that she always acknowledged the importance of my research, even at times I doubted it. Her love, companionship and care were a warm home even in the cold winters of Montreal. I dedicate this dissertation to her.

INTRODUCTION

Zīj-i Ulugh Beg is regarded as one of the most important astronomical handbooks produced in the pre-modern period. It is named after Ulugh Beg (d. 853/1449), who at his death was the Timurid ruler based in Transoxania and the commissioner of the Samarqand Observatory in which this *zīj* was prepared. In its introduction, Ulugh Beg singled out three astronomers for their contribution to this monumental project: Ghiyāth al-Dīn Jamshīd al-Kāshī (d. 832/1429); Qāḍīzāde al-Rūmī (d. after 843/1440); and ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī (d. 879/1474). It is not surprising that the patron and contributor of this astronomical handbook praises the merits of the first two scholars, who were already celebrated mathematicians and astronomers in the Islamic East at the time. However, the way Ulugh Beg talks about Qūshjī, who was then much younger than the two senior colleagues, is much more intriguing. He remarks in the Introduction that Qūshjī was able to surpass earlier scholars in the mathematical sciences despite his young age and expresses his hope that Qūshjī's works will be disseminated across different parts of the world within a short of period of time.[1]

Ulugh Beg's hopes would be realized! Qūshjī would become one of the most eminent scholars in the Islamic East, so much so that his works were read in most parts of the pre-modern World, stretching beyond what Shahab Ahmad calls the "Balkans-to-Bengal Complex,"[2] extending from India to England where Isaac Newton (d. 1727) was emerging as one of the most influential figures in human history.[3]

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[1] Uluğ Bey, *Uluğ Bey'in Astronomi Cetvelleri (Zîc-i Uluğ Bey)*, trans. Mustafa Kaçar and Atilla Bir (Ankara: Kültür ve Turizm Bakanlığı, 2012), 24. (This publication also includes the facsimile edition of the following copy, which I have also consulted: Istanbul, Topkapı Museum Library, Revan Collection, MS 1714, f. 2b).
[2] According to Ahmad, this complex "represents the most geographically, demographically and temporally extensive instance of a highly-articulated shared paradigm of life and thought in the history of Muslims- it is, demographically, spatially, and temporally, an (if not *the*) *historically major paradigm* of Islam." For further

This dissertation contributes to Qūshjī studies by focusing on one of his last works, namely *al-Risāla al-Fatḥiyya*, a work in the field of *hayʾa* (theoretical astronomy). It was written in 1473 under Ottoman patronage and dedicated to Sultan Meḥmed II in honor of his victory over Uzun Ḥasan, the then Āq Qoyūnlū ruler, during the Otlukbeli War that took place in the same year. I intend to demonstrate that Qūshjī's *Fatḥiyya* deserves to be examined carefully to address various aspects of intellectual and scientific life in the Islamic East, including that of the Ottomans, in "the long fifteenth century."[4]

There is little doubt regarding Qūshjī's contribution in Islamic Intellectual history and the significance of his ideas for the history of Islamic science, but modern studies on him are inadequate. However, there has been renewed interest and a rise in Qūshjī-scholarship over the last few decades. The situation regarding scholarship on Qūshjī's astronomical contribution is not much different. The literature on his astronomy that has emerged recently gives us a convincing sense that his approach to astronomy in both theoretical and practical ways bears some distinctive characteristics compared to his contemporaneous and preceding figures. Although Ottoman science studies tend to portray a very positive image of Qūshjī, this image is hardly based on careful and detailed examination of his writings. While the *Fatḥiyya* is frequently mentioned in works that touch upon Qūshjī's role in Ottoman astronomy, they are mostly encyclopedic or general,

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details, see Shahab Ahmad, *What is Islam? The Importance of Being* Islamic (Princeton: Princeton University Press, 2016), 82.

[3] As I will explain further, an Oxford professor named John Greaves (d. 1652) translated a section from Qūshjī's *Risālah dar hayʾah* into Latin. For further details, see below: "The Literature on Qūshjī's *Hayʾa* Works" in Chapter 1 entitled "Literature Review of Modern Scholarship on ʿAlī al-Qūshjī."

[4] For further details of this periodization (roughly speaking between the late fourteenth to the early sixteenth centuries) and its relevance to Islamic astronomy, see, Christopher S. Celenza, "What did It Mean to Live in the Long Fifteenth Century?," in *Before Copernicus: The Cultures and Contexts of Scientific Learning in the Fifteenth Century*, ed. Rivka Feldhay and F. Jamil Ragep (Montreal: McGill-Queen's University Press, 2017), 17–28; and Sally P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," in *Before Copernicus: The Cultures and Contexts of Scientific Learning in the Fifteenth Century*, ed. Rivka Feldhay and F. Jamil Ragep (Montreal: McGill-Queen's University Press, 2017), 143–60.

with little discussion of actual content of the text and its context. The obvious discrepancy between a very favorable view of the *Fatḥiyya* and its author and the somewhat rudimentary knowledge we have of the text itself partly stems from the lack of its critical edition and studies that would situate and contextualize it within the history of *hayʾa*.

In order to address this gap in Qūshjī studies and modern literature on *hayʾa*, this dissertation aims to examine the *Fatḥiyya* by drawing on both internalist and externalist historiographical approaches. That is to say, while I will present a critical edition and translation of, as well as a commentary to, the *Fatḥiyya*, by acknowledging the significance of focusing on "content within context," I will relate the text to Qūshjī's intellectual life, as well as to various questions that address historical, scientific, intellectual, and political contexts within which it was written.

It is with this understanding that the dissertation comprises two main Parts, apart from an introduction and conclusion. Part I has three chapters. Chapter 1 entitled "Literature Review of Modern Scholarship on ʿAlī al-Qūshjī" is engaged with all the available secondary literature I could access on Qūshjī. The chapter divides the literature into three categories, namely, general accounts of Qūshjī and his works, including biographies and encyclopedia entries, studies on Qūshjī's works in Islamic intellectual studies, and studies on Qūshjī's mathematical and astronomical scholarship. Since the main concern of the dissertation is his astronomy, my literature review of studies dealing with it will be more detailed. The chapter concludes with my reflection on the future of Qūshjī studies.

Chapter 2 seeks to present one of the most detailed intellectual biographies of Qūshjī in the English language. I will identify four main episodes in Qūshjī's biography: The

Early Timurid period in which Qūshjī spent most of his time in Samarqand until the execution of his teacher and patron Ulugh Beg; the Late Timurid period in which he lived in Herat and Samarqand under the patronage of the then Timurid Sultan Abū Saʿīd; the transitional period in which he decided to leave the Timurid lands and became a diplomatic mediator between the Ottomans and Aq Qoyunlūs; and finally, his last few years under Ottoman patronage. In the last episode, his intellectual and scientific activities, along with a preliminary observation on his network of scholars in the Ottoman context, are treated.

Chapter 3 turns its attention to the *Fatḥiyya*, exploring the historical, local, and scientific contexts in which it was written. I attempt to analyze the *Fatḥiyya* in relation to Qūshjī's *Risālah dar hayʾah*, which was written earlier in Persian in Samarqand, to the commentaries and translations of the *Fathiyya and Risālah*, and to some of the most significant *hayʾa* works written before the *Fatḥiyya*. Based on this analysis, I propose three major characteristics of this text: its unique approach in Islamic intellectual history to the relationship between natural philosophy and astronomy; its Ottoman character that yet bears a significant legacy of the Samarqand Observatory and Madrasa experience; and its critical, new, and synthetic approach to the earlier *hayʾa* literature.

Part 2 includes the last four chapters of the dissertation. Chapter 4 includes a description of all the *Fatḥiyya* copies I could access. The chapter also explains my editorial procedures for establishing the critical edition. In this respect, I demonstrate that the *Fatḥiyya* has three versions on which the critical edition relies. Chapter 5 comprises the Arabic edition of the text, followed by Chapter 6 that includes my translation of the *Fatḥiyya*. My translation will be as literal as possible. Since I have identified several sentences that are also found in Naṣīr al-Dīn al-Ṭūsī's *Tadhkira* and Qūṭb al-Dīn al-Shīrāzī's

Nihāyat al-idrāk, I quote F. Jamil Ragep's translation of the former and Fateme Savadi's partial translation of the latter on several occasions.[5] Chapter 7 is a commentary to the *Fatḥiyya*, in which I explain the historical, textual, codicological, and scientific aspects of the text. In this chapter, I will consult major *hay'a* works preceding the *Fatḥiyya,* including Qūshjī's *Risālah* and the commentaries on the *Fatḥiyya* by Ghulām Sinān (d. 912/1506), one of Qūshjī's students in Istanbul, and by Mīrim Chalabī (d. 931/1525), a descendant of Qūshjī and a prominent astronomer who flourished at the turn of the sixteenth century in Istanbul. *Zīj-i Ulugh Beg* and the derivative works of the *Risālah* are also used. Finally, the dissertation ends with a conclusion in which I summarize the main points of the dissertation.

[5] F. Jamil Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī ʿilm al-hay'a)*, 2 vols. (New York: Springer-Verlag, 1993); Fateme Savadi, "The Historical and Cosmographical Context of *Hay'at al-arḍ* with a Focus on Quṭb al-Dīn Shīrāzī's *Nihāyat al-Idrāk*" (PhD diss., McGill University, 2018).

PART 1

ʿALĪ AL-QŪSHJĪ AND HIS *AL-RISĀLA AL-FATḤIYYA*

CHAPTER 1

LITERATURE REVIEW OF MODERN SCHOLARSHIP ON ʿALĪ AL-QŪSHJĪ

ʿAlī al-Qūshjī was a prolific scholar who wrote many works in various disciplines, including theoretical and observational astronomy, mathematics, rational theology (*kalām*), Arabic linguistics, Qur'anic exegesis (*tafsīr*), and legal theory (*uṣūl al-fiqh*). Although his scholarship has attracted increased attention over the past few decades, a considerable body of this research has remained relatively unknown to an English-speaking audience, since it is mostly in Persian, Russian, Turkish, and Uzbek. In this respect, this chapter aims to offer a synthesis of the secondary literature on Qūshjī, at least that which I am able to access.

In an attempt to present a comprehensive treatment of the literature on Qūshjī, I have classified the relevant literature under three main headings: 1) modern biographies and general accounts of Qūshjī's life and works; 2) Qūshjī in Islamic intellectual history studies; 3) Qūshjī in studies in the history of science in Islamic societies. The latter two categories will be further classified into subcategories so that one can easily trace the varying degrees of interest in various subjects associated with Qūshjī. Lastly, I will make some remarks regarding possible directions into which Qūshjī studies will evolve in the near future. This will be significant for my concern to highlight the contribution to the field of study which I hope to make in this dissertation project on Qūshjī's *Fatḥiyya*.

1.1) **Modern Biographies and General Accounts of Qūshjī's Life and Works**

Many modern bio-bibliographical works prepared in both Islamic and European intellectual contexts included a section on Qūshjī's life and works.[6] That is to say, Qūshjī's biography can be found in various forms of publications in Europe, Iran, North America, the Soviet Union (both in Russian and Uzbek languages), and Turkey.[7] These encyclopedic and

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[6] Among many references that include information about Qūshjī and his works are the following: Khayr al-Dīn Al-Ziriklī, *Al-Aʿlām: Qāmūs tarājim li-ashar al-rijāl wa-al-nisāʾ min al-ʿArab wa-al-Mustaʿribīn wa-al-Mustashriqīn*, 15th ed., vol. 5 (Beirut: Dār al-ʿilm lil-Malāyīn, 2002), 9; Carl Brockelmann, *Geschichte der arabischen Litteratur (Band 2)* (Leiden: E. J. Brill, 1949), 305; Carl Brockelmann, *Geschichte der arabischen Litteratur (Supplement 2)* (Leiden: E. J. Brill, 1938), 329–30; Heinrich Suter, *Die Mathematiker und Astronomen der Araber und ihre Werke* (Leipzig: B.G. Teubner, 1900), 178–79; Mehmed Süreyya Bey, *Sicill-i Osmānī Yahud Tezkire-yi Meşāhir-i Osmāniye*, vol. 3 (Istanbul: Matbaa-yi Āmire, 1311), 486–87; Faik Reşad, *Eslâf* (Istanbul: Asır Kütüphanesi, 1894), 117–23.

[7] It is hardly possible to cite every single work that includes Qūshjī's biography; but I think that the ones cited below will give an idea of the extent to which Qūshjī's biography can be found in various secondary sources. İhsan Fazlıoğlu, "Ali Kuşçu," in *İslam Düşünce Atlası*, ed. İbrahim Halil Üçer, accessed August 7, 2019, www.islamdusunceatlasi.org/detail/person359; F. Rahman and D. Pingree, "ʿAlī Qūšǰī," in *Encyclopædia Iranica*, vol. I/8, 876–77, accessed April 17, 2019, http://www.iranicaonline.org/articles/ali-qusji-qusju-ala-al-din-ali-mohammad-theologian-and-scientist-d; Salim Aydüz, "ʿAlī al-Qushjī," in *The Oxford Encyclopedia of Philosophy, Science, and Technology in Islam*, ed. İbrahim Kalın, Salim Aydüz, and Caner Dagli, vol. 2 (New York: Oxford University Press, 2014), 173–76; Süleyman Zeki Bağlan, "Semerkand'da Yetişti, Osmanlı'da Yükseldi," *Dil ve Edebiyat Dergisi*, no. 5 (2009): 26–32; İhsan Fazlıoğlu, "Ali Kuşçu," in *Encyclopedia of Ottoman Empire*, ed. Gábor Ágoston and Bruce Masters (New York: Facts on File, 2009), 35–36; Musa Yıldız, "Gökyüzünün Kapılarını Açtı," *Dil ve Edebiyat Dergisi*, no. 5 (2009): 21–25; İhsan Fazlıoğlu, "Alī al-Qūshjī (Abū al-Qāsim ʿAlāʾ al-Dīn ʿAlī ibn Muḥammad Qushjī-zāde)," in *Complete Dictionary of Scientific Biography.*, vol. 19 (Detroit: Charles Scribner's Sons, 2008), 45–47; İhsan Fazlıoğlu, "Qūshjī: Abū al-Qāsim ʿAlāʾ al-Dīn ʿAlī ibn Muḥammad Qushči-zāde," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 946–48; İlay İleri, "Ali Kuşçu and His Contributions to Mathematics and Astronomy = Ali Kuşçu ve Ali Kuşçu'nun Matematik ve Astronomiye Katkıları," *Ankara Üniversitesi Osmanlı Tarihi Araştırma ve Uygulama Merkezi Dergisi* 20, no. 20 (2006): 175–83; Musa Yıldız, "Ali Kuşçu," *Diyanet Avrupa Aylık Dergi*, no. 57 (2004): 44–45; Bekir Karlığa, "Ali Kuşçu (Mevlânâ Alâeddîn İbn Alî İbn Muhammed Kuşcî, öl. 1470)," in *Tarihi, Kültürü ve Sanatıyla VI. Eyüpsultan Sempozyumu: Tebliğler (10-12 Mayıs 2002)* (Istanbul: Eyüp Belediyesi Kültür Yayınları, 2003), 120–27; İhsan Fazlıoğlu, "Ali Kuşçu," in *Yaşamları ve Yapıtlarıyla Osmanlılar Ansiklopedisi*, vol. 1 (Istanbul: Yapı Kredi Yayınları, 1999), 216–19; Ahmet Kankal, "Ali Kuşçu," *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi* 36, no. 1–2 (1993): 103–18; Āzar Tafaẓẓulī and Mahīn Faẓāʾilī Javān, *Farhang-i buzurgān-i Islām va Īrān: Az qarn-i avval tā chahārdahum hijrī* (Mashhad: Āsitān-i Quds-i Raẓavī, Bunyād-i Pizhūhishhā-yi Islāmī, 1993), 384; Cengiz Aydın, "Ali Kuşçu," in *TDV İslâm Ansiklopedisi*, vol. 2 (Istanbul: TDV Yayınları, 1989), 408–10; H. Sohrweide, "ʿAlī b. Ḳūšǧī," in *Lexikon des Mittelalters*, 10th ed., vol. 1 (München, Zürich: Aachen bis Bettelordenskirchen, 1980), 412; Muḥammad ʿAlī Mudarris, "Qushjī," in *Rayḥānat al-adab fī tarājim al-maʿrūfīn bi-al-kunya va al-laqab yā kunā va alqāb: Mushtamil bar tarjumah-i ḥāl-i fuqahā va ḥukamā va ʿurafā va udabā va aṭibbā va fuẓalā va shuʿarā-yi buzurg-i Islāmī kih bā laqab va kunyah ishtihār dārand* (Tabriz: Chāpkhānah-i shafīq, 1970), 495–96; M. Şakir Ülkütaşır, "Ali Kuşçu," *Yücel Aylık Sanat ve Fikir Mecmuası*, no. 111 (1946): 153–54; Y. I. Sarkis, *Muʾjam al-maṭbuʿat al-ʿarabiyya wa-al-muʿarraba* (Cairo, 1928), 1530–31. Uzbek and Russian scholars in the Soviet period showed a considerable interest in Ulugh Beg and his intellectual circles that include Qūshjī. For some of the sources in those languages, one may consult the references of the following

bio-bibliographical sources are undeniably helpful for obtaining handy and accurate information about Qūshjī and his works. However, they mostly are in the same style, present similar content, and are not exclusively devoted to Qūshjī, I therefore will not review them title by title. Instead, I will focus here on two Istanbulite intellectuals from the late-Ottoman period, even though Qūshjī was not their main focus. In my opinion, their significance mainly stems from the fact that their works are among the earliest attempts to write a history of science in Islamic societies as a distinct discipline of knowledge in the late nineteenth century Ottoman milieu. One of those intellectuals is Süleyman Sūdī Efendī (d. 1896), who compiled *Ṭabaqāt-i Munajjimīn* (A Biographical Dictionary of Astronomers) in Turkish, which remained in draft form in a private collection until 15 years ago.[8] A bio-bibliographical work that covers scholars of astronomy in Islamic history, including Qūshjī, *Ṭabaqāt-i Munajjimīn* also provides a general history of astronomy by surveying major astronomical figures, works and activities in the Mesopotamian, Greek, and Islamic traditions, with an emphasis on Ottoman scholarship. Although Süleyman Sudi Efendi's attempt to write a history of astronomy that focuses on Islamic history and considers the historical continuity in astronomical activities across different cultures is noteworthy, one should still treat it cautiously. To give an example, the author wrongly identifies *Risālah dar hayʾah* as the *Fatḥiyya*, which we know to be two separate works, both written by Qūshjī. Due to this misidentification, he describes the *Fatḥiyya* as a Persian *hayʾa* text and

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source: Boris A. Rosenfeld and Ekmeleddin İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars of Islamic Civilization and Their Works (7th- 19th c.)* (Istanbul: IRCICA, 2003), 285–87.

[8] A bureaucrat who worked in various fiscal positions and wrote on issues on Ottoman fiscal policy, Süleyman Sūdī Efendī's special interest in astral sciences in Islamic history is also reflected in his personal library, which includes many astronomical and astrological books, including Naṣīr al-Dīn al-Ṭūsī's *Taḥrīr al-Majisṭī*, a Turkish translation of Ṭūsī's *Sī Faṣl*, a book by Qūshjī whose title is not given, and Mīrim Chalabī's commentary on *Zīj-i Ulugh Beg*. Salim Aydüz, "Süleyman Sûdî Efendi'nin Kütüphanesi," in *Essays in Honour of Ekmeleddin İhsanoğlu*, ed. Mustafa Kaçar and Zeynep Durukal, vol. 1 (Istanbul: IRCICA, 2006), 775–811.

therefore introduces the content of the *Risala* as an outline of the *Fatḥiyya*. Another of Sūdī Efendī's statement in the *Ṭabaqāt-i munajjimīn* that should be taken cautiously is his claim that Qūshjī wrote a commentary on Quṭb al-Ḍīn al-Shīrāzī's *Nihāyat al-idrāk*; however, no copy of it is known. Given the fact that Qūshjī has a partial commentary on Shīrāzī's *al-Tuḥfa al-shāhiyya*, it is more likely that Süleyman Sūdī Efendī has these works by Shīrāzī confused. Generally speaking Süleyman Sūdī Efendī's account of Qūshjī is relied on Ṭāshkubrīzādā's *al-Shaqāʾiq al-nuʿmāniyya*, presenting Qūshjī's life with a few works of him. [9]

The second notable figure in the formation of the historiography of Islamic science during the late Ottoman period is Salih Zeki (d. 1921), who is considered among the most eminent Ottoman historians of science. [10] His work, *Āthār-i Bāqiya* (*Vestiges of the Past*), written in Turkish and published in two volumes, deals with the development and major topics in such branches of mathematics as trigonometry, algebra, and arithmetic, as well as in astronomy in Islamic societies. He also situates the trajectories of the topics he examines in the Greek and early modern European contexts. Salih Zeki also appends biographies of the scholars he mentioned in the work, including a biography of Qūshjī.[11] Salih Zeki's other

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[9] Süleyman Sûdî Efendi, *Tabakāt-ı Müneccimīn*, ed. Salim Aydüz (Istanbul: Fatih Üniversitesi Yayınları, 2005), 168, 179–81.

[10] For a short biography and scholarship, see Hüseyin Gazi Topdemir, "Salih Zeki," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 1007–8.

[11] For Qūshjī's biography see, Salih Zeki, *Āthār-i Bāqiya*, vol. 1 (Istanbul: Maṭbaʿa-yi ʿĀmira, 1329), 195–99. The first two volumes of *Āthār-i Bāqiya* on mathematics were published in the Ottoman period. These volumes were also transliterated into modern Turkish. Salih Zeki, *Âsâr-ı Bâkiye: Bilginlerin Yaşamları ve Yapıtları*, ed. Melek Dosay Gökdoğan and Mutlu Kılıç, vol. 3 (Ankara: Babil Yayıncılık, 2004); Salih Zeki, *Âsâr-ı Bâkiye: Ortaçağ İslam Dünyası'nda Hesap ve Cebir*, ed. Melek Dosay Gökdoğan, vol. 2 (Ankara: Babil Yayıncılık, 2003); Salih Zeki, *Âsâr-ı Bâkiye: Ortaçağ İslam Dünyası'nda Trigonometri*, ed. Remzi Demir and Yavuz Unat, vol. 1 (Ankara: Babil Yayıncılık, 2003). However, the astronomy volumes of the work are still in draft form, which are available at Istanbul University. For the details, see Ekmeleddin İhsanoğlu et al., eds., *Osmanlı Astronomi Literatürü Tarihi (History of Astronomy Literature During the Ottoman Period)*, vol. 2 (Istanbul: IRCICA, 1997), 708–9.

important work entitled *Kāmūs-i Riyāziyyāt* (*Dictionary of Mathematics*), a dictionary for astronomical and mathematical terms, also includes the same biography of Qūshjī that he included in the *Āthār-i Bāqiya*.[12] Along with the available contemporary sources on the general history of science available to him, Salih Zeki benefited from having direct access to the manuscript copies of the scientific works he examined, analysing them from both historical and scientific points of view. His account of Qūshjī's biography relies on Ṭāshkubrīzāda's *Shaqāʾiq*. Salih Zeki introduces some of his mathematical and astronomical works with brief information about them.

Studies in the history of science with a particular attention to the Ottoman period continued thanks to Abdülhak Adnan Adıvar, an eminent historian of science as well as a physician and politician in both the Ottoman and Republican periods. He was one of the first figures during the early period of the Turkish Republic who dealt with Qūshjī's scholarship and his importance in the Ottoman context. In his *La Science chez les Turcs Ottomans*, published in Paris in 1939, and in its expanded Turkish edition entitled *Osmanlı Türklerinde İlim* published in Ankara in 1943, both of which were the first monographs devoted exclusively to Ottoman science, Adıvar underlines the significance of Qūshjī's arrival in Istanbul, claiming that a "shining age" for the Ottomans in terms of the mathematical sciences started with his emigration.[13] From a historiographical point of view, it is important to note that the positive image of Qūshjī in Adıvar's narrative is strongly linked to his ideas about Sultan Meḥmed II who, according to him, was "a great

[12] Only the first volume of the *Kāmus-i Riyāziyyāt* was published; the rest of the work is only available in draft form in the author's handwriting. Istanbul University, Nadir Eserler Library, Türkçe Yazmalar, MS 915, ss. 1028-1030. For the details of the drafts located at Istanbul University, see İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 2:709.

[13] A. Adnan Adıvar, *Osmanlı Türklerinde İlim* (Istanbul: Maarif Matbaası, 1943), 32; Abdülhak Adnan Adıvar, *La science chez les Turcs Ottomans* (Paris: Librairie Orientale et Americaine G.P. Maisonneuve, 1939), 33.

secularist who wanted to establish the hegemony of rational sciences in the Ottoman Empire."[14] Thus, in Adıvar's opinion, the fact that the Sultan convinced Qūshjī to emigrate to Istanbul is one of his profound achievements in patronizing scientific activities in his new capital. Apart from this account of Qūshjī, Adıvar was also the author of the entries on Qūshjī in the *Encyclopedia of Islam* in its Turkish, French, and English editions.[15]

Süheyl Ünver (d. 1986), a prominent physician, traditional artist, and historian of science, especially of medicine, occupies a prominent place in Qūshjī studies in the twentieth century.[16] In 1948, he published his monograph on Qūshjī as the first book of the History of Science series supported by the Faculty of Science at Istanbul University.[17] By the time it was published, Ünver's monograph was the most comprehensive work on Qūshjī, which expanded our knowledge of him substantially by collecting numerous anecdotes about Qūshjī's life, works, and descendants. The importance of this book stems not only from its being the first monograph exclusively dedicated to Qūshjī, but also from

[14] A. Adnan Adıvar, "The Cultural Situation of Byzantines and Turks at the Time of the Conquest of Constantinople 1453," *The Muslim World* 45, no. 1 (1955): 71.

[15] A. Adnan Adıvar, "ʿAlī b. Muḥammad al- Ḳūshd̲j̲ī," in *Encyclopaedia of Islam, Second Edition*, accessed April 18, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_0525; A. Adnan Adıvar, "ʿAlī b. Muḥammad al- Ḳūshd̲j̲ī," in *Encyclopédie de l'Islam*, accessed April 18, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/9789004206106_eifo_SIM_0525; Abdülhak Adnan Adıvar, "Ali Kuşçu," in *İslâm Ansiklopedisi: İslâm Âlemi Tarih, Coğrafya, Etnografya ve Biyografi Lugati*, 5th ed., vol. 1 (Istanbul: Milli Eğitim Basımevi, 1978), 321–23.

[16] For an account of Ünver's biography and his scholarly and artistic works, see Ahmet Güner Sayar, "Ahmet Süheyl Ünver," in *TDV İslâm Ansiklopedisi* (Istanbul: TDV Yayınları, 2012), vol. 42, 350–52.

[17] A. Süheyl Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, İstanbul Üniversitesi Fen Fakültesi Monografileri (İlim Tarihi Kısmı) 1 (Istanbul: Kenan Matbaası, 1948). It is important to note that Ünver had a broad range of research interests in the history of science and the arts in their Islamic context. As far as the history of science is concerned, he published books on such topics as scientific and intellectual life during the time of Meḥmed II, Qāḍīzāde al-Rūmī and his contemporaneous scholars, and Istanbul Observatory. Given his publications on Qūshjī and Qāḍīzade, it is not far-fetched to assume that he had a particular interest in the circulation of knowledge and scholars between the Ottoman and Timurid periods. A. Süheyl Ünver, *İstanbul Rasathanesi*, 3rd ed. (Ankara: Türk Tarih Kurumu, 2014); A. Süheyl Ünver, *Bursalı Kadızâde Rûmî ve Devrinin Diğer Bilimcileri* (Izmir: Ege Üniversitesi Matbaası, 1970); A. Süheyl Ünver, *İlim ve Sanat Bakımından Fatih Devri Notları* (Istanbul: Belediye Matbaası, 1947); A. Süheyl Ünver, *İstanbul Üniversitesi Tarihine Başlangıç: Fatih Külliyesi ve Zamanı, İlim Hayatı* (Istanbul: Istanbul Üniversitesi Yayınları, 1946).

the fact that it was largely based upon Ünver's long-term research on manuscript copies.[18] Besides this, the book gives insights into Ünver's understanding of Ottoman science, which is crucial for understanding the historiography of science during the early Republican period of Turkey. While one is impressed by the contribution of Ünver's pioneering work on Qūshjī, it does not fully avoid anachronistic and decline-oriented approaches. For instance, in the preface of the book, Ünver calls the Ṣaḥn-i Thamān Madrasas, which were established by Sultan Meḥmed II in 1470, Istanbul University, as though the latter was the continuation of the former. He also contends that while the exact sciences started to flourish in post-conquest Istanbul with the arrival of Qūshjī who would teach and produce works there, the Ottomans could not continue in the same direction, "as they could not comprehend the importance of those disciplines."[19]

In the following years after the publication of Ünver's monograph, a few more devoted to Qūshjī were published. Muammer Dizer in 1988 and Yavuz Unat in 2009 published their monographs in Turkey, whereas J. X. Ibodov and T. P. Matvievskaya published their study in Uzbekistan in 1994.[20] Given the fact that Samarqand, Qūshjī's homeland, is in Uzbekistan, and that Istanbul, the city where he died, is in Turkey, the fact that historians in those countries have paid attention to Qūshjī speaks to the fact that he remains an important figure of their historical imaginations.

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[18] Ünver's contribution to the Qūshjī literature continued even after the publication of this monograph. As an example, he published a teaching permission (*tedris beratı*) issued by Meḥmed II in the last days of Dhū al-Qāʿīda 877 (April 1473), to a scholar known as Efdalzāde to teach at Ṣaḥn-i Thamān Madrasas. The importance of this permission is that Efdalzāde assumed this position after Qūshjī left it; it thus gives chronological information about his life. See, A. Süheyl Ünver, "Fâtih Sultan Mehmet Zamanında Tedris Berâtları Vesilesiyle Ali Kuşcu ve Efdal-zâde," *İstanbul Fetih Derneği Mecmuası*, no. 3–6 (1954): 351–56.
[19] See, Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 4.
[20] Yavuz Unat, *Ali Kuşçu: Çağını Aşan Bilim İnsanı* (Istanbul: Kaynak Yayınları, 2009); J. X. Ibodov and T. P. Matvievskaya, *Ulug'bek Shogirdi – Ali Qushchi* (Tashkent, 1994); Muammer Dizer, *Ali Kuşçu* (Ankara: Kültür ve Turizm Bakanlığı, 1988).

The 500th anniversary of Qūshjī's death in 1974 stimulated a few activities and publications that were supported by the National Library of Turkey (Milli Kütüphane) in Ankara. Its most important output was the publication of the *Ali Kuşçu Bibliyografyası* (*The Bibliography of ʿAlī al-Qūshjī*) by Müjgan Cunbur, the then director general of the Library. Relying upon the manuscript catalogues available to her, Cunbur lists more than 60 works attributed to Qūshjī, with the catalog information of their available copies. Furthermore, she gives information about the commentaries on some of Qūshjī's works including the *Fatḥiyya*, again with their copy details. By organizing all the bibliographical details that were available to her, Cunbur's work fills a significant gap in Qūshjī studies. Having said this, as she fairly points out, many catalogues she relied upon when preparing her bibliography are either incomplete or not fully reliable. Thus, it should be noted that Cunbur's noteworthy work should be revised and expanded through the consultation of the actual copies of Qūshjī's works, and the catalogues that have been prepared or revised since the publication of Cunbur's bibliography.[21]

Another anniversary program on the occasion of the 530th year after Qūshjī's death and the 140th year after Salih Zeki's birth, the aforementioned Ottoman historian of science, was organized by the History of Science program at Istanbul University in 2004. The majority of the papers that were presented in the symposium were on Salih Zeki, but the

[21] To give an example, some of Qūshjī's *Risālah dar hay'ah* copies are listed under the *Fatḥiyya*, which will be elaborated more in the "Description of the Manuscripts" section below. See, Müjgan Cunbur, *Ali Kuşçu Bibliyografyası: Ölümünün 500. Yıldönümü Dolayısıyla* (Ankara: Başbakanlık Basımevi, 1974), 40–41. In addition to the publication of this work, the Turkish National Library hosted another event to commemorate the 500th anniversary of Qūshjī's death, in which scholars including Süheyl Ünver talked about Qūshjī in various aspects. I contacted the Library to reach the video or audio record of this program, but unfortunately I was told that they could not share it since the quality of the record is so bad. A group of manuscripts copies that were presumably of Qūshjī's works were also exhibited as part of this event. See, "Ali Kuşçu'nun Anma Töreni," Milli Kütüphane, accessed April 19, 2019, https://kasif.mkutup.gov.tr/SonucDetay.aspx?MakId=777829.

papers on Qūshjī are follows: *ʿAlī al-Qūshjī's Astronomy and Its Possible Influence on the Copernican Revolution* by F. Jamil Ragep; *Kaynakları ve Etkileri Açısından Ali Kuşçu'nun Sayı Tanımı* (*ʿAlī al-Qūshjī's Definition of Number with Respect to Its Sources and Influences*) by İhsan Fazlıoğlu; *Ali Kuşçu'nun Varlık Felsefesi* (*ʿAlī al-Qūshjī's Philosophy of Existence*) by Dücane Cündioğlu. To the best of my knowledge, only Ragep's paper would eventually be published, which I consider in the astronomy part of my literature review.[22]

Before concluding this section, I would like to underscore an intriguing aspect of the Qūshjī literature that occurred in Turkey over the last few decades. Qūshjī has been the subject of a number of popular books, essays and documentaries, which aim to introduce him to a larger audience as a leading Ottoman "scientist."[23] Not surprisingly, rather than providing new insights into Qūshjī's life and scholarship, studies on the popular level mostly follow the same format and content, comprising a general account of his life, works and scientific activities and highlighting the Ottoman part of his life, his relationship with the Sultan Meḥmed II and his influence on Ottoman science.[24]

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[22] Sevtap Kadıoğlu, "Ali Kuşçu ve Salih Zeki Sempozyumu, İstanbul, 20-21 Aralık 2004," *Osmanlı Bilimi Araştırmaları* 7, no. 1 (2005): 193–95.

[23] As touched upon before, Qūshjī, as a core member of the Samarqand school and observatory that were formed by Ulugh Beg, has played an important role in the imagination of modern Uzbekistan. As much as this deserves particular attention, I will not be able to address it within the scope of this dissertation.

[24] There are quite a few popular works that aim to introduce Qūshjī and his significance in Ottoman and Islamic science to a wider audience including students. Among them are Hasan Yiğit, *Ali Kuşçu* (Istanbul: Maviçatı Yayınları, 2017); Orhan-Erhan Dündar, *Ali Kuşçu: Matematikçi ve Astronom* (Ankara: Ankara Büyükşehir Belediyesi, 2016); Ali Kuzu, *Ali Kuşçu* (Istanbul: Parola Yayınları, 2015); Behzat Taş, *Kültürümüzün Yapı Taşları* (Istanbul: Okuryazar Yayınevi, 2014); Ahmet Uçar, *Ali Kuşçu* (Istanbul: Gizemli Bahçe, 2014); Ali Kuzu, *Bilgi Güneşi Gökbilimci: Ali Kuşçu* (Istanbul: Paraf Yayınları, 2013); Salim Aydüz, "Sultanların Bilim Adamı Ali Kuşçu," *Yedikıta,* no. 49 (2012): 62–69; Salim Aydüz, "3 Sultanın Alimi, 3 Şehrin İlim Bekçisi: Ali Kuşçu," *Derin Tarih*, no. 8 (2012): 42–47; İsmail Bilgin, *Ali Kuşçu* (Istanbul: Damla Yayınevi, 2011); Remzi Demir, "Ali Kuşçu Devrimi mi?," *Bilim ve Ütopya* 16, no. 194 (2010): 61; Yeliz Aksoy, *Tarihte Osmanlı Bilim ve Teknolojisi: Piri Reis, Ali Kuşçu, Emir Çelebi, Takiyüddin, Uluğbey, Katip Çelebi, İbrahim Müteferrika* (Istanbul: Karma Kitaplar, 2008); Tosun Terzioğlu, "İçinde Ali Kuşçu Olan Bir Hikaye," *Sanat Dünyamız*, no. 73 (1999): 177–80; Necati Akgür, "Ali Kuşcu'nun Ölüm Günü (Yanlış:16 Aralık 1474 Cumartesi/Doğru: 17 Aralık 1474 Cumartesi)," *Türk Dünyası Tarih Dergisi*, no. 17 (1990): 37–42.

Beside this, the archetype of Qūshjī as a "scientist" is promoted for educational purposes. As an example, in 2012, "Ali Kuşçu Science and Technology Scholarship" was established as a state-funded program for international students to study in Turkey in the fields of science, engineering and technology.[25] Another relevant example of the representation of Qūshjī with reference to his scientific background in modern Turkey is *Bilim ve Teknik* (*Science and Technique*), a popular science journal published by the Scientific and Technological Research Council of Turkey (TÜBİTAK). The journal, whose main interest is basically to issue essays on scientific developments in Turkey and abroad, also publishes papers on the history of science, including those on Qūshjī.[26] Another example of the promotion of Qūshjī as a leading "scientist" is that in recent years two science centers were established in his name: "Ali Kuşçu Uzay Evi (ʿAlī Qūshjī Space Center)" supported by Eyüpsultan Municipality in Istanbul, and "Ali Kuşçu Gökbilim Merkezi (ʿAlī Qūshjī Center for Astronomy)" by Mamak Municipality in Ankara.[27] Equally interesting, one can even find Qūshjī as the main character of a children's book.[28]

[25] Olgun Gündüz, "Uluslararası Burslu Öğrencilerin Türkiye'de Eğitim Görme Beklentileri ve Kariyer Hedefleri" (Speciality Thesis, Yurtdışı Türkler ve Akraba Topluluklar Başkanlığı, 2012), 39.
[26] Hüseyin Gazi Topdemir, "Osmanlı Biliminin Öncülerinden Ali Kuşçu," *Bilim ve Teknik* 44, no. 522 (2011): 86–89; Abdülhakim Koçin, "Çağını Aşanlar: Onbeşinci Yüzyılın Ünlü Astronom ve Matematik Bilgini Ali Kuşçu," *Bilim ve Teknik* 24, no. 282 (1991): 42; Muammer Dizer, "Büyük Türk Düşünürü Ali Kuşçu'nun Astronomiye Katkısı," *Bilim ve Teknik* 10, no. 115 (1977): 13–15.
[27] "Ali Kuşçu Gökbilim Merkezi," accessed April 19, 2019, https://www.alikuscugokbilim.com/; "Ali Kuşçu Uzay Evi," *Eyüpsultan Belediyesi*, accessed April 19, 2019, https://www.eyupsultan.bel.tr/tr/main/pages/ali-kuscu-uzay-evi/928.
[28] Didem Demirel, *Ali Kuşçu ve Uçamayan Gülibik* (Istanbul: Timaş Çocuk, 2016).

1.2) Qūshjī in Islamic Intellectual History Studies

Although Qūshjī has been well known in the literature for his scientific works, he was also a prominent author in such intellectual disciplines as *kalām*, Arabic linguistics, Quranic exegesis (*tafsīr*), and legal theory (*uṣūl al-fiqh*). One can observe an increased scholarly interest in Qūshjī's non-mathematical works over the last two decades, which, as will be elaborated shortly, explore aspects of Qūshjī's connections to the networks of scholars, ideas and texts that shaped the intellectual environment in the post-classical period[29], particularly in the Timurid Empire. I will classify the secondary literature that has been produced so far according to the discipline to which the relevant works of Qūshjī belong.

1.2.1. *Kalām*

In the preface of her aforementioned bibliographical work, Müjgan Cunbur highlights the significance of Qūshjī's *Sharḥ al-Tajrīd,* a commentary on Naṣīr al-Dīn al-Ṭūsī's famous *kalām* work titled *Tajrīd al-iʿtiqād*. She lists more than 30 derivatives of the commentary, with the catalog details of their copies.[30] Better known as "the new commentary (*al-sharḥ al-jadīd*)," Qūshjī's work gained such a remarkable reputation in the

[29] By the post-classical period, I adopt Robert Wisnovsky's chronology, dating it from the twelfth century to the beginning of the twentieth century, which is also be considered the post-Avicennian period. Having said this, I also would argue that such a long period should be subject to more nuanced sub-periodizations, as well as by discipline-oriented periodizations, so that one can trace the internal dynamics of a discipline, in addition to general and contextual ones that can be extended to all the philosophical/intellectual disciplines including the scientific ones. Robert Wisnovsky, "The Nature and Scope of Arabic Philosophical Commentary in Post-Classical (ca. 1100—1900 AD) Islamic Intellectual History: Some Preliminary Observations," in *Philosophy, Science and Exegesis in Greek, Arabic and Latin Commentaries*, ed. P. Adamson, H. Baltussen, and M. W. F. Stone, vol. 2 (London: Institute of Classical Studies, 2004), 149–91.

[30] Cunbur, *Ali Kuşçu Bibliyografyası*, 6–23. At this point, I should highlight that I use the phrase "derivative works" as an umbrella term to denote works in different genres (commentary, gloss, translation, etc.), which were produced by taking the text in question as a starting point. I do not mean at all that they lack originality. As will be seen below, I have extensively relied on "derivatives" of the *Fatḥiyya* to uncover many interesting historical and scientific aspects of it.

Islamic East that Jalāl al-Dīn al-Dawānī (d. 908/1502) and Ṣadr al-Dīn al-Dashtakī (d. 903/1498), who were among the most influential polymaths in the late fifteenth and early sixteenth centuries in Persia, disputed metaphysical issues by writing several texts in response to each other, placing Qūshjī's commentary at the center of their discussion.[31]

Regarding the historical significance of Qūshjī's commentary, Ertuğrul Ökten, in his dissertation on ʿAbd al-Raḥmān Jāmī (d. 898/1492), a notable Timurid scholar and poet who studied astronomy with Qūshjī, points to the fact that as soon as Qūshjī's *Sharḥ al-Tajrīd* was released, it sparked discussions among the leading scholars in Herat, including Jāmī. He criticized Qūshjī's theological and philosophical ideas, sometimes very harshly, and the details of those criticisms have come down to us thanks to the biographers of Jāmī whose accounts provide us with many details regarding Qūshjī's intellectual life in Herat.[32]

In spite of the prominence of Qūshjī's lengthy commentary on the *Tajrīd* in Islamic intellectual history, it has only been the subject of research for a few decades. Those studies address, to varying degrees, issues discussed in the commentary, the intellectual connection of Qūshjī's work to the earlier *kalām* and philosophical literature, its place within the *Tajrīd* tradition, and contexts within which Qūshjī's commentary were written. The literature has produced two strands of research: Works in the first group examine his ideas about various theological and philosophical topics and their relevance to the earlier literature on related subjects. As far as the studies in the second group are concerned, they approach his commentary in order to unfold Qūshjī's understanding of natural philosophy

[31] Reza Pourjavady, "Jalāl al-Dīn al-Dawānī (d. 908/1502), Glosses on ʿAlāʾ al-Dīn al-Qūshjī's Commentary on Naṣīr al-Dīn al-Ṭūsī's *Tajrīd al- Iʿtiqād*," in *The Oxford Handbook of Islamic Philosophy*, ed. Khaled El-Rouayheb and Sabine Schmidtke (New York, NY: Oxford University Press, 2016), 419.
[32] Ertuğrul İ. Ökten, "Jāmī (817-898/1414-1492): His Biography and Intellectual Influence in Herat" (PhD diss., University of Chicago, 2007). Ökten's account of the checkered relationship between Jāmī and Qūshjī is of particular importance, since almost all the biographies of Qūshjī are silent about his life in Herat. I will raise this issue in more detail in the following chapter on Qūshjī's biography.

and his philosophy of science, particularly of astronomy. I will postpone the discussion of this latter group until the section on the Qūshjī's philosophy of science" below.

As far as the first strand of research is concerned, I first point out two studies that use Qūshjī's commentary as one of their main sources in order to understand how the philosophical subjects they deal with were discussed in the *Tajrīd* tradition.[33] Ayşe Betül Tekin's dissertation discusses the issues of existence and essence in the *Tajrīd* tradition with reference to such commentators and glossators as ʿAllāma al-Ḥillī (d. 726/1325), Shams al-Dīn al-Iṣfaḥānī (d. 749/1349), Qūshjī, ʿAbd al-Razzāq al-Lāḥijī (d. 1072/1661), and Sayyid al-Sharīf al-Jurjānī.[34] Yasin Apaydın's book, in turn, focuses on the first chapter of the *Tajrīd* entitled "On General Topics (*al-umūr al-ʿāmma*)," with reference to more than 20 derivative works of the *Tajrīd* including Qūshjī's commentary, which were written until the middle of the seventeeth century.[35] What one can easily infer from the observations made by both Tekin and Apaydın is that Qūshjī's commentary was one of the key texts in the *Tajrīd* tradition, which was frequently cited in metaphysical discussions by later scholars.[36]

[33] Al-Ṭūsī's *Tajrīd* includes six chapters (al-*maqāṣid*) that are also divided into sub-chapters: Chapter One: On General Topics (*al-umūr al-ʿāmma*); Chapter Two: On Substances and Accidents (*al-jawhar wa-al-aʿrāḍ*); Chapter Three: On the Proof of the Existence of the Creator, His Attributes and Actions (*ithbāt al-Ṣānīʿ wa-ṣifātihi wa-āthārihi*); Chapter Four: On Prophecy (*al-nubuwwa*); Chapter Five: On the Supreme Leadership (*al-imāma*); Chapter Six: On Issues Pertaining to the Hereafter (*al-maʿād wa-al-waʿd wa-al-waʿīd wa-mā yattaṣilu bidhālik*). Naṣīr al-Dīn al-Ṭūsī, *Tajrīd al-ʿAqāʾid*, ed. ʿAbbās Muḥammad Ḥasan Sulaymān (Alexandria: Dār al-Maʿrifat al-Jāmiʿa, 1996).

[34] Ayşe Betül Tekin, "Tusi'nin Tecridü'l-İtikad'ı ve Şerhlerinde Varlık ve Mahiyet" (PhD diss., Marmara University, 2013).

[35] Yasin Apaydın, *Metafiziğin Meselesini Temellendirmek: Tecrîd Geleneği Bağlamında Umûr-ı Âmme Sorunu* (Istanbul: Endülüs Yayınları, 2019).

[36] Another important set of works that should be regarded as part of Qūshjī studies includes those dealing with how his ideas were received by scholars after him. Unfortunately, the scope of this dissertation does not allow me to extend my review to such studies, but at least I should say that such works are crucial to understand the place of Qūshjī's scholarship in Islamic intellectual history.

Another topic in Qūshjī's commentary that attracted attention is the issue of the *imāma*, the question of who has the right to rule the Muslim community after the death of the Prophet Muḥammad. One of the central controversies between the Sunni and Shiʿa traditions, the *imāmā* started to be discussed in an extensive manner in the *kalām* and *fiqh* corpus from the very beginning of those disciplines. Naṣīr al-Dīn al-Ṭūsī's *Tajrīd*, which deals with the theological issues including the *imāma* from the perspective of the Shiʿa tradition, devotes a chapter to this topic, and scholars who wrote derivative works of the *Tajrīd*, including Qushjī, deal with it, but in various approaches and lengths.[37]

In his work about Ṭūsī's approach to the *imāma* in his *Tajrīd*, ʿAlī Maḥmūd Muqallid examines the opinions of ʿAllāma Ḥillī and Qūshjī, who are among the commentators of the *Tajrīd*, with reference to their different theological positions. In so doing, Muqallid addresses that those commentaries are helpful to understand Ṭūsī's main text.[38] In an article, İhsan Fazlıoğlu proposes to read *kalām* texts as a set of sources for the history of Islamic political thought. He, in turn, stresses the significance of the major *kalām* texts that circulated among the Ottoman scholars, including Qūshjī's commentary, with reference to their discussions on the *imāma*, by highlighting the "political" aspect of such texts. Fazlıoğlu also appends to his article an edition and Turkish translation of a section in which Qūshjī elaborates on the necessity of the political ruler in his commentary. His observation that this section is found almost verbatim in Saʿd al-Dīn al-Taftāzānī's (d. 792/1390) *Sharḥ al-*

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[37] For a general account of the discussion on the *imāma* throughout Islamic history, see W. Madelung, "Imāma," in *Encyclopaedia of Islam, Second Edition*, ed. P. Bearman et al., accessed March 31, 2019, <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_COM_0369>.

[38] ʿAlī Maḥmūd Muqallid, *Al-Nubuwwa wa-al-imāmā ʿinda Naṣīr al-Dīn al-Ṭūsī*, 2nd ed. (Beirut: Markaz al-Ḥaḍāra li-Tanmiyat al-Fikr al-Islāmī, 2010).

Maqāṣid is remarkable, as it speaks of the intellectual connection between Qūshjī and Taftāzānī.[39]

The interest in the *imāma* in the *Tajrīd* tradition is also reflected in a master's thesis that has been completed recently by Muhammed Osman Doğan who compares the opinions of two commentators on the *Tajrīd*, namely Iṣfaḥānī and Qūshjī, on the subject. In line with Fazlıoğlu's observation regarding the connection between Taftāzānī and Qūshjī, Doğan stresses that although Qūshjī on the *imāma* issue refers to such *kālam* texts as the commentaries on the *Tajrīd* by Iṣfahānī and ʿAllāma Ḥillī, and al-Sayyid al-Sharīf al-Jurjānī's *Sharḥ al-Mawāqif*, Taftāzānī's *Sharḥ al-Maqāṣid* is the one he uses the most.[40]

The intertextual connections between Qūshjī's work and those written in the fourteenth- and fifteenth-century Persia are also addressed in a recent dissertation by Mehmet Fatih Soysal. He provides a critical edition of the last four chapters of Qūshjī's commentary: Chapter Three: On the Proof of the Existence of the Creator, His Attributes and Actions; Chapter Four: On Prophecy; Chapter Five: On the Supreme Leadership; Chapter Six: On Issues Pertaining to the Hereafter. The dissertation also includes a detailed analysis of the third chapter, based on which he underlines that Qūshjī quotes a number of earlier prominent texts in the *kalām* tradition, including commentaries on the *Tajrīd* by ʿAllāma Ḥillī and Iṣfaḥānī, ʿAḍūḍ al-Dīn al-Ījī's (d. 756/1355) *Mawāqif*, Jurjānī's *Sharḥ al-Mawāqif* and his gloss on Iṣfaḥānī's commentary on the *Tajrīd*, and Taftāzānī's *Sharḥ al-Maqāṣid*. Soysal points out that the literature produced so far focuses largely on Qūshjī as a

[39] İhsan Fazlıoğlu, "Osmanlı Düşünce Geleneğinde 'Siyasî Metin' Olarak Kelâm Kitapları," *Türkiye Araştırmaları Literatür Dergisi* 1, no. 2 (2003): 379–98.
[40] Muhammed Osman Doğan, "Tecrîdü'l-İtikâd Şârihlerinde İmâmet: İsfahânî ve Ali Kuşçu Örneği" (MA Thesis, Istanbul 29 Mayıs University, 2018).

leading astronomer and mathematician, which overshadows Qūshjī as an eminent scholar of *kalām*.[41]

Although we do not have a critical edition of Qūshjī's commentary in its entirety, some publications have made available parts of the text since the early 2000s. Ṣābir ʿAbduh Abā Zayd published the metaphysics section (*ilāhiyyāt*) in 2002 in Egypt.[42] Muḥammad Ḥusayn al-Zarʿī al-Raḍāyī has recently published the first volume of his critical edition in Iran in 2014, which covers the first chapter (*maqṣad*) of the commentary. This edition also includes a lengthy account concerning the lives of Ṭūsī and Qūshjī, the historical context within which Qūshjī wrote his commentary and its importance in the *Tajrīd* tradition[43] And finally, Soysal's aforementioned dissertation is another contribution to those issues. As far as Qūshjī's understanding of natural philosophy and his approach to such issues as the heavenly bodies and mathematical objects are concerned, one should keep mind that the the second chapter, which is about substances and accidents, is yet to be edited.

1.2.2. Arabic Linguistics

Over the last two decades, several critical editions and studies on Qūshjī's linguistic works have been published. Musa Yıldız published Qūshjī's treatise entitled *Risāla fī al-istiʿāra*, a work that basically covers topics related to the science of rhetoric (*ʿilm al-bayān*). Yıldız underlines that one of the significant aspects of this treatise is that Qūshjī was actively engaged with such earlier authoritative texts in Arabic linguistics as al-Sakkākī's

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[41] Mehmet Fatih Soysal, "Ali Kuşçu'nun Şerhu Tecrîdi'l-Kelâm'ından Usûl-i Selâse Konularının Tahkiki ve İlâhiyat Meselelerinin Tahlili" (PhD diss., Marmara University, 2014).
[42] ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī, *Sharḥ al-Qūshjī ʿalā Tajrīd al-ʿAqāʾid lil-Ṭūsī (Mabḥath al-Ilāhiyyāt)*, ed. Ṣābir ʿAbduh Abā Zayd (Alexandria: Dār al-Wafāʾ li-Dunyā al-Ṭabāʿa wa-al-Nashr, 2002).
[43] ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī, *Sharḥ Tajrīd al-ʿAqāʾid al-mashhūr bi-Sharḥ al-Jadīd*, ed. Muḥammad Ḥusayn al-Zārʿī Al-Raḍāyī, vol. 1 (Qum: Rāʾid, 1393).

(d. 626/1229) *Miftāḥ al-ʿulūm* and Jalāl al-Dīn al-Qazwīnī's (d. 739/1338) *al-Īḍāḥ fī ʻulūm al-balāgha* and *Talkhīṣ al-Miftāḥ*. Moreover, according to him, Qūshjī's work is pedagogically well written, which attests to the fact that it was produced within the madrasa context.[44] Yıldız later published a book that covers a revised critical edition of the aforementioned treatise with a study and Turkish translation of it, a critical edition of the commentary on the text by an Ottoman scholar called Ismail Ayvalı (d. 1194/1780), and a Turkish translation of Qūshjī's text by an anonymous Ottoman scholar.[45] Additionally, another critical edition of the same text based upon different manuscript copies was prepared in a master's thesis submitted by Murat Sula. An important aspect of Sula's thesis is that it includes a catalog of copies of Qūshjī's works on linguistics that are kept in Trabzon Public Library (İl Halk Kütüphanesi).[46]

Another of Qūshjī's work in Arabic linguistics that has attracted attention is *ʿUnqūd al-zawāhir fī niẓām al-jawāhir*, a work that treats subjects pertaining to semantic theory (*ʿilm al-waḍʿ*), etymology (*ishtiqāq*), and morphology (*al-ṣarf*). It was written upon the request of Meḥmed II when Qūshjī was in Istanbul. Aḥmad ʿAfīfī published a critical edition of the text with a study in Cairo in 2001.[47] In addition, Musa Alp, in his dissertation, focuses on the same work and presents editions and translations of Qūshjī's shorter treatises on

[44] It is also important to note that Yıldız lists at least 12 treatises in linguistics attributed to Qūshjī. Musa Yıldız, "Ali Kuşçu'nun Risâle fi'l-İstiʿâre'si," *İslam Araştırmaları Dergisi*, no. 3 (1999): 215–34; Musa Yıldız, "ʿAlī Qūshjū wa-taḥqīq risālatihi fī al-istiʿāra," *Dirasat: An International Refereed Research Journal* 33, no. 2 (2006): 313–23.
[45] Musa Yıldız, *Bir Dilci Olarak Ali Kuşçu ve Risâle fi'l-isti'âre'si* (Ankara: T.C. Kültür Bakanlığı, 2002).
[46] Murat Sula, "Trabzon İl Halk Kütüphânesi'ndeki Arap Dili ve Belâğatı Alanındaki Yazmalar ve Ali Kuşçu'nun 'Risâle Fi'l-Mecâz ve'l-İsti'âre'Sinin Edisyon Kritiği" (MA Thesis, Dokuz Eylül Üniversitesi, 2000).
[47] ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī, *ʿUnqūd al-zawāhir fī al-ṣarf*, ed. Aḥmad ʿAfīfī (Cairo: Maṭbaʿat Dār al-Kutub al-Miṣriyya, 2001).

the same subjects, such as *Risāla fī al-waḍʿ*, *Risāla fī taqdīm al-musnad ilayh*[48], *Risāla fī taḥqīq lām al-taʿrīf*, and *Risāla fī al-ḥamd*. With respect to the history of education in the Islamic East, it is important to note Alp's observation that Qūshjī's works in Arabic linguistics were prepared in a madrasa context. In terms of Qūshjī's intertextual connections, Alp also observes that Qūshjī was actively engaged with the scholarship produced by Ījī, Jurjānī, and Taftāzānī in linguistic studies.[49] Abdullah Yıldırım's master's thesis on the *waḍʿ* section of the same treatise also reaches a similar conclusion regarding Qūshjī's intellectual outlook.[50]

1.2.3. Quranic Exegises (*Tafsīr*)

Another field in which Qūshjī compiled a work is *tafsīr* (Quranic exegises). In his book published in 2014, Mehmet Çiçek provides a critical edition of Qūshjī's gloss on Taftāzānī's gloss/summary of al-Tībī's (d. 743/1342) commentary on al-Zamakhsharī's (d. 538/1144) *al-Kashshāf*, one of the most widely studied *tafsīr* works in the post-classical period. In addition, Çiçek gives a detailed analysis of Qūshjī's text and its connections to the earlier works in the *Kashshāf* tradition. Qūshjī's gloss covers the introduction of the

[48] A critical edition of this work, also known as *Risāla mā ana qultu,* a work that deals with the phrase "mā ana qultu," which is a subject found in al-Taftāzānī's famous work in *ʿilm al-balāgha* (science of eloquence), *al-Muṭawwal*, was published by the same historian. Musa Alp, "Takdîm al-musnad ilayh (Ma ana qultu) to Ali al-Qoushgi: Achievement and Study," *Çukurova University Journal of Faculty of Divinity* 7, no. 2 (2007): 147–68. Although its title is given in English, the article is fully in Arabic. For the publication of several important texts on the subject of "mā ana qultu," see Sedat Şensoy, *Ma Ene Kultu Risaleleri: Tahkik ve İnceleme* (Konya: Aybil Yayınları, 2013).

[49] Musa Alp, "Arap Dili ve Belâğatı Açısından Ali Kuşçu ve *ʿUnkûdü'z-zevâhir fî nazmi'l-cevâhir* Adlı Eseri" (PhD diss., Dokuz Eylül University, 2006). For a recent book on Qūshjī with reference to the same subjects, published by the same scholar, see Musa Alp, *Ali Kuşçu ve Arap Dilbilimleri: Vaz' ve İştikâk* (Lambert Academic Publishing, 2017).

[50] Abdullah Yıldırım, "Vaz İlmi ve *Unkûdu'z-zevâhir*/ Ali Kuşçu (İnceleme- Değerlendirme)" (MA Thesis, Marmara University, 2007). Yıldırım also published a critical edition and Turkish translation of Qūshjī's *Risāla fī waḍʿ al-mufradāt*, a treatise that addresses such issues discussed in *ʿilm al-waḍʿ* as simple and compound words: Abdullah Yıldırım, "Ali Kuşçu ve *Risâle fî vaz'i'l-müfredât*'ı," *İslâm Araştırmaları Dergisi*, no. 19 (2008): 63–85.

Kashshāf, the First Chapter of the Quran (*al-Fātiḥa*) and the first verse of the Second Chapter (*al-Baqara*). It is important to note that this work gives insights into Qūshjī's intellectual connections especially to his Timurid predecessors. Like scholars who study Qūshjī's works in *kalām* and linguistics, Çiçek also notes Qūshjī's interest in Taftāzānī's scholarship by writing a gloss on his *tafsīr*. Moreover, it is important to note that Qūshjī's gloss also frequently refers to Jurjānī's work on the *Kashshāf*, even sometimes in a critical manner.[51]

Another important aspect of Qūshjī's work is that it was dedicated to Abū Saʿīd Gurgān (d. 1469), the then Timurid Sultan, which means that it was written between 1451-1469 in the Timurid Empire. Çiçek highlights that Qūshjī refers to a number of scholars and their works, such as Zamakhsharī, Taftāzānī, the commentators of the *Kashshāf* (i.e. al-Qazwīnī, Tībī, Quṭb al-Dīn al-Rāzī (d. 766/1364), and Jurjānī), Ibn Sīnā (d. 428/1037), al-Juwaynī (d. 478/1085), and many linguistic and dictionary-type works. In another study, Çiçek reiterates the intertextual networks of the Qūshjī's work that he had already discussed in his book.[52]

It is important to note that by writing his gloss, Qūshjī connects himself to the *Kasshāf* tradition, which consists of a number of derivative works of this famous work,[53] particularly to those produced in the Timurid context by such leading figures as al-Taftāzānī and al-Jurjānī. Çiçek also informs us that Qūshjī's method of exegeses is linguistic-

[51] Mehmet Çiçek, *Tefsirde Şerh Geleneği: Ali Kuşçu Örneği* (İzmir: Tıbyan Yayıncılık, 2014).
[52] Mehmet Çiçek, "Teftâzânî'nin Keşşâf Hâşiyesi'ne Hâşîye'si Bağlamında Ali Kuşçu Şerhçiliği," in *Osmanlı'da İlim ve Fikir Dünyası: İstanbul'un Fethinden Süleymaniye Medreselerinin Kuruluşuna Kadar*, ed. Ömer Mahir Alper and Mustakim Arıcı (Istanbul: Klasik Yayınları, 2015), 101–26.
[53] For a comparative and chronological study of major derivatives of the *Kashshāf*, see M. Taha Boyalık, "The Debate on the Nature of the Science of *Tafsīr* in the Tradition of *Sharḥ*s and *Ḥāshiya*s on *al-Kashshāf*," trans. Hakime Reyyan Yaşar, *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 4, no. 1 (2017): 87–114.

based, and theological or philosophical issues are touched on only in a few topics in a limited way. To summarize, Çiçek's research on Qūshjī's *tafsir* gives us another insight into his intellectual life as a Timurid scholar, as well as into his strong engagement with the works that had been produced or circulated in the same context.

1.2.4. <u>Legal Theory (*Uṣūl al-fiqh*)</u>

A work in the field of legal theory entitled *Ḥāshiya ʿalā al-Talwīḥ* is attributed to Qūshjī. It is a gloss on Taftāzānī's commentary, commonly known as *Talwīḥ* in the literature, on Ṣadr al-Sharīʿa's (d. 747/1347) *Tanqīḥ al-uṣūl* as well as on his own commentary called *al-Tawḍīḥ fī ḥall ghawāmiz al-Tanqīḥ*. Given the fact that only one copy of Qūshjī's work is known (Süleymaniye Manuscript Library, Carullah collection MS 1438, ff. 13-20), it was not widely circulated among the intellectual circles in which Qūshjī was involved. Recep Cici, in his survey on Ottoman legal scholars, states that Qūshjī's gloss consists of issues related to the problem of what is good (*ḥusn*) and evil (*qubḥ*).

Qūshjī's preference in writing on this issue is consistent with the fact that Ṣadr al-Sharīʿa's position that the issue of the good and evil is one of the most important topics in both legal theory and *kalām*. Indeed, the diverging ideas proposed by Ṣadr al-Sharīʿa and Taftāzānī on this subject gave rise to its own literature, as a number of scholars wrote treatises on these two scholars' controversies.[54] Cici also opines that Qūshjī's gloss strives to defend opinions of Ṣadr al-Sharīʿa against criticisms by his commentator Taftāzānī.[55] The *editio princeps* of the work was published by Hasan Özer without analysis. As far as the

[54] Şükrü Özen, "Tenkīhu'l-Usûl," in *TDV İslâm Ansiklopedisi*, vol. 40 (Istanbul: TDV Yayınları, 2011), 454–58.
[55] Recep Cici, *Osmanlı Dönemi İslam Hukuku Çalışmaları: Kuruluştan Fatih Devrinin Sonuna Kadar* (Bursa: Arasta Yayınları, 2001), 192–94.

intersection across such disciplines as legal theory, *kalām*, and natural philosophy is concerned, even a quick glance suggests that Qūshjī also deals with such issues related to natural philosophy as body, motion and time in his works on legal theory and *kalām*.[56]

Like his aforementioned work in *tafsīr*, this work on legal theory is also an indication of Qūshjī's interest in Taftāzānī's scholarship. The secondary sources I have consulted do not mention any clue as to when Qūshjī wrote his gloss. As mentioned earlier, Qūshjī wrote his work on *kalām* and *tafsīr* when he lived in the Timurid lands. One might assume that those works were the result of Qūshjī's thorough engagement with the intellectual environment in which topics of the traditional sciences were intensely discussed during the reign of Abū Saʿīd, and therefore his gloss in legal theory might have been written in that Timurid context. However, it is not far-fetched to assume that it might have been compiled later when he was in Ottoman Istanbul, since works of Ṣadr al-Sharīʿa and Taftāzānī, including the aforementioned ones, were circulated widely across various intellectual centers in the Islamic East. Indeed, the Ottoman case is quite intriguing regarding the extent to which Ṣadr al-Sharīʿa's opinions given in his *Tanqīḥ* and Taftāzānī's criticisms of them in the *Talwīh* resonated in the Ottoman intellectual milieu. The Ottoman Sultan Meḥmed II asked a group of eminent Ottoman scholars to evaluate both positions in his presence. Some of them, including Molla Luṭfī (d. 900/1495), one of Qūshjī's students in Istanbul, wrote treatises about these two scholars' different positions.[57]

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56 Hasan Özer, "Ali Kuşçu ve "Hâşiye ʿale't-Telvîh" Adlı Eseri," *İslam Hukuku Araştırmaları Dergisi*, no. 13 (2009): 361–92.
57 Özen, "Tenkīhu'l-Usûl," 456.

<u>1.3) Qūshjī in Studies on the History of Science in Islamic Societies</u>

This part will cover the secondary literature that has been put forth on Qūshjī's works in the mathematical sciences. I will devote to each discipline a separate section, but first, I would like to briefly mention general and introductory studies of Qūshjī's scientific works.

Several of the previously mentioned scholars, such as Süleyman Sudi, Salih Zeki, Adnan Adıvar, Süheyl Ünver, Müjgan Cunbur, Muammer Dizer, and Yavuz Unat have published studies on Qūshjī's astronomy and mathematics. I should differentiate the bio-bibliographical sources on Ottoman scientific literature, which were published between 1997 and 2001 by the Research Center for Islamic History, Art and Culture (IRCICA) in Istanbul, from previous scholarship in terms of their impact on Ottoman science studies in general, and Qūshjī studies in particular. The 18 IRCICA volumes list manuscript details of the works written in the Ottoman Empire, with helpful biographies of their authors and combine information from manuscript catalogs worldwide along with extensive research in manuscript libraries primarily in Turkey. The first two volumes are devoted to astronomy, and another two volumes to mathematics. They also include detailed information about the life and works of Qūshjī and other contemporaneous Ottoman figures who produced works in those disciplines. Having been published more than two decades after Cunbur's aforementioned bibliographical publication, the IRCICA catalogs make the task of researchers much easier in accessing information about the copies of Qūshjī's scientific works.[58]

[58] Ekmeleddin İhsanoğlu et al., eds., *Osmanlı Astroloji Literatürü Tarihi ve Osmanlı Astronomi Tarihi Literatürü Tarihi Zeyli (History of Ottoman Astrology Literature and Supplement to the History of Ottoman Astronomy Literature)*, vol. 1 (Istanbul: IRCICA, 2011), 306; Ekmeleddin İhsanoğlu et al., eds., *Osmanlı Bilim Literatürü*

Another significant work that deserves to be mentioned is Cevad İzgi's work entitled *Osmanlı Medreselerinde İlim* (*Science at the Ottoman Madrasas*). Relying on his extensive research on manuscript copies of the scientific texts that were written or studied during the Ottoman period, İzgi presents numerous textual evidence that many scientific texts, including those of Qūshjī, were studied at the Ottoman madrasas. In this respect, İzgi's work is a clear example of the importance of manuscript-based research in order to unfold aspects of Ottoman science.[59]

In the following pages, I will first review the literature on Qūshjī's mathematics, followed by those related to his astronomy.

1.3.1. Mathematics

Apart from the encyclopedic works that mention Qūshjī's mathematical treatises in a general manner, a small amount of research on them has been published. Earlier studies were published during the Soviet period between the early 1960s and 1970s. Among those, U. Atayeva's translation of one of Qūshjī's books on arithmetic into Russian as well as

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Tarihi Zeylleri (Matematik, Coğrafya, Musiki, Askerlik, Tabii ve Tatbiki Bilimler, Tıbbi Bilimler) ve Osmanlı Mavżūʻat al-ʻUlūm Literatürü Tarihi = Supplements to the History of Ottoman Scientific Literature (Mathematical, Geographical, Music, Military Arts, Natural and Applied Sciences, and Medical Sciences Literature) and History of Ottoman Classification of Sciences Literature, vol. 2 (Istanbul: IRCICA, 2011), 511; Ekmeleddin İhsanoğlu, Ramazan Şeşen, and Cevat İzgi, eds., *Osmanlı Matematik Literatürü Tarihi (History of Mathematical Literature During the Ottoman Period)*, vol. 1 (Istanbul: IRCICA, 1999), 20–27; Ekmeleddin İhsanoğlu et al., eds., *Osmanlı Astronomi Literatürü Tarihi,* 1:27–38. Two other bibliographical sources also deserve to be mentioned. Published in Russian in 1983, the bibliographical work devoted to Islamic mathematicians and astronomers prepared by G. P. Matvievskaya and B. A. Rosenfeld provides more comprehensive information about the catalog details of Qūshjī's scientific works than previous bibliographical publications. The work prepared in English in 2003 by B. A. Rosenfeld and Ekmeleddin İhsanoğlu relies primarily on the aforementioned Russian work and the catalogs published by IRCICA. Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 285–87; the aforementioned Russian work is G. P. Matvievskaya and B. A. Rosenfeld, *Matematiki i Astronomi Musulmanskogo Srednevekovya i Ikh Trudi (VIII-XVII Vv.)*, vol. 2 (Moscow: Nauka, 1983), 504–6.

[59] Cevad İzgi, *Osmanlı Medreselerinde İlim*, vol. 1 (Istanbul: İz Yayıncılık, 1997).

Gadoyboy Sobirovich's (Sobirov's) articles on aspects of Qūshjī's mathematics can be mentioned.[60]

In Turkey, İhsan Fazlıoğlu has studied Qūshjī's mathematical corpus. One of his earliest articles comprises a critical edition, translation and study of a treatise entitled *Risāla fī al-zāwiya al-ḥādda idhā furiḍat ḥarakat aḥad ḍilʿayhā taḥsīl zāwiya munfarija* (Treatise on [Finding] an Acute Angle if one assumes the motion of one of its two sides resulting in an Obtuse Angle [without Having a Right Angle Whatsoever], attributed to Sinān Pāshā (d. 891/1486), a prominent Ottoman scholar contemporaneous with Qūshjī. Fazlıoğlu states that the treatise was written as a response to Qūshjī's question to which the title of the treatise attests. Qūshjī asked it to a group of Ottoman scholars while they were in a gathering with Sultan Meḥmed II. Although this treatise was not written by Qūshjī, it helps us trace his scholarly engagement with local Ottoman scholars, as well as some of the intellectual debates he stimulated in the Ottoman context. This treatise also indicates that Sultan Meḥmed II seems to have promoted scholarly exchanges and debates among the *ʿulamaʾ* of his country.[61]

Another article by Fazlıoğlu includes an edition, Turkish translation as well as historical and mathematical analysis of a section from Qūshjī's *al-Risāla al-Muḥammadiyya*, based on the autograph copy (Ayasofya, MS 2733, ff. 150a-152b). In this section, Qūshjī

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[60] Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 285–87; Matvievskaya and Rosenfeld, *Matematiki i Astronomi Musulmanskogo Srednevekovya i Ikh Trudi*, 2:504–6. In this catalog, it is written that U. Atayeva's translation is that of *Risālat al-Muḥammadiyya fī ʿilm al-ḥisāb*, which Qūshjī presented to the Ottoman Sultan Meḥmed II when he emigrated to Istanbul upon the Sultan's request. However, they also attribute to Atayeva a translation of Qūshjī's arithmetic text in Persian, *Risālah dar ʿilm-i ḥisāb*, by referring to a book entitled *Astronomiya Oid Risala* (*A Treatise on Astronomy*); at this point, I prefer to call the Atayeva's work a "translation of one of the Qūshjī's books on arithmetic," as I have not had a chance to examine it.
[61] İhsan Fazlıoğlu, "Ali Kuşçu'nun Bir Hendese Problemi ve Sinan Paşa'ya Nispet Edilen Cevabı: Tenkitli Metin ve Çalışma," *Divan: Disiplinlerarası Çalışmalar Dergisi*, no. 1 (1996): 85–106.

briefly explains two methods, known as the "rule of double false position (*al-ḥisāb al-khaṭaʾayn*)" and "analysis (*taḥlīl*)," which were used in various mathematical traditions including the Islamic one, in order to find an unknown value in an equation. The importance of this work in Ottoman science stems from the fact that Qūshjī presented it to Sultan Meḥmed II when he emigrated to Istanbul upon the Sultan's request, and that it was used as an elementary textbook in Ottoman madrasas. Fazlıoğlu's article is the first close study of this work of Qūshjī and attempts to situate it within the history of Islamic and Ottoman mathematics.[62]

Fazlıoğlu also makes an important intervention regarding Qūshjī's number theory. Based upon his *al-Risāla al-Muḥammadiyya* and sections from his *Sharḥ al-Tajrīd*, Fazlıoğlu argues that Qūshjī's legacy on the subject would resonate in the works of Ottoman successors, including that of the famous astronomer Taqī al-Dīn al-Rāṣid (d. 993/1585), the founder of the Istanbul Observatory. Moreover, that *Sharḥ al-Tajrīd* was studied for the mathematical issues discussed in it is another indication of the significance of Qūshjī's commentary for history of science studies.[63]

Another article of Fazlıoğlu reveals Kātib Chalabī's (d. 1067/1657) interest in Qūshjī's *Muḥammadiyya* by focusing on his commentary on its introduction, entitled *Aḥsan al-hadiyya bi-sharḥ al-Muḥammadiyya*. We know from Kātib Chalabī's personal account given in his work entitled *Mīzān al-Ḥaqq* that he taught Qūshjī's *Muḥammadiyya*, and, while teaching it, commented on it.[64] The article includes an edition of the few extant pages from

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[62] İhsan Fazlıoğlu, "Ali Kuşçu'nun El-Muhammediyye fî el-Hisâb'ının 'Çift Yanlış' ile 'Tahlîl' Hesâbı Bölümü," *Kutadgubilig Felsefe-Bilim Araştırmaları*, no. 4 (2003): 135–55.
[63] İhsan Fazlıoğlu, "Kaynakları ve Etkileri Açısından Ali Kuşçu'nun Sayı Tanımı," in *Ali Kuşçu'nun Ölümünün 530. ve Salih Zeki'nin Doğumunun 140. Yılı Anısına Ali Kuşçu ve Salih Zeki Sempozyumu, İstanbul, 20-21 Aralık 2004* (unpublished paper). I am grateful to Prof. Fazlıoğlu for kindly sharing with me his paper.
[64] Kātib Chalabī, *Mīzān al-ḥaqq fī ikhtiyār al-aḥaqq* (Istanbul: Ali Rıza Efendi Matbaası, 1286), 133.

this commentary along with a historical analysis. Regarding Kātib Chalabī's close attention to Qūshjī's work, two points can be raised: first, it indicates that Qūshjī's scientific works continued to be studied into the seventeenth century; second, Kātib Chalabī's notes in the commentary that Qūshjī's text has connections to such major mathematical works as Ibn al-Khawwām's (d. 724/1324) *al-Fawāʾid* and Jamshīd al-Kāshī's *al-Miftāḥ al-ḥisāb*,[65] which indicates that Qūshjī's scientific connection to the Samarqand school continued in every aspect of his scholarship, including mathematics.[66]

Qūshjī's mathematics has so far attracted little attention in western countries; Roshdi Rashed is one of the few who have dealt with it. In his remarkable work, Rashed put together an edition, translation, and study of the several important texts on the notion of angle and magnitude that were written by the end of the fifteenth century. Rashed starts his book with an account of Euclid's *Elements* on the subject in order to set the stage for the discussions that would take place in the Islamic world. He examines the works by such scholars as Ibn Sīnā, Ibn al-Haytham (d. after 432/1040), al-Sijzī (d. 405/1015), and Kamāl al-Dīn al-Fārīsī (d. 709/1310). He also presents a text, with a brief account, entitled *Fī zāwiyat al-tamās* which Rashed attributes to Qūshjī. Rashed draws attention to the relevance of the text with reference to the problem of continuity, which became a significant subject of discussion in different intellectual trends including philosophy, *kalām*,

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[65] For the modern publications of these two texts, see İhsan Fazlıoğlu, "İbn El-Havvām (öl. 724/1324) ve Eseri El-Fevāid El-Bahāiyya Fi El-Ḳavaʾid El-Ḥisābiyye (Tenkitli Metin ve Tarihi Değerlendirme)" (MA Thesis, Istanbul University, 1993); Jamshid b. Masʿūd Al-Kāshī, *Miftah al-ḥisab d'Al-Kashi: Édition, Notes et Introduction*, ed. Nader Nabulsi (Damascus: Imp. de l'Université de Damas, 1977); Nuh Aydin, Lakhdar Hammoudi, *Al-Kāshī's Miftāh al-ḥisāb, Volume I: Arithmetic (Translation and Commentary)* (Cham: Birkhäuser, 2019).

[66] İhsan Fazlıoğlu, "Ali Kuşçu'nun El-Risâlet el-Muhammediyye fi el-Hisâb Adlı Eserine Kâtip Çelebî'nin Yazdığı Şerh: Ahsen el-Hediyye bi-Şerh el-Muhammediyye," *Türk Dilleri Araştırmaları* 17 (2007): 113–25.

and mathematics.[67] Nevertheless, one should be reminded that the text Rashed published is generally attributed to Sinān Pāshā, as Fazlıoğlu established in the aforementioned article in which the critical edition is presented.[68] Since the copy of the text used by Rashed (Konya, Yusuf Ağa, MS 5477, ff. 226r-227r) lacks the introduction to the text in which Sinān Pāshā states that he wrote the treatise in response to Qūshjī's question that was posed to the Ottoman scholars in a gathering with Sultan Meḥmed, the copyist might have misattributed it to Qūshjī. In an earlier article, Rashed also discussed the concept of angle in an Islamic context. There he also analyses a number of texts including the one he attributes to Qūshjī.[69]

1.3.2. **Astronomy**

This section will review the secondary literature on Qūshjī's astronomical works and activities. Since the primary concern of my dissertation is to contribute to studies on Qūshjī's astronomy by focusing on his *Fatḥiyya*, the aim of my review in this part is twofold: first, to trace the main subjects and discussions in studies on Qūshjī's astronomy; second, to highlight the significance of studying the *Fatḥiyya*. I will divide this section into four categories, which are the main categories under which Qūshjī's astronomical corpus can be arranged: a) Qūshjī's work on planetary theories; b) Qūshjī's philosophy of science; c) Qūshjī's work in observational and practical astronomy; d) Qūshjī's *hayʾa* works.

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[67] Roshdi Rashed, *Angles et grandeur. D'Euclide à Kamāl al-Dīn al-Fārisī* (Boston & Berlin: De Gruyter, 2015), 176–80, 300–303.
[68] Fazlıoğlu, "Ali Kuşçu'nun Bir Hendese Problemi," 85–106.
[69] Roshdi Rashed, "L'Angle de contingence: un problème de philosophie des mathématiques," *Arabic Sciences and Philosophy* 22 (2012): 1–50.

1.3.2.1. **The Literature on Qūshjī's Work on Planetary Theories**

Since the beginning of the second half of the twentieth century, planetary theories that had been proposed in Islamic contexts in response to Ptolemaic models have attracted increasing attention from historians of Islamic astronomy. This development was driven mainly by two main factors: 1) the discovery that for centuries Islamic scholars discussed extensively the problems of Ptolemaic models and attempted to revise parts of them; 2) scholars of Islamic astronomy have discovered technical similarities and circumstantial connections between the planetary theories proposed by Islamic astronomers, especially those by Ibn al-Shāṭir (d. ca. 777/1375)[70], an outstanding Mamluk astronomer from fourteenth-century Damascus, and Copernican models.[71] As a matter of fact, the intense engagement of Islamic astronomers with Ptolemaic models goes back to the first translations of the Ptolemaic corpus into Arabic. Moreover, scholars in various parts of the Islamic world, such as Ibn al-Haytham and al-Biṭrūjī (fl. sixth/twelfth century), had serious criticisms of Ptolemaic assumptions, on the ground that some of them violate Aristotelian metaphysical and natural principles.[72] Consequently, all of these developments would lay the foundation for many non-Ptolemaic models developed by scholars, including Qūshjī, especially in the Islamic East after the twelfth century. [73]

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[70] For an account of Ibn al-Shāṭir's biography and scientific contributions, see Sajjad Nikfahm-Khubravan and F. Jamil Ragep, "Ibn al-Shāṭir," in *Encyclopedia of Islam, THREE*, ed. Kate Fleet et al., accessed April 22, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_32244.

[71] For some of the earliest studies in this direction, see E. S. Kennedy, "Late Medieval Planetary Theory," *ISIS* 57, no. 3 (1966): 365–78; E. S. Kennedy and Victor Roberts, "The Planetary Theory of Ibn al-Shāṭir," *ISIS* 50, no. 3 (1959): 227–35; Victor Roberts, "The Solar and Lunar Theory of Ibn ash-Shāṭir: A Pre-Copernican Copernican Model," *ISIS* 48, no. 4 (1957): 428–32.

[72] A. I. Sabra, "The Andalusian Revolt Against Ptolemaic Astronomy: Averroes and al-Biṭrūjī," in *Transformation and Tradition in the Sciences*, ed. E. Mendelsohn (Cambridge: Cambridge University Press, 1984), 133–55; Ibn al-Haytham, *Al-Shukūk ʿalā Baṭlamyūs*, ed. A. I. Sabra and Nabīl Shihābī (Cairo: Maṭbaʿat Dār al-Kutub, 1971).

[73] Among such contributions are Sajjad Nikfahm-Khubravan and F. Jamil Ragep, "The Mercury Models of Ibn Al-Šāṭir and Copernicus," *Arabic Sciences and Philosophy* 29, no. 1 (2019): 1–59; Amir-Mohammad Gamini,

Works of two historians of Islamic astronomy have shown the significance of the non-Ptolemaic models proposed by Qūshjī. George Saliba deals with Qūshjī's treatise entitled *Rīsāla fī ḥall ishkāl al-muʿaddil lil-masīr* (A Treatise Regarding the Solution of the Equant Problem), which he thinks was written between 1420 and 1449. His article notes that Qūshjī is engaged with the equant problem embedded within the Ptolemy's Mercury model, proposing a new non-Ptolemaic one, in which he draws on Muʾayyad al-Dīn al-ʿUrḍī's (d. ca. 664/1266) *Lemma*.[74] Providing a critical edition, translation, and commentary of Qūshjī's text, with a historical and scientific analysis, Saliba demonstrates that Qūshjī's alternative is compatible with Ptolemy's values for the motion of Mercury. Equally important, the article shows that Qūshjī's alternative model would resonate in non-Ptolemaic discussions afterwards, as al-Khafrī (d. after 931/1525), a leading astronomer of the late fifteenth and early twentieth century, quotes a section from Qūshjī's treatise almost *verbatim* in his *Takmila fī sharḥ al-Tadhkira*, a commentary on Naṣīr al-Dīn al-Ṭūsī's *Tadhkira*. In summary, Saliba takes Qūshjī's treatise as an example showing that proposing non-Ptolemaic models continued in the fifteenth century and beyond, which is a solid response to the so-called decline paradigm in Islamic intellectual history. In the same vein, he argues that such reform activities "became the main feature of Arabic astronomy."[75]

"Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century," *Arabic Sciences and Philosophy* 27, no. 2 (2017): 165–203; F. Jamil Ragep, "Ibn al-Shāṭir and Copernicus: The Uppsala Notes Revisited," *Journal for the History of Astronomy* 47, no. 4 (2016): 395–415; George Saliba, "A Sixteenth-Century Arabic Critique of Ptolemaic Astronomy: The Work of Shams al-Dīn al-Khafrī," *Journal for the History of Astronomy* 25, no. 1 (1994): 15–38; George Saliba, "A Medieval Arabic Reform of the Ptolemaic Lunar Model," *Journal for the History of Astronomy* 20, no. 3 (1989): 157–64.

[74] For the exposition of the tool, see George Saliba, *The Astronomical Work of Muʾayyad al-Dīn al-ʿUrḍī (Kitāb al-Hayʾa): A Thirteenth-Century Reform of Ptolemaic Astronomy* (Beirut: Markaz Dirāsāt al-Waḥda al-ʿArabiyya, 1990).

[75] George Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury," *Arabic Sciences and Philosophy* 3, no. 2 (1993): 162. Another edition of the same text is prepared by Heiderzadeh in his master's thesis. Tofigh Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri" (MA Thesis, University of Istanbul, 1997), 54–63.

George Saliba, in another article, remarks that the Qūshjī's text is not the only work which speaks of the interest in theoretical astronomy at the court of Ulugh Beg. Apart from a general account of his findings about Qūshjī's non-Ptolemaic Mercury model drawn from the aforementioned article, Saliba provides two sections from Fatḥ Allāh al-Shirwānī's (d. 891/1486) commentary on the *Tadhkira*, with their translation, which demonstrate that Ulugh Beg (d. 853/1449) attended classes in theoretical astronomy at the Samarqand madrasa regularly. Saliba also points out that Shirwānī's account is another example of texts in theoretical astronomy being studied in the madrasa context.[76]

F. Jamil Ragep is another historian of Islamic astronomy who contributed to our understanding of Qūshjī's non-Ptolemaic theories. Ragep provides a critical edition, translation and historical and scientific analysis of Qūshjī's treatise entitled *Risāla fī anna aṣl al-khārij yumkin fī al-sufliyyīn ka-mā fī ghayrihimā lil-Mawlā ʿAlī al-Qushjī* (Treatise on the Eccentric Hypothesis Being Possible for the Two Lower [Planets] Just as For the Others by Master ʿAlī Qushjī), written presumably between 1428-1449. Ragep points out that, unlike Ptolemy and Shīrāzī, who think that transforming epicyclic models into eccentric ones are possible only for the upper planets, Qūshjī challenges them by proposing a model that would allow the transformation for the lower planets, just as the upper ones. This discovery is quite remarkable; as Ragep states, with reference to Noel Swerdlow's research: "Copernicus had transformed Ptolemy's epicyclic models of the planets into eccentric

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[76] George Saliba, "Reform of Ptolemaic Astronomy at the Court of Ulugh Beg," in *Studies in the History of the Exact Sciences in Honour of David Pingree*, ed. Charles Burnett et al. (Leiden & Boston: Brill, 2004), 810–24. Indeed, İhsan Fazlıoğlu had earlier also pointed out the significance of Shirwānī's commentary as evidence for astronomy education in what he calls "the Samarqand Mathematical-Astronomical School," by providing a critical edition, translation and analysis of a section from that commentary that includes the teaching license Shirwānī received from Qāḍīzāda. İhsan Fazlıoğlu, "Osmanlı Felsefe-Biliminin Arka Planı: Semerkand Matematik-Astronomi Okulu," *Dîvân İlmî Araştırmalar*, no. 14 (2003): 1–66. For the English translation of this article, see İhsan Fazlıoğlu, "The Samarqand Mathematical-Astronomical School: A Basis for Ottoman Philosophy and Science," *Journal for the History of Arabic Science* 14 (2008): 3–68.

models as a first step in developing a Sun-centred astronomy." Swerdlow had maintained that the most plausible source for Copernicus to begin his transformation was Regiomontanus's *Epitome of the Almagest*. What is striking is that what Regiomontanus proposes is the same as Qūshjī's model and Qūshjī is Regiomontanus' older contemporary. Ragep's article opens up to the question as to whether Qūshjī's proposition was received beyond the Islamic World.[77]

1.3.2.2. The Literature on Qūshjī's Philosophy of Science

As I have mentioned before, Qūshjī's commentary on Ṭūsī's *Tajrīd* has been the subject of a few studies that discuss his approach to the interplay between astronomy, natural philosophy and metaphysics. One of the earliest examples that can be classified in this category is Ragep's 2001 article entitled "Freeing Astronomy from Philosophy: An Aspect of Islamic Influence on Science." It contributes to the relatively small but growing literature that deals with *kalām* texts to analyse issues that are also relevant to the history of science,[78] by challenging the conflict model of science and religion with reference to

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[77] F. Jamil Ragep, "ʿAlī Qushjī and Regiomontanus: Eccentric Transformations and Copernican Revolutions," *Journal for the History of Astronomy* 36, no. 4 (2005): 359. For the Turkish translation of this article see, F. Jamil Ragep, "Ali Kuşçu ve Regiomontanus: Dışmerkezli Dönüşümler ve Kopernik Devrimi," trans. Yavuz Unat, *Osmanlı Bilimi Araştırmaları* 8, no. 1 (2006): 81–96. An edition of the same text was prepared by Heiderzadeh in his master's thesis. Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 64–67.

[78] Astronomical issues in *kalām* texts have also been discussed in a few more studies such as: A. I. Sabra, "Science and Philosophy in Medieval Islamic Theology: The Evidence of the Fourteenth Century," *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 9 (1994): 1–42; Ahmad Dallal, *Islam, Science, and the Challenge of History* (New Haven: Yale University Press, 2010), 129-39; Robert Morrison, "What was the Purpose of Astronomy in Ījī's *Kitāb al-Mawāqif fī ʿilm al-kalām*?," in *Politics, Patronage and the Transmission of Knowledge in 13th-15th Century Tabriz*, ed. Judith Pfeiffer (Leiden & Boston: Brill, 2014), 201–29; Moiz Hasan, "Foundations of Science in the Post-Classical Islamic Era: The Philosophical, Historical, and Historiographical Significance of Sayyid al-Sharīf al-Jurjānī's (d. 1413) Project" (PhD diss., University of Notre Dame, 2017). Additionally, topics in natural philosophy, such as cosmology, causality and determinism, atomism and the theory of *minima naturalia*, motion, time and space, have been subjects of several studies for a few decades. For a review of the literature on those topics, see Jon McGinnis, "Arabic and Islamic Natural Philosophy and Natural Science," in *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, 2018,

Qūshjī's commentary as an example of "constructive engagement" of religion with scientific activities. Furthermore, he situates Qūshjī's understanding of astronomy within the context of one of the most debated issues in Islamic intellectual history, which is the checkered relationship between science (astronomy in his case), natural philosophy, and metaphysics. Ragep contrasts Qūshjī's philosophy of astronomy with the position of most Islamic astronomers, who believe that astronomy should rely on premises drawn from natural philosophy and metaphysics.[79] Qūshjī, however, is in favour of the idea that astronomy should be based on geometrical premises and observation, making it independent of natural philosophical and metaphysical premises.[80]

Ragep's elaboration of Qūshjī's philosophy of science in the *Tajrīd* commentary is discussed in two other articles. The first one focuses on Ṭūsī and Copernicus with respect to their position as to whether the Earth performs the daily rotation, rather than this being due to the Greatest Orb. Qūshjī's opinion on the subject, again found in the *Tajrīd* commentary, is also discussed in the article. Ragep notes that Qūshjī is "almost unique among medieval astronomers and philosophers," by being seemingly open to the idea of the rotation of the Earth, as he argues that the observational evidence does not verify conclusively the premise that the Earth does not rotate.[81] In another article, Ragep argues that Copernicus' dependence upon Islamic astronomy should be understood not only with

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https://plato.stanford.edu/archives/win2018/entries/arabic-islamic-natural/; Alnoor Dhanani, *The Physical Theory of Kalām: Atoms, Space, and Void in Basrian Muʿtazilī Cosmology* (Leiden & New York: E. J. Brill, 1994).

[79] Arguably, the most significant proponent of the idea of astronomy's dependence on natural philosophy is Naṣīr al-Dīn al-Ṭūsī, who articulates it in his *Tadhkira* as such: "The subject of astronomy is the simple bodies, both superior and inferior, with respect to their quantities, qualities, positions, and intrinsic motions. Those of its principles that need proof are demonstrated in three sciences: metaphysics, geometry, and natural philosophy." See, F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:90.

[80] F. Jamil Ragep, "Freeing Astronomy from Philosophy: An Aspect of Islamic Influence on Science," *Osiris* 16 (2001): 49–71.

[81] F. Jamil Ragep, "Ṭūsī and Copernicus: The Earth's Motion in Context," *Science in Context* 14, no. 1/2 (2001): 157.

reference to planetary models, but also with reference to the "conceptual revolution" that emerged in the Islamic intellectual milieu, which would set the stage for "an alternative 'astronomical' physics that was independent of Aristotelian physics;" and Qūshjī was the loudest voice in favor of the possibility of such a non-Aristotelian physics.[82]

Fazlıoğlu treats Qūshjī's commentary from the perspective of the philosophy of mathematics in Islamic context. His article delves into Qūshjī's ideas on the nature of mathematical objects. Focusing on the intellectual discussions that occurred in the post-classical period, particularly in the fifteenth century, regarding the ontological and epistemological value of mathematical objects for the description of nature, Fazlıoğlu argues that this subject can be better explained with reference to the concept of *nafs al-amr*, which, he argues, came to denote the ontological dimension of the mathematical objects. In line with Jurjānī's perspective on the subject, according to Fazlıoğlu, Qūshjī also needed to adopt *nafs al-amr* in such a way that as "a new, autonomous, ontological-epistemological principle," it would sustain "the soundness of mathematical entities and models."[83]

Mustapha Kara-Ali's dissertation is another project that attempts to propose a holistic approach to Qūshjī's scholarship. His study is largely based upon the literature on Qūshjī's astronomy, particularly the research by Ragep, as well as the recent studies (mentioned above) on *kalām* and semantics. It analyses what he calls the "revolutionary program of Qūshjī." Kara-Ali basically argues that Qūshjī's project is constructivist, that it

[82] F. Jamil Ragep, "Copernicus and His Islamic Predecessors: Some Historical Remarks," *Filozofski Vestnik* 25, no. 2 (2004): 139. The article was republished again with an appdendix indicating the significance of Qūshjī's advocacy of a non-Aristotelian physics. See, F. Jamil Ragep, "Copernicus and His Islamic Predecessors: Some Historical Remarks," *History of Science* 45, no. 1 (2007): 65–81, esp. 74-76.
[83] İhsan Fazlıoğlu, "Between Reality and Mentality: Fifteenth Century Mathematics and Natural Philosophy Reconsidered," *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 1, no. 1 (2014): 24.

developed within the tradition of *kalām*, and that it is free from the problems inherited in Peripatetic philosophy, which is realist, and from Platonic philosophy, which is idealist. In Kara-Ali's opinion, this constructivist model provides a contingent world which is open to new scientific investigations. Accordingly, he deems Qushjī as the peak of this process, whose constructivist legacy seems to have been transferred into Europe, being reflected in the Scientific Revolution. Although one might pay attention to Kara-Ali's attempt to make sense of Qūshjī's scholarship from the perspective of cross-cultural exchanges, as my literature review remarks, the available literature on Qūshjī is not mature enough to identify trajectories of his ideas in the Islamic World in a precise manner, let alone in cross-cultural contexts. Likewise, given the availability of only a small, albeit growing, amount of research on Qūshjī's *Sharḥ al-Tajrīd*, one might question if there is enough evidence to claim that Qūshjī completed the "emerging constructivist project of later Ashʿarite *kalām.*"[84]

Finally, the article published in Persian by Iraj Nikseresht and Sadegh Shahriar indicates that Qūshjī's *Tajrīd* commentary was studied for specific philosophical topics. In their article, Nikseresht and Shahriar give an account of the discussions on the simplicity of the delimiter of the directions (*muḥaddid al-jihāt*). Generally considered to be the outermost sphere in Islamic tradition, it determines the directions of the rectilinear motions. The authors deal with the subject with reference to such scholars as Ibn Sīnā, Fakhr al-Dīn al-Rāzī (d. 606/1210), Naṣīr al-Dīn al-Ṭūsī, Quṭb al-Ḍīn al-Shīrāzī, and Qūshjī. The authors point out that although Qūshjī does not refute the idea of the delimiter of the

[84] Mustapha Kara-Ali, "Constructivism at the Birth of the Scientific Revolution: A Study of the Foundations of Ali Qushji's Fifteenth-Century Astronomy" (PhD diss., International Institute of Islamic Thought and Civilization, IIUM, 2014), ii. I am grateful to Mustapha Kara-Ali for kindly sharing with me a digital copy of his dissertation.

directions, he was critically engaged with the opinions regarding its simplicity, proposed by his predecessors.[85]

1.3.2.3. The Literature on Qūshjī's Work in Observational and Practical Astronomy

In the introduction to *Zīj-i Ulugh Beg*, one of the most important astronomical tables prepared during the premodern period, Ulugh Beg, then ruler of Transoxania under the Timurid Empire and the commissioner of those astronomical tables, acknowledges the contributions of three astronomers, who helped him in the preparations of the astronomical tables: Ghiyāth al-Dīn Jamshīd al-Kāshī, Qāḍīzāda al-Rūmī, and Qūshjī.[86] Ulugh Beg's mentioning of Qūshjī as one of the contributors to his large scale observatory project leaves no doubt that he had experience in many branches of astronomy including observational astronomy.

Equally important, Qūshjī also wrote a commentary on this *zīj.* Salih Zeki claims in *Āthār-i Bāqiya* that Qūshjī's *Sharḥ-i Zīj-i Ulugh Beg* is his most important work. He goes on to say that Qūshjī discusses subjects and theorems mentioned in the Introduction to the *Zīj*, by elaborating their proofs (*burhān*) in his commentary.[87] Qūshjī also puts forth his criticisms towards the *Zīj*.[88] In line with Salih Zeki's opinion of Qūshjī's commentary, Adnan

[85] Iraj Nikseresht and Sadegh Shahriar, "Problem of Simplicity of Muḥaddid Al-Jihāt Sphere and Qūshchī's Challenge in It," *Tarikh-e Elm: Iranian Journal for the History of Science* 13, no. 1 (2016): 133–45.
[86] Uluğ Bey, *Uluğ Bey'in Astronomi Cetvelleri (Zîc-i Uluğ Bey)*, 24. For the English translation of the relevant section, see Aydın Sayılı, *The Observatory in Islam and Its Place in the General History of the Observatory* (Ankara: Türk Tarih Kurumu Basımevi, 1960), 265. And for a French translation, see Ulugh Beg, *Prolégomènes des tables astronomiques d'Oloug-Beg (Traduction et Commentaire)*, trans. L. P. E. A. Sédillot (Paris: Firmin Didot, 1853), 5–6.
[87] Salih Zeki, *Āthār-i Bāqiya*, 1:198.
[88] Tofigh Heiderzadeh states that Qūshjī's commentary includes criticisms towards both *Zīj-i Ulugh Beg* and *Zīj-i Īlkhānī*. More importantly, based on some copies of the former, he remarks that Qūshji made some

Adıvar states that it includes the most advanced theoretical and mathematical knowledge of its time, adding that Qūshjī's commentary is different from that of Mīrim Chalabi on the same work.[89] That being said, research on Qūshjī's observational astronomy is still in its early stages, so the question of what stimulated him to write a commentary on the *Zīj* whose preparation he contributed to remains unclear.[90]

The available sources do not provide any information as to when Qūshjī's commentary on *Zīj-i Ulugh Beg* was compiled. According to the list provided by the OALT, the oldest copy of the Qūshjī's commentary was copied in Istanbul in the last days of Dhū al-Ḥijja 879/April-May 1475, four months or so after the passing of Qūshjī. More interestingly, among the 12 copies that have come down to us, 10 copies are currently located in libraries in Istanbul (the other two copies are in Amasya, Turkey, and Majlis-i Shurā-yi Millī, Iran).[91] This evidence is certainly not enough to conclude that Qūshjī wrote his commentary in Istanbul. However, as mentioned above, Qūshjī also taught *Zīj-i Ulugh Beg* in Istanbul[92], and these two historical and codicological phenomena suggest that the

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revisions on the *Zīj-i Ulugh Beg* with the permission of Ulugh Beg. Therefore, his assumption is that Qūshjī's commentary also includes corrections which he and Ulugh Beg had made, but which could not be incorproted into the *Zīj* since Ulugh Beg had died. For Heiderzadeh's account of Qūshjī's *Zīj-i Ulugh Beg*, see Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 42–49.

89 Adıvar, "Ali Kuşçu," 323.

90 Crucial evidence for Qūshjī's active involvement in the preparation of the *zīj* is that Qushjī calls the observations and astronomical tables "our observation (*raṣadunā*)" in various occasions in the *Fatḥiyya*. Another interesting detail is that based upon his research on a of the *Zīj-i Ulugh Beg* (only catalog number 2693 is provided, which is presumably Ayasofya), Heiderzadeh comes across a marginal note showing that Qūshjī made corrections with the permission of Ulugh Beg, See, Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 44; Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 278. Additionally, one can note that although it is not directly related to his commentary, Fateme Savadi's introduction to her critical edition of Qāḍīzāda's treatise entitled *Risāla fī istikhrāj jayb daraja wāḥida* makes occasional references to Qūshjī's approach to the finding of the value of degree 1 in Qūshjī's *Zīj-I Ulugh Beg* commentary. See, Mūsā ibn Muḥammad Qāḍīzāda Rūmī, *Risālah fī istikhrāj jayb darajah wāḥidah*, ed. Fateme Savadi (Tehran: Mīras-i Maktūb, 2009).

91 İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:37.

92 Taha Yasin Arslan, "A Fifteenth-Century Mamluk Astronomer in the Ottoman Realm: ʿUmar al-Dimashqī and His *ʿilm al-mīqāt* Corpus the Hamidiye 1453," *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 4, no. 2 (2018): 123–24.

possibility of its completion in Istanbul deserves further attention. In any case, one can safely say that Qūshjī's commentary attracted attention largely in the Ottoman context.

Aydın Sayılı, in his study of the observatories that were established throughout Islamic history, gives a space to the establishment, development, and important figures of the Samarqand Observatory, in which he mentions Qūshjī as one of the key figures there.[93] With respect to Qūshjī studies, Sayılı's contribution provides us with valuable circumstantial evidence regarding the scientific environment and networks of scholars within which Qūshjī worked in Ulugh Beg's observation programs. Yet, it does not give us any detail concerning the extent to which Qūshjī continued his interest in observational astronomy after the release of the *Zīj-i Ulugh Beg*. In this respect, Taha Yasin Arslan's article is welcome. Although Arslan's main focus is not Qūshjī *per se*, but one of his students named ʿUmar al-Dimashqī, who was a major figure in the development of the science of timekeeping (*ʿilm al-mīqāt*) in fifteenth century Ottoman context, Arslan published two very valuable notes in Qūshjī's handwriting that were given to ʿUmar al-Dimashqī. As the notes suggests, Qūshjī confirmed that ʿUmar al-Dimashqī studied *Zīj-i Ulugh Beg* with him. These notes reveal that Qūshjī's interest in the genre of the *zīj* continued throughout his life.[94]

Arslan's article attests to the fact that some of Qūshjī's students in the Ottoman period, like ʿUmar al-Dimashqī who was an expert in timekeeping, were actively involved in practical astronomy. It brings up the possibility as to whether Qūshjī was involved in any activities to promote practical astronomy in Istanbul. In that regard, Süheyl Ünver makes an argument in line with what Arslan's article indicates. According to Ünver, Qūshjī was

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[93] For Sayılı's account of the Samarqand Observatory, see Sayılı, *The Observatory in Islam*, 260–89.
[94] Arslan, "A Fifteenth-Century Mamluk Astronomer in the Ottoman Realm," 119–40.

involved in the construction of the first sundial in Ottoman Istanbul in 878/1473, located at the Fatih Mosque. Ünver goes on to say that Qūshjī might also have had a role in the construction of a sundial at the Hagia Sofia Mosque. The article ends with drawings of some sundials at Istanbul mosques, one of which is the one supposedly made with the help of Qūshjī. Although the article's argument is quite intriguing in terms of the extent of Qūshjī's scientific activities in Istanbul, it does not provide any historical evidence that demonstrates Qūshjī's involvement in the construction of those sundials.[95]

1.3.2.4. The Literature on Qūshjī's *Hayʾa* Works

Qūshjī is the author of at least three *hayʾa* works: *Risālah dar hayʾah* in Persian; *al-Risāla al-Fatḥiyya* in Arabic; and *Sharḥ al-Tuḥfa al-shāhiyya fī al-hayʾa* in Arabic, a partial commentary on Shīrāzī's famous work, *al-Tuḥfa al-shāhiyya fī al-hayʾa*.[96] In the chapter on the historical and scientific contexts of the *Fatḥiyya*, I will deal with the development of *hayʾa* and significance of Qūshjī's works in this tradition.

Earlier studies on Qūshjī's *hayʾa* were produced during the Soviet period primarily by Uzbek and Russian historians. His *Risālah dar hayʾah*, written in Samarqand in 1458, is at the center of those earlier studies. I. M. Muminov published an Uzbek translation of the

[95] Another important aspect of Ünver's article with respect to the development of practical astronomy in Ottoman lands is that he also lists 49 sundials he could identify in Turkey, which had been made mostly during the Ottoman period. A. Suheyl Unver, "Sur les cadrans solaires horizontaux et verticaux en Turquie," *Archives de internationales d'histoire des sciences* 7, no. 28–29 (1954): 254–66. The sundials found on the façade of Fatih Mosque have been recently renovated; their technical details are briefly given in the following article: Atilla Bir, Burak Barutçu, and Mustafa Kaçar, "Fatih Sultan Mehmed Camii Güneş Saatlerinin Yenilenmesi (The Renovation of the Fatih Sultan Mehmed Mosque Sundials)," *Vakıf Restorasyon Yıllığı*, no. 7 (2013): 15–20.
[96] For a detailed account of the development of *hayʾa*, see F. Jamil Ragep, "Astronomy," in *Encyclopaedia of Islam, THREE*, ed. Kate Fleet et al., accessed April 22, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_22652; Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ: An Islamic Introduction to Ptolemaic Astronomy* (Cham, Switzerland: Springer Nature, 2016), 26–67.

Risālah, with a facsimile edition of a copy at a Tashkent library (Tashkent MS 3356/1). A. U. Usmanova also translated Qūshjī's text and Muṣlih al-Dīn al-Lārī's commentary on it into Russian as two separate publications.[97] Among those scholars who published on aspects of the Qūshjī's *Risālah* are Amed-Asan Khatipov, A. U. Usmanova, I. M. Muminov, and Khalil Siddyq ugli (Siddyqov).[98]

In addition to such studies that aim to make available the *Risālah* in vernacular languages, it has been the subject of studies that address the cross-cultural character of the *hayʾa* tradition, especially in the seventeenth century. More specifically, two articles demonstrate that Qūshjī's *Risālah* crossed linguistic and geographical borders by being translated into Sanskrit and Latin. David Pingree, in an article on the circumstances under which astronomical works of the post-classical period Islamic period were translated into Sanskrit, points out that the *Risālah*, along with Ṭūsī's *Tadhkira*, was a major vehicle for the transmission of Ptolemaic astronomy via Islam, into India. Pingree states that Qūshjī's *Risālah* was translated into Sanskrit in the seventeenth century under the title of *Hayatagrantha* by an anonymous translator. This article is also significant as it reveals how a set of astronomical texts that had been produced with a certain cosmological understanding was received or rejected in another context.[99]

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97 ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī, *Astronomicheskiy Traktat (Posobiye Dlya Studentov)*, trans. A. U. Usmanova (Samarkand, 1970); Muṣliḥ al-Dīn al-Lārī, *Kommentariĭ k Astronomicheskomu Traktatu "Risala dar falakiiat" Ali Kushchi (Posobiye Dlya Studentov)*, trans. A. U. Usmanova (Samarkand, 1971).
98 Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 285–87; Matvievskaya and Rosenfeld, *Matematiki i Astronomi Musulmanskogo Srednevekovya i Ikh Trudi*, 2:504–6. Rosenfeld and İhsanoğlu do not mention explicitly which manuscript library was referred to by Tashkent (MS 3356/1).
99 David Pingree, "Indian Reception of Muslim Versions of Ptolemaic Astronomy," in *Tradition, Transmission, Transformation: Proceedings of Two Conferences on Pre-Modern Science Held at the University of Oklahoma*, ed. F. Jamil Ragep, Sally P. Ragep, and Steven Livesey (Leiden & New York & Köln: E. J. Brill, 1996), 471–85. See also David Pingree, "Islamic Astronomy in Sanskrit," *Journal for the History of Arabic Science* 2, no. 2 (1978): 315–30.

For the Latin context, Gregg De Young provides an English translation of *Astronomica Quaedam*, a Latin text written by a professor of astronomy at Oxford named John Greaves (d. 1652) in 1650. This work is a Latin translation of the first chapter of the introductory section of the *Zīj* prepared during the reign of Maḥmūd Shāh Khiljī (or Khaljī), an Indian ruler, in the middle of the fifteenth century. What makes this article relevant for Qūshjī studies is that Greaves appended translations of sections from two other works, along with their original texts: a section from al-Farghānī's (fl. 3th/9th century) *Elements of Astronomy* on "what relations the epicycles have to the orb of the eccentric, and how much the center of the eccentric is distant from the center of the Earth"; and another section from Qūshjī's *Risālah* on "the magnitude of the Earth and the distance of the celestial spheres from the Earth."[100] It should also be noted that Greaves was interested in Egyptology and Islamic astronomy, particularly that produced in Persian and had paid visits to such places as Athens, Egypt, Istanbul, and Rome to collect manuscripts and books, now located in the Greaves Manuscript Collection at Oxford.[101] Greaves' interest in Qūshjī's astronomy also manifests itself in a codex from the collection that includes the *Risālah*. Since this codex has notes in Greaves' handwriting in the margins of the *Risālah*, it leaves no doubt that he studied the *Risālah* in this particular codex when he was preparing his translation.[102]

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[100] Gregg De Young, "John Greaves' Astronomica Quaedam: Orientalism and Ptolemaic Cosmography in Seventeenth-Century England," *Indian Journal of History of Science* 39, no. 4 (2004): 467–510. For the original Persian and Arabic texts and their Latin translation, see Johannis Gravii, *Astronomica Quaedam Ex Traditione Shah Cholgii Persae: Una Cum Hypothesibus Planetarum*, 2nd ed. (Londini, 1652).
[101] Raymond Mercier, "English Orientalists and Mathematical Astronomy," in *The "Arabick" Interest of the Natural Philosophers in Seventeenth-Century England*, ed. Gül A. Russell (Leiden: Brill, 1994), 161–77; Palmira Brummett, *Mapping the Ottomans: Sovereignty, Territory, and Identity in the Early Modern Mediterranean* (New York, NY: Cambridge University Press, 2015), 305.
[102] Importantly, the two pages in this copy, which have the section on "the magnitude of the Earth and the distance of the celestial spheres from the Earth," translated by Greaves into Latin, include numerical values for the distances of the planets in Greaves' handwriting in the margin. See, ʿAlī al-Qūshjī, *Risālah dar hayʾah*, Oxford, Oxford University, Bodleian Library, Oriental Manuscripts Greaves Collection, MS 21, ff. 64b-65a.

Unlike the *Risālah*, which has attracted the attention of historians from different countries, Qūshjī's *Fatḥiyya* has been studied almost exclusively by Turkish-speaking scholars. The first modern study written in Turkish devoted exclusively to the *Fatḥiyya* is Yavuz Unat's master's thesis defended at the University of Ankara in 1990. It covers the fourth ("On the Configuration of the Orbs of the Wandering Planets") and fifth chapters ("On the Motions of the Orbs of the Wandering Planets") of Part 1 of the *Fatḥiyya*. Unat provides the Arabic original, but it is not a critical edition since it is based solely on the autograph copy of the *Fatḥiyya* located at the Ayasofya 2733.[103] Having translated those sections into Turkish, Unat also compares those chapters to the relevant parts in the *Almagest*. Unat's thesis should be considered to be a significant step for Qūshjī studies; by taking the orbs and their motions mentioned in the *Fatḥiyya* as an example, it attempts to present Qūshjī's astronomy with reference to Ptolemy's authoritative work. Yet, it does not contextualize the *Fatḥiyya* within the larger *hayʾa* tradition nor does it give us any clue regarding the evolution of the *Fatḥiyya*.[104]

Unat's other significant contribution to the study of Qūshjī's astronomy is the transliteration of Sayyid ʿAlī Pāsha's (d. 1262/1846) annotated translation of the *Fatḥiyya* into Ottoman Turkish, with an introductory chapter about the translator, translated text and its historical significance.[105] Unat's interest in Qūshjī's astronomy, particularly in the *Fatḥiyya*, has continued until the present.[106] Tuba Uymaz's master's thesis is another

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[103] For further details, see the "Editorial Procedures" in this dissertation.

[104] Yavuz Unat, "Ali Kuşçu'nun Risâlat al Fathiyya Adlı Eserinin, Gök Küreleri Üzerine Olan Dördüncü ve Beşinci Makaleleri Üzerine Bir Çalışma" (MA Thesis, University of Ankara, 1990).

[105] Seyyid Ali Paşa, *Mirʿâtü'l-ʾÂlem (Evrenin Aynası) Ali Kuşçu'nun Fethiyye Adlı Eserinin Çevirisi*, ed. Yavuz Unat (Ankara: Kültür Bakanlığı Yayınları, 2001).

[106] Yavuz Unat, "Ali Kuşçu'nun 'Fethiye' Adlı Astronomi Eseri," *Felsefe Dünyası*, no. 12 (1994): 42–48. Almost the same article appeared in another publication later. Yavuz Unat, "Ali Kuşçu ve Fethiye," in *Uluğ Bey ve Çevresi Uluslararası Sempozyumu Bildirileri (Ankara, 30 Mayıs-1 Haziran)*, ed. Songül Boybeyi (Ankara:

important intervention into the literature. It includes transliteration, and historical and scientific analysis, of *Khulāṣat al-hayʾa* written by Saydī ʿAlī Raʾīs (d. 970/1562), a prominent Ottoman admiral, which, according to Uymaz, is an annotated translation of Qūshjī's *Fatḥiyya*. Indeed, she follows the widely accepted idea on Qūshjī's astronomy that *Khulāṣat al-hayʾa* is a translation of the *Fatḥiyya*. I will problematize this general acceptance in the following Part, in which I will show how an Ottoman scholar reconstructed a *hayʾa* text when translating it. Uymaz also appends the facsimile edition of the work (Süleymaniye Manuscript Library, Nuruosmaniye Collection, MS 2911).[107]

Tofigh Heiderzadeh's master's thesis defended at the University of Istanbul in 1997 is an important study of certain aspects of Qūshjī's astronomy.[108] Heiderzadeh provides us with a considerable body of information concerning Qūshjī's intellectual life and astronomical works. I can summarize the major contribution of this thesis to the field with two main points. First, by drawing on as many primary sources as possible, Heiderzadeh's biography of Qūshjī reveals new details about Qūshjī's life, some of which had not been given in the earlier modern research on Qūshjī. Second, the thesis attempts to increase our knowledge of Qūshjī's astronomy by discussing as many of his works as were available to Heiderzadeh. In fulfilling this aim, Heiderzadeh compares major works of Qūshjī,

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Atatürk Kültür Merkezi Yayını, 1996), 323–29; Remzi Demir and Yavuz Unat, "Ali Kuşçu ve El-Muhammediyye, El-Fethiyye ve Risâle fi Hall Eşkâl El-Muaddil li'l-Mesir Adlı Eserlerinin Türk Bilim Tarihindeki Yeri," in *Osmanlılarda Bilim ve Teknoloji Makaleler*, ed. Yavuz Unat (Ankara: Nobel Yayıncılık, 2010), 457–82; Yavuz Unat, "Osmanlı Dönemi Astronomlarından Ali Kuşçu: Çalışmaları ve Batı'ya Etkileri," in *Uluslararası Katılımlı Osmanlı Bilim ve Düşünce Tarihi Sempozyumu 08-10 Mayıs 2014 Bildiriler Kitabı*, ed. Mehmet Fatih Gökçek, Orhan Bingöl, and M. Ahmet Tüzen (Ankara: Gümüşhane Üniversitesi Yayınları, 2014), 16–48.

[107] Tuba Uymaz, "Seydî Ali Reis'in Hülâsa El-Heyʾe (Astronominin Özeti) Adlı Eseri Üzerine Bir İnceleme" (MA Thesis, University of Ankara, 2009).

[108] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri." Heiderzadeh's introductory chapter on Qūshjī's biography that appeared in an encyclopedic volume on Ottoman science is another contribution of his to Qūshjī studies. Tofigh Heiderzadeh, "Ali Kuşçu," in *Osmanlı: Bilim*, ed. Güler Eren, Kemal Çiçek, and Cem Oğuz, vol. 8 (Ankara: Yeni Türkiye Yayınları, 1999), 421–30.

particularly his *Risālah* and *Fatḥiyya*, with each other[109] as well as with earlier authoritative texts by Ṭūsī (mainly with his *Tadhkira* in Arabic, and *Muʿīniyya* and *Zubdah al-hayʾah* in Persian) to draw attention to the connections among the texts. Moreover, he provides editions of Qūshjī's short astronomical treatises entitled *Risāla fī ḥall ashkāl muʿaddil al-qamar lil-masīr*[110], *Risāla fī anna aṣl al-khārij yumkin fī al-sufliyyayn ka-mā fī ghayrihimā*[111], *Risāla fī anna kull mā yustaʿmal bi-al-shaklayn al-mughnī wa-al-ẓillī yumkin ʿan yustaʿmal bi-al-misṭara wa-al-firjār*[112], *Risāla fī anna ḥukm al-khārij ḥukm al-tadwīr bi-ʿaynihī fī wuqūf al-kawākib*[113]. He also appends a facsimile edition of a work on optics attributed to Qūshjī, entitled *Risāla fī taḥqīq al-abṣār.* The edition is based on the only available copy of the work, Tehran University (MS 2028).[114] In the upcoming chapters, while benefiting from the information provided in the thesis, I will also critically engage with Heiderzadeh's arguments regarding Qūshjī's astronomical corpus, particularly those about the *Fatḥiyya* and the *Risālah*.[115]

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[109] With reference to *Risālah dar hayʾah* and the *Fatḥiyya*, I also made a preliminary and brief observation regarding the relation between the two texts, and their possible connection to Qūshjī's understanding of astronomy as stated in his commentary on the *Tajrīd*. Hasan Umut, "Risâle der ʿİlm el- Heyʾe'den el-Fethiyye'ye: Bir Metnin Osmanlı Dünyasında Dönüşümü," in *Osmanlı'da İlim ve Fikir Dünyası: İstanbul'un Fethinden Süleymaniye Medreselerinin Kuruluşuna Kadar*, ed. Ömer Mahir Alper and Mustakim Arıcı (Istanbul: Klasik Yayınları, 2015), 215–25.

[110] As introduced earlier, George Saliba had already published a critical edition, translation, and study of this text. Heiderzadeh refers to Saliba's study, but adds that he used one more copy of the text in his critical edition (Topkapı Manuscript Library, III. Ahmed Collection, MS. 3483). Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury," 161–203; Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 54–63.

[111] As mentioned before, F. Jamil Ragep would later publish an article based on this treatise, with reference to the fact that Qūshjī's model proposed in the treatise might have been transferred to the early modern European context. Although the copies used by both Heiderzadeh and Ragep are the same, the style and even contents of their editions vary. F. J. Ragep, "ʿAlī Qushjī and Regiomontanus," 359–71; Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 64–67.

[112] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 72–92.

[113] Ibid, 93–98.

[114] Ibid, 99–104.

[115] Another thesis that covers in a general manner all Qūshjī's astronomical works available to the author of thesis was defended by Sadegh Shahriar in 2010 at the University of Tehran. Since I could only access its table of contents with a few pages from its Introduction, I cannot make any informed observations about it. Yet, the table of contents suggests that Shahriar's thesis gives a general account of Qūshjī's astronomical works,

1.4) Concluding Remarks: The Future of Qūshjī Studies

In this chapter, I have reviewed the secondary literature on Qūshjī's life and scholarship. As I have remarked above, Qūshjī has increasingly drawn the interest of scholars in Islamic intellectual history and history of science studies, especially over the last few decades. In light of my review above, let me conclude this chapter by highlighting possible directions in which studies on Qūshjī might continue to develop in the near future:

1) As mentioned above, Müjgan Cunbur lists more than 60 works attributed to Qūshjī, most of which, however, have yet to be edited, let alone been subject of extensive research. To give an example, although the literature asserts that Qūshjī is one of the most eminent scholars in astronomy and mathematics, only a few short treatises by him have been edited; his major works including *al-Risāla al-Fatḥiyya*, *Risālah dar hay'ah*, *Sharḥ-i Zīj-i Ulugh Beg*, *Risālah dar ʿilm-i ḥisāb*, and *al-Risāla al-Muḥammadiyya fī ʿilm al-ḥisāb*, are yet to be edited and studied extensively. When it comes to his famous commentary on the *Tajrīd*, this gap has started to be filled by recent publications of critical editions of its various parts, but we do not yet have it in full. The preparation of critical editions of Qūshjī's works is crucial for setting the stage for a more comprehensive and verified

followed by a closer look at Qūshjī's *Risālah dar hay'ah*, *Shārḥ-i Zīj-i Ulugh Beg*, *Sharḥ al-Tajrīd*, and the Mercury model. As far as his focus on Qūshjī's commentary on the *Tajrīd* is concerned, he provides a Persian translation and study of half the second sub-chapter (*faṣl*) of the second chapter (*maqṣad*) that is on heavenly and elemental bodies, which also handles issues pertaining to cosmological and astronomical issues. Sadegh Shahriar, "Ārāʾ u āthār-i nujūm-i Qushjī" (MA Thesis, University of Tehran, 2010). Sadegh Shahriar's interest in Qūshjī's role in transferring scientific knowledge from the Timurid Empire to the Ottoman lands, as well as in a general comparison of Qūshjī's *Risālah dar hay'ah* and *Fatḥiyya* is reflected in an article he published later as a co-author. Iraj Nikseresht and Sadegh Shahriar, "Investigating the Role of Mulla Ali Qushji in Transferring Knowledge from Samarqand School to Ottoman Emperorship (in Persian)," *Muṭālaʿāt Tārīkh Islām* 8, no. 30 (2016/1395): 179–98.

bibliography, as those works need to be examined by scholars in relevant fields to verify the authenticity of those attributions.

2) The available literature succinctly suggests that Qūshjī had strong affiliations with the networks of scholars, texts, and subjects that were influential in fifteenth-century Timurid Empire. Given the fact that Qūshjī himself was a prominent Timurid scholar, such an observation is not surprising. However, it is still worth noting for future studies that Qūshjī's active and sometimes critical engagement with the corpus of Taftāzānī and Jurjānī could well have the potential to uncover aspects of the intellectual life in the Islamic East during the early modern period.
3) Being studied and translated into various languages, Qūshjī's works reached an audience in a wide region stretching from India to England. Considering this, it is not far-fetched to assume that the reception of Qūshjī's scholarship across different languages and intellectual landscapes will be a promising subject of study.
4) As I have partially addressed and will point out more in the next chapter on Qūshjī's intellectual life, although available sources of Qūshjī's biography are quite informative about many sides of his life, there are still many discrepancies to be resolved, especially when it comes to determining within which contexts Qūshjī wrote his works. It is my strong conviction that the expansion of our knowledge of Qūshjī's life will aid our understanding of intellectual life in the

fifteenth-century in Islamic East. Likewise, the expansion of our knowledge of Qūshjī would be helpful for studies of other major figures of the period.[116]

[116] In this respect, a remark by İlker Evrim Binbaş deserves to be mentioned specifically. In his book on Sharaf al-Dīn ʿAlī Yazdī, one of the most notable Timurid historians who flourished in the first half of the fifteenth century, Binbaş rightly points out that in order to understand Yazdī's unknown life in Samarqand in the service of Ulugh Beg, one would expect to have "further research on the Samarkand scientific circle, especially a detailed biography of ʿAlī Qushji (d. 879/1474), who was in Samarkand when Yazdī went there." İlker Evrim Binbaş, *Intellectual Networks in Timurid Iran: Sharaf al-Dīn 'Alī Yazdī and the Islamicate Republic of Letters* (New York: Cambridge University Press, 2016), 66.

CHAPTER 2

ʿALĪ AL-QŪSHJĪ'S INTELLECTUAL BIOGRAPHY

As mentioned in the previous chapter, secondary sources on Qūshjī generally include varying degrees of information on his intellectual life. In spite of the availability of a wide range of primary sources, the majority of them are based on Ṭāshkubrīzāda's entry on Qūshjī in his *al-Shaqāʾiq al-nuʿmāniyya*; compiled in the sixteenth century, it is one of the most important biographical works on Ottoman scholars up to that time. There is no doubt that this work is a significant source for Qūshjī's life, especially during his short Ottoman period. While I will also draw from it in this chapter, Ṭāshkubrīzāda's entry should be carefully approached and used comparatively with other historical sources, some of which have been used in recent studies. Doing this will yield a more coherent and sound account of Qūshjī's life.

This chapter is a survey of Qūshjī's life, concentrating on the localities he lived in, the major figures he engaged with, the main intellectual currents in which he was educated, and his flourishing as an eminent scholar. I will also show how Qūshjī's life was remarkably intertwined with the intellectual, political, and social dynamics of the places where he lived. I aim to demonstrate that his migration from one city to another, or from one dynasty to another, was directly linked to the complex, multifaceted, and changing conditions of the Islamic East. My narrative is arranged chronologically, which I divide into the following stages: 1) The Early Timurid Period; 2) The Late Timurid Period: Between Samarqand and Herat; 3) Towards Pilgrimage or Istanbul? Qūshjī Emigrating Westward; 4) Qūshjī as a Diplomatic Mediator between the Ottomans and Āq Qoyūnlūs; 5) Qūshjī under Ottoman Patronage: Science and Education in Istanbul.

2.1) The Early Timurid Period

2.1.1. Qūshjī as a Student, Friend, and Protégé of Ulugh Beg

Al-ʿĀlim al-Fāḍil al-Kāmil al- Mawlā ʿAlāʾ al-Dīn ʿAlī b. Muḥammad al-Qūshjī, also known as al-Mawlā Qūshjīzāda[117] or ʿAlī al-Qūshjī, who was called "the Ptolemy of his times"[118], was one of the most prominent scholars in the Timurid Empire and the wider Islamic East in the fifteenth century. We do not have much information about his early life. It is generally assumed that he was born in or around Samarqand, Tīmūr's capital city. As for his birth date, it is reported that by 873-75/1469-70, when he was preparing to abandon his home country, Qūshjī was 70 years old. Although this account does not provide a clue as to whether his age was given in solar or lunar calendar, a good approximation is that he was born around 803-5/1399-1402.[119]

There are two accounts as to why he was given the nickname Qūshjī. The first account, which Ṭāshkubrīzāda mentions, is that his father was among the servants of Amīr Ulugh Beg as the "protector of the Amīr's falcons (*ḥāfiẓ al-bāzī*)", which corresponded to the word "al-Qūshjī in their language."[120] The second account is found in Khwāndamīr's

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[117] Aḥmad b. Muṣṭafā Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya fī ʿulamāʾ al-Dawlat al-ʿUthmāniyya*, ed. Ahmed Subhi Furat (Istanbul: Edebiyat Fakültesi Basımevi, 1985), 159. Bağdatlı İsmail Paşa mentions that Qūshjī was also called as "al-Samarqandī," "al-Rūmī," and "al-Ḥanafī." Ismāʿīl Bāshā al-Baghdādī, *Hadiyyat al-ʿārifīn: Asmāʾ al-muʾallifīn wa-āthār al-muṣannifīn*, vol. 1 (Istanbul: Wakālat al-Maʿārif, 1951), 736. For various aliases of Qūshjī's name, see Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 21.

[118] V. V. Barthold, *Ulugh-Beg*, trans. V. and T. Minorsky (Leiden: E. J. Brill, 1963), 131.

[119] ʿAbd al-Raḥmān Jāmī, *Abdur-Rahman Jami's Autograph Letters from the Muraqqa of Mir Ali Sher Nawayi (Nāmah-hā-yi dastnavīs-i Jāmī)*, ed. A. Urunbaev and Mayel Herawi (Kabul: Maṭbaʿah-i Dawlatī, 1364), 174–75. A different date of 808/1405-6 is also proposed, although it lacks justification; Al-Qūshjī, *Sharḥ Tajrīd al-ʿAqāʾid al-mashhūr bi-Sharḥ al-Jadīd*, 1:23. Additionally, İsmail Hakkı Uzunçarşılı, an eminent Ottoman historian, says that Qūshjī was born around 800/1397; İsmail Hakkı Uzunçarşılı, *Osmanlı Devletinin İlmiye Teşkilâtı*, 3rd ed. (Ankara: Türk Tarih Kurumu Basımevi, 1988), 231.

[120] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 159. It is important to note that the term "Qūshjī" has been used in Persia since the 7th/13th century to denote falconry. Muhammad Ali Mowlavi and Stephen Hirtenstein, "Falconry," in *Encyclopaedia Islamica*, ed. Wilfred Madelung and Farhad Daftary, trans. Alireza Sameti, accessed May 20, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1875-9831_isla_COM_036086. As for "their language" expressed by Ṭāshkubrīzāda, it is said that Johann Schiltberger (d. 1440), a European traveler who was enslaved in both the Ottoman and Timurid states and spent some time in Samarqand during

Ḥabīb al-siyar. He writes that Qūshjī had so close a relationship with Ulugh Beg that he sometimes put an "animal (*jānwar*)" in Qūshjī's hand, which made him famous as Qūshjī.[121] Concerning the extent of their friendship, the following examples seem convincing. In his introduction to *Zīj-i Ulugh Beg*, the ruler called Qūshjī "my dear son (*farzand-i arjumand*)".[122] Moreover, when Ulugh Beg was given secret information about his wife, he let Qūshjī hear it as his close friend.[123] In the introduction of his treatise on the Mercury model, Qūshjī himself acknowledges that he was favored by Ulugh Beg from a very early age: "ever since I have come to distinguish right from left, I have been blessed with his company."[124]

Another dimension of Qūshjī's close relationship with Ulugh Beg is that he served the ruler in diplomatic missions. Intriguingly, it is reported that Ulugh Beg sent him to China, presumably as an ambassador, and asked him to write down his observations about his journey. For the time being, such a report/treatise attributed to Qūshjī has not surfaced.[125] As will be elaborated below, Qūshjī's diplomatic experience would be

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the reign of Tīmūr, reports that the language that was spoken there was a mixed one of Persian and Turkish. Mustafa Gökçe and Tuba Tombuloğlu, "10. ve 15. Yüzyıl Seyyahlarının İzlenimlerinde Semerkand (Travellers Impressions of Samarkand Between 10 and 15th Centuries)," *History Studies: International Journal of History* 10, no. 10 (2018): 138–39.

[121] Ghiyāth al-Dīn b. Humām al-Dīn al-Ḥusaynī Khwāndamīr, *Tārīkh-i ḥabīb al-siyar fī akhbār afrād bashar*, vol. 4 (Tehran: Kitābkhāna-yi Khayyām, 1954), 38. In his biographical work entitled *Sullam al-wuṣūl*, Kātib Chalabī narrates both the reports provided by Ṭāshkubrīzāda and Khwāndamīr that Qūshjī's father was a servant of Ulugh Beg, and that Qūshjī might have carried his falcons in his hand, and therefore Qūshjī became well known with this nickname: "*wa-kāna rubbamā yaḥmil al-bāzī fī yadihi fa-ashtahara bihi*." Muṣṭafā b. ʿAbd Allah al-Qosṭanṭīnī al-ʿUthmānī Kātib Chalabī (Ḥājī Khalīfā), *Sullam al-wuṣūl ilā ṭabaqāt al-fuḥūl*, ed. Maḥmūd ʿAbd al-Qādir al-Arnāʾūṭ et al., vol. 2 (Istanbul: IRCICA, 2010), 393.

[122] Uluğ Bey, *Uluğ Bey'in Astronomi Cetvelleri (Zîc-i Uluğ Bey)*, 24.

[123] Barthold, *Ulugh-Beg*, 132, 139.

[124] Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury," 169.

[125] In the Rosenfeld and İhsanoğlu catalog, a book entitled *Khiṭāy-nāma* (or *Khaṭaynāmah*) is misattributed to Qūshjī; a recent study reveals that it is by Sayyid ʿAlī Akbar Khaṭāyī who dedicated his work to the Ottoman Sultan Selim I in 922/1516. Kaveh Louis Hemmat, "A Chinese System for an Ottoman State: The Frontier, the Millennium, and Ming Bureaucracy in Khaṭāyī's Book of China" (PhD diss., University of Chicago, 2014), 157; Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 287. There were several diplomatic exchanges between the Timurid and Chinese rulers after the reign of Tīmūr. For instance, in 1415,

important in the ongoing conflicts between Uzun Ḥasan, the Āq Qoyūnlū ruler, and Meḥmed II.

The relationship between Ulugh Beg and Qūshjī started mainly on a scholarly level. Having an admirable interest and talent in seeking knowledge even in his young age, Qūshjī attracted Ulugh Beg's special attention, which earned him his training under the supervision and patronage of Ulugh Beg.[126] Yet, it is important to note that although Ulugh Beg and Qāḍīzāda Rūmī, who was a teacher of both Ulugh Beg and Qūshjī, had a decisive role in Qūshjī's emergence as a leading scholar of the period, especially in the mathematical sciences, it is necessary to take into consideration the intellectual environment of the fifteenth-century Timurid Empire, particularly in Samarqand, in order to properly contextualize Qūshjī's intellectual outlook beyond these personal relationships. The following section will focus on this point.

2.1.2. Qūshjī's Educational Background: Texts and Institutions in the Fifteenth-Century Timurid Empire

In order to better understand Qūshjī's intellectual outlook that underlies his works in various fields, one should consider his education, teachers, and the intellectual and political networks with which he was actively engaged when he lived in his homeland, Samarqand. Unfortunately, Qūshjī's *ijāza* (license to teach) is not currently extant, but the sources written by two contemporaneous members of the Samarqand school are

1420, and 1430, Timurid embassies visited China. It is also reported that Ulugh Beg received a letter from the Chinese Emperor in 1445. Barthold, *Ulugh-Beg*, 180–81.

[126] Qūshjī describes being trained by Ulugh Beg, and as such "he has favored me from among his servants with the study of the philosophical sciences, and permitted me to read with him the famous mathematical books. As a result, I came to know, with God's help, the universal and the particular of the various disciplines that he introduced me to." Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury," 169.

invaluable in that they provide us with many details concerning the intellectual and pedagogical circumstances in which Qūshjī was trained and then became an eminent scholar.

The first primary sources are two letters written by Jamshīd al-Kāshī, an outstanding astronomer and mathematician of the period, who played a major role in the construction of the Samarqand Observatory and initiated the observations there.[127] Upon Ulugh Beg's invitation to join his ambitious observatory project, Kāshī came to Samarqand. These letters were sent to his father in Kāshan—a historically significant city close to Isfahan—within a few years after Kāshī's arrival in Samarqand. Kāshī informed his father of a number of intriguing observations and details regarding the intellectual life in the Samarqand madrasa and the observatory. He also introduced major figures with whom he collaborated during the establishment of the Observatory, such as Ulugh Beg and Qāḍīzāda. The relevance of these letters with Qūshjī's intellectual biography comes from the fact that Qūshjī was raised in the same intellectual circle. He probably had an acquaintance with Kāshī, either as a student at the madrasa or a colleague in the observatory project or both.[128]

[127] E. S. Kennedy is one of the first historians of science who reveal that Kāshī is among the most prominent scholars in the history of science in premodern Islamic societies. He published many works that discuss aspects of Kāshī's scholarship especially in mathematics and observational astronomy. For some of such works see, E. S. Kennedy and Colleagues and Former Students, *Studies in the Islamic Exact Sciences*, ed. David A. King and Mary Helen Kennedy (Beirut: American University of Beirut, 1983). One can consult the following entry for a general account of al-Kāshī's major contributions: Petra G. Schmidl, "Kāshī: Ghiyāth (al-milla wa-) al-Dīn Jamshīd ibn Masʿūd ibn Maḥmūd al-Kāshī [al-Kāshānī]," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 613–15.

[128] Mohammad Bagheri published the first letter in its original language (Persian) with a study, English translation, and a commentary in two separate publications. Mohammad Bagheri, "A Newly Found Letter of Al-Kāshī on Scientific Life in Samarkand," *Historia Mathematica* 24, no. 3 (1997): 241–56; Mohammad Bagheri, *Az Samarqand be Kāshān: Nāmahā-ye Ghiyāth al-Dīn Jamshīd Kāshānī be pedarash (From Samarkand to Kāshān: Letters of Al-Kāshī to His Father)* (Tehran: Scientific & Cultural Publications Co., 1996). As for Kāshī's second letter, it was published in two independent articles by E. S. Kennedy and Aydın Sayılı in 1960. While Kennedy's piece includes an English translation of the text and commentary, Sayılı provides the

The second primary source I use for constructing Qūshjī's educational background is an *ijāza* given by Qāḍīzāda to a brilliant student by the name of Fatḥ Allāh al-Shirwānī, who studied with him at the Samarqand madrasa between 838-39/1435-844/1440. Needless to say, Qūshjī was a prominent member of the Ulugh Beg court when Shirwānī was studying in Samarqand. More importantly, we know that Qūshjī also studied with Qāḍīzāda in Samarqand. Thus it is not far-fetched to assume that the texts which Qūshjī and Shirwānī studied with Qāḍīzāda should overlap. Indeed, the intellectual trajectories of these two students are comparable. Since Qāḍīzāda encouraged his students to go to his homeland to teach, some of them including Qūshjī and Shirwānī came to Anatolia and Istanbul, taught students, and produced new works. Unlike Qūshjī who was favored remarkably by the Meḥmed II, Shirwānī's relationship with the Ottoman elites was checkered. As a result, he decided to return to his homeland Shirwān after many years in the lands of *Rūm*.[129] In his article on the influence of "the Samarqand Mathematical-Astronomical School" on the philosophical and scientific foundations of the Ottoman intellectual system, İhsan Fazlıoğlu published a critical edition and study of Shirwānī's *ijāza,* which has come down to us through Shirwānī's commentary on Naṣīr al-Dīn al-Ṭūsī's *Tadhkira*, which I will discuss below. In this commentary, Shirwānī also gives some anecdotes regarding how Ulugh Beg was involved in teaching activities at the Samarqand Madrasa, which makes Shirwānī's

original text in Persian, along with its English and Turkish translations, and a study. Aydın Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti Hakkında Gıyasüddin-i Kâşî'nin Mektubu (Ghiyâth al Dîn al-Kâshî's Letter on Ulugh Bey and the Scientific Activity in Samarqand)*, 3rd ed. (Ankara: Atatürk Kültür Merkezi Yayını, 1991); E. S. Kennedy, "A Letter of Jamshid Al-Kāshi to His Father: Scientific Research and Personalities at a Fifteenth Century Court," *Orientalia NOVA SERIES* 29, no. 2 (1960): 191–213. The Persian text on which Kennedy's translation is based has been published by M. Ṭabāṭabāʾī, whose detail is found in Kennedy's article.

[129] For a brief biography of Shirwānī, see Scott Trigg, "Optics and Geography in the Astronomical Commentaries of Fatḥallāh al-Shirwānī," in *Islamic Literature and Intellectual Life in Fourteenth- and Fifteenth-Century Anatolia*, ed. A. C. S. Peacock and Sara Nur Yıldız (Würzburg: Ergon Verlag Würzburg in Kommission, 2016), 362–65.

testimony quite significant.[130] It goes without saying that I will also benefit from other primary and secondary sources that provide us with any circumstantial details related to Qūshjī's intellectual life.

2.1.2.1. Timurid Rulers as Patrons of Intellectual Life: An Overview

The Timurid Empire, which took its name from its founder, Tīmūr (d. 807/1405), became the most powerful political entity in Central Asia and Western Persia after he succeeded in filling the political vacuum that came with the dissolution of the Mongol Empire in the region. Tīmūr and his successors made substantial efforts to encourage cultural, scientific, and educational activities in their territories, as well as to establish new institutions and support scholars. One can identify at least 60 new madrasas that were founded by the Timurids in various parts of the Empire.[131] As far as the patronage of scholars in the Timurid territory is concerned, arguably the most notable examples are Tīmūr's patronage of Taftāzānī and Jurjānī, who were among the most influential scholars of their period. In the following centuries, their intellectual legacy in the Islamic East would be enormous, due partly to the hundreds of students they had in Samarqand.[132] These students would disseminate their teachers' scholarship to many parts of the Islamic world. Furthermore, Taftāzānī and Jurjānī compiled their *magnum opus*es, *Sharḥ al-maqāṣid* and *Sharḥ al-mawāqif,* respectively, in Samarqand.

Institutionalization of educational and intellectual activities continued after the death of Tīmūr. Through the efforts of Shāhrukh (d. 850/1447), who assumed the rulership

[130] Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 35–61.
[131] Kishimjan Eshenkulova, "Timurlular Devri Medrese Eğitimi ve Ulûm El-Evâ'il (Matematik, Astronomi ve Tıp)" (MA Thesis, Istanbul University, 2001), 78.
[132] Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 34.

after his father Tīmūr, and Shāhrukh's wife Gawharshād (d. 861/1457), there was an increased interest in establishing new madrasas in the major cities of the Empire including Herat and Samarqand.[133] To give an example, Shāhrukh founded a new madrasa in 813/1410-11 in his capital Herat to promote Sunni legal and theological doctrines in opposition to Shiʿite learning, various heterodox movements that were in circulation at the time, and, to some extent, even the Mongol laws, which Tīmūr had adopted. This was part of his policy called the "Sunni revival." It is quite striking that unlike his father, who had favored Jurjānī over Taftāzānī in a discussion that had occurred in front him, Shāhrukh preferred Taftāzānī's descendants and students when making appointments to key educational and bureaucratic positions. For example, a student of Taftāzānī, was appointed as the first *mudarris* (professor) of Shāhrukh's new madrasa. Moreover, his descendants would "come to monopolize the newly reinstituted post of *shaikh al-Islām*" in Khorasan until the end of the Empire.[134]

While his father Shāhrukh was implementing several intellectual projects in Herat, Ulugh Beg, the governor of Transoxiana based in Samarqand, marked a relatively distinct rulership compared to his father and even to his successors. First, he was himself a scholar who was trained by Qāḍīzāda; he then went on to become Qūshjī's teacher in the mathematical sciences. In his letters, Kāshī expresses his admiration for Ulugh Beg's personality as well as for the intellectual vibrancy in the city.[135] He describes Samarqand's

[133] Maria E. Subtelny, "Tamerlane and His Descendants: From Paladins to Patrons," in *The New Cambridge History of Islam*, ed. D. Morgan and A. Reid (Cambridge: Cambridge University Press, 2010), 182.
[134] Maria E. Subtelny and Anas B. Khalidov, "The Curriculum of Islamic Higher Learning in Timurid Iran in the Light of the Sunni Revival Under Shāh-Rukh," *Journal of the American Oriental Society* 115, no. 2 (1995): 213–14. It is also said that a madrasa was built in Taftāzānī's name in Herat. Eshenkulova, "Timurlular Devri Medrese Eğitimi," 73.
[135] According to J. S. Bailly, there were more than a hundred scholars from various fields at Ulugh Beg's court. Quoted in Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 40.

intellectual milieu in these words: “I came out to such a huge city and joined a group of such learned people and the circle of a learned, wise, scholarly, and world-ruling king.”[136]

Kāshī’s account reveals that Ulugh Beg received a solid education in both the traditional and rational sciences, primarily the mathematical sciences. He mentions that Ulugh Beg knew Arabic, Persian, Turkish, Mongolian and some Chinese. He memorized all the Qurʾān with an extensive knowledge of its many exegeses (*tafāsīr*) and was knowledgeable in jurisprudence (*fiqh*). His knowledge of Arabic literature was so admirable that he wrote some “excellent” poems.[137] At the time Kāshī wrote his letter, Ulugh Beg had been seriously engaged with the mathematical sciences for the past twelve years.[138] Given the fact that Kāshī’s letters were written most probably between 1420-1425, Ulugh Beg’s preoccupation with mathematics and astronomy seems to have started around 1408-1413 when he was under 20 years old. It is intriguing to note that Qāḍīzāda wrote his *Sharḥ al-Mulakhkhaṣ* and *Sharḥ Ashkāl al-taʾsīs* in 814/1412, both of which were dedicated to Ulugh Beg. In other words, Qāḍīzāda’s production of pedagogical scientific texts coincided chronologically with the emergence of Ulugh Beg’s interest in these sciences. This fact can be interpreted in two ways: 1) Qāḍīzāda might be the one who stimulated Ulugh Beg’s interest in the mathematical sciences; 2) The fact that Ulugh Beg accepted Qāḍīzāda at his court might indeed be a result of Ulugh Beg’s already existing interest in these sciences. No matter which case is assumed, what is clear is that Ulugh Beg’s projects of establishing an observatory and madrasa that paid particular attention to the mathematical sciences were the result of his ongoing and growing enthusiasm for these

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[136] Ibid, 105.
[137] Bagheri, “A Newly Found Letter of al-Kāshī,” 247; Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 94.
[138] Bagheri, “A Newly Found Letter of al-Kāshī,” 243.

sciences. More importantly, as Sayılı argues, given the fact that Ulugh Beg was young when he started to study the mathematical sciences, it is more likely that they were already studied in Samarqand by Ulugh Beg's time.[139]

Before concluding this section, one might pay attention to Edward S. Kennedy's remark to better understand Ulugh Beg's scientific personality. Kennedy points out that Ulugh Beg's scientific capability was mainly recounted by those "who were directly dependent upon the Sultan for their positions," and that one needs more evidence for hıs scientific skill. In this respect, by analysing a marginal note, attributed to Ulugh Beg and found on a copy of Kāshī's *Zīj–i Ḥāqānī*, regarding the calculation of the distance between two stars, Kennedy shows us that Ulugh Beg had a high level of knowledge in the mathematical sciences.[140]

2.1.2.2. **<u>The Making of Qūshjī's Intellectual Personality (1): The Samarqand Madrasa</u>**

The most important factors for the formation of Qūshjī's astronomical background are two institutions founded by Ulugh Beg. The first is the Samarqand madrasa with which he was affiliated as a student and *mudarris*.[141] It is considered to have been established in

[139] Sayılı proposes the years 1408-1410 for Ulugh Beg's first studies of the mathematical sciences. Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 38. Moreover, İhsan Fazlıoğlu remarks that the three rulers, namely Tīmūr, Shāhrukh, and Ulugh Beg, favored three major scholars of the time, namely Jurjānī, Taftāzānī, and Qāḍīzāda respectively. Thus, the intellectual trends in the cities those rulers resided in were mainly characterized by those scholars' outlook. In other words, Qāḍīzāda's focus on the mathematical sciences was a important indication for the increased attention to those sciences; Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 7.
[140] Edward S. Kennedy, "Ulugh Beg as Scientist," in *Astronomy and Astrology in the Medieval Islamic World* (Aldershot, Brookfield USA, Singapore, Sydney: Ashgate Variorum, 1998), 1-6 [Article X].
[141] Adıvar, "Ali Kuşçu," 321.

823/1420.[142] This madrasa seems to have been part of Ulugh Beg's larger project of establishing new institutions compatible with his intellectual vision in which the mathematical sciences occupied a significant place. It is reported that before the Samarqand madrasa, Ulugh Beg had established a madrasa in the city of Bukhara in 820/1417. The interesting aspect of this institution is that its walls were decorated with astronomical figures.[143] This again speaks to his special attention to the mathematical sciences. As for Qūshjī's career as a *mudarris*, another important report suggests that he was affiliated with the earlier Bukhara madrasa for a while.[144] Although we do not know when and what he taught there, one might safely assume that the texts studied in these two institutions must have overlapped substantially, since both madrasas were founded around the same period by the same patron.

Kāshī's account regarding the number of students studying in Samarqand is a significant testimony that educational activities, particularly that of the mathematical sciences during the Ulugh Beg period, were very vibrant: "ten thousand-odd students steadily engaged in learning and teaching, and qualifying for a financial aid, were listed. There are the same number of students among the notables and their sons, who dwell in their own homes. Among them there are five hundred persons who have begun to study mathematics." Kāshī goes on to express his appreciation for the state of the mathematical

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[142] Sayılı, *The Observatory in Islam*, 270–71. Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 10. In their article, which compares information included in contemporary sources, Hamid-Reza Giahi Yazdi and Pouyan Rezvani propose different dates as the most probable for the establishment of the madrasa: "Starting date of the Samarqand school foundation: 824/1421; Date in which the building of Samarqand school finished: 828/1425." However, I am inclined to assume its establishment date as 823/1420, which was proposed by the historian ʿAbd al-Razzāq al-Samarqandī, a contemporary Timurid scholar of Qūshjī from Herat. Hamid-Reza Giahi Yazdi and Pouyan Rezvani, "Chronology of the Events of the Samarqand 'Observatory and School' Based on Old Persian Texts: A Revision," *Suhayl* 14 (2015): 149, 157-60.
[143] Eshenkulova, "Timurlular Devri Medrese Eğitimi," 52–53.
[144] Ibid, 78.

sciences in Samarqand by reporting that the students tried "their hardest" to learn these sciences, which were offered in twelve places. As Kāshī notes, there were more teachers who were experts on mathematics than the number of places where they taught.[145]

Ulugh Beg's special interest in this madrasa manifests itself in many respects. On an architectural level, the walls, entrances and minarets of the madrasa were decorated with geometrical ornaments.[146] Administratively, Ulugh Beg was actively involved with the running of the madrasa. For example, he tested candidates for the position of *mudarris* for the madrasa himself.[147] More importantly, we learn from Kāshī's letters that Ulugh Beg visited the madrasa regularly. During his visits, he discussed mathematical subjects covered in classes with students and teachers. Other times, he taught astronomy himself.[148] Moreover, as Kāshī relates, Ulugh Beg encouraged students and scholars to be actively involved in discussions without feeling any hierarchical inferiority in front of him.[149]

As far as teachers and texts that were studied at the madrasa are concerned, Kāshī's account and Shirwānī's teaching license are informative. *Hayʾa* had a prominent place in science education at the madrasa. Ulugh Beg taught primarily two authoritative texts in the field: Naṣīr al-Dīn al-Ṭūsī's *al-Tadhkira fī ʿilm al-hayʾa* and Quṭb al-Dīn al-Shīrāzī's *al-Tuḥfa al-shāhiyya*. He was apparently so good at teaching these texts that "the slightest addition to it cannot be imagined." Kāshī also notes that Qāḍīzāda had a commentary on Jaghmīnī's *Mulakhkhaṣ*, a text which would become the most widely studied *hayʾa* work in Islamic

[145] Bagheri, "A Newly Found Letter of al-Kāshī," 243.
[146] Eshenkulova, "Timurlular Devri Medrese Eğitimi," 54. Peter J. Lu and Paul J. Steinhardt published a remarkable article in which they analyze the *girih* tiling on the walls of several madrasas in the Islamic East including Central Asia, finding evidence of quasi-crystalline Penrose patterns that were first proposed in the West in the 1970s. Peter J. Lu, Paul J. Steinhardt, "Decagonal and Quasi-Crystalline Tilings in Medieval Islamic Architecture," *Science* 315 (2007): 1106-10.
[147] Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 11.
[148] Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 37.
[149] Ibid, 109–10.

history.[150] From Shirwānī's teaching license, we also learn that another significant text that Qāḍīzāda taught was Niẓām al-Dīn al-Nīsābūrī's commentary on Ṭūsī's *Tadhkira*.[151] Kāshī also informs us that, apart from Qāḍīzāda, the following scholars also taught at the madrasa at the time the letter was written: a certain Maulānā Muḥammad Khānī, who had studied astronomy with Jurjānī, the author of two widely circulated commentaries on the *Tadhkira* and *Mulakhkhaṣ*, and a certain Maulānā Abū al-Fatḥ, who was expert in jurisprudence and who wrote a treatise "on astrolabe reading."[152]

In one meeting, Kāshī informs Ulugh Beg of positions that he had objections to in texts such as Quṭb al-Dīn al-Shīrāzī's *Ṭuhfa* and *Nihāyat al-idrāk*, and commentaries on the *Tadhkira* by al-Nīsābūrī and al-Jurjānī,. In another meeting, in which prominent scholars at Ulugh Beg's court were also present, Kāshī explained these objections. Furthermore, Ptolemy's *Almagest* and al-Bīrūnī's *al-Qānūn al-Masʿūdī* also became the subject of discussions in some other scholarly exchanges.[153]

As for the mathematical works that were studied in the Samarqand school, Kāshī tells us that some of the "calculators [*mustakhrij*]" started to study Euclid's *Elements*.[154] He also mentions that the subjects included in *Ashkāl al-taʾsīs* attracted attention of some scholars in the circle. He explicitly mentions Qāḍīzāda's commentary on the text. We also learn that at the time, one of the scholars was writing a commentary on *Tajnīs fī al-ḥisāb*, an arithmetic book compiled by Abū Ṭāhir al-Sajāwandī (d. after 596/1200); another one was

150 Ibid, 95.
151 Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 47.
152 Bagheri, "A Newly Found Letter of al-Kāshī," 246.
153 Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 99–100, 107. Kāshī relates that none of the people in Samarqand knew of Ptolemy's *Almagest*, except for Qāḍīzāda who only knew its "theoretical knowledge." Kāshī's observation deserves further study to make sense of the extent of the Samarqand school's acquaintance with Ptolemy's *magnum opus*. But one might still assume that over the period of the activities at the observatory, the *Almagest* would have been the subject of discussion among the Samarqand scholars.
154 Bagheri, "A Newly Found Letter of al-Kāshī," 243.

writing a treatise on "the geometrical proof for the rule of double false position," and four of them "have apportioned (among themselves) the explanation [i.e. commentary] of the *Ashkāl al-taʾsīs*."[155]

Kāshī also informs his father about his ongoing book projects. Having five or six incomplete books, Kāshī only gives the names of two of them: *Miftāḥ al-ḥisāb* and *Amthila-ye aʿmāl-e zīj*. Bagheri, in his commentary section on Kāshī's letter, points out that the second work may have never been finished since no copy seems to have survived.[156] Given the fact that Kāshī dedicated his *Zīj-i Ḥāqānī* to Ulugh Beg in Samarqand, one wonders whether there is any connection between this incomplete *Amthila* and the *Zīj*. However, it is not possible to answer this question until a copy of it is found. Yet, we know that the *Miftāḥ*, which was dedicated to Ulugh Beg, was completed in 830/1427 and became a well-known arithmetic textbook.[157] Therefore, one can safely assume that it was also among the mathematics books that were studied in the Samarqand circle. Indeed, its dissemination is evidenced by the fact that, as mentioned in the previous chapter, Kātib Chalabī writes in his partial commentary on Qūshjī's mathematical work, the *Muḥammadiyya*, that the *Miftāḥ* was part of Qūshjī's scientific background as it is one of the sources of the *Muḥammadiyya*.[158]

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[155] Kennedy, "A Letter of Jamshid al-Kāshi to His Father," 194. Sayılı translates the passage as "four persons are half through writing the fundamental theorems of geometry," but I prefer Kennedy's interpretation that Kāshī refers to the famous book of geometry when he uses the phrase, "*ashkāl al-taʾsīs*." Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 95.

[156] Bagheri, "A Newly Found Letter of al-Kāshī," 250, 255.

[157] George Saliba, "Kāši, Ḡiāṯ-al-Din," in *Encyclopædia Iranica*, vol. 16/1, 2012, 64–67, http://www.iranicaonline.org/articles/kasi.

[158] Fazlıoğlu, "Ali Kuşçu'nun El-Risâlet el-Muhammediyye fi el-hisâb Adlı Eserine," 113–25. There is also evidence that copies of Kāshī's *Miftāḥ* were in the Ottoman palace library at the turn of the sixteenth century. Elaheh Kheirandish, "Books on Mathematical and Mixed-Mathematical Sciences: Arithmetic, Geometry, Optics, and Mechanics," *Treasures of Knowledge: An Inventory of the Ottoman Palace Library (1502/3-1503/4)*, ed. Gülru Necipoğlu, Cemal Kafadar, and Cornell H. Fleischer (Leiden: Brill, 2019), 860.

The mathematical sciences were not the only ones that were taught by the Samarqand scholars. From Shirwānī's license, one sees that he studied the following texts with Qāḍīzāda: Jurjānī's famous *kalām* work, *Sharḥ al-Mawāqif*,[159] ʿAḍud al-Dīn al-Ījī's (d. 756/1355) *Sharḥ al-mukhtaṣar fī ʿilmay al-uṣūl wa-al-jadal* in legal theory, and other works that are not named in the teaching license.[160] This is an important detail for Qūshjī's intellectual biography. As will be discussed shortly, Qūshjī wrote his famous *kalām* work *Sharḥ al-Tajrīd* presumably in the 1450s. Shirwānī's license offers a strong indication that Qūshjī's earlier study of *kalām* was under the supervision of Qāḍīzāda. There are also reports that Qūshjī studied with Jurjānī. But this is unlikely, given the fact that when Qūshjī was born around 803-5/1399-1402, Jurjānī left Samarqand for Shiraz after Tīmūr died in 807/1405.[161] Moreover, considering the fact that Qūshjī had a work on legal theory, as mentioned in the previous chapter, his engagement with this discipline must have started in Samarqand.

There is no doubt that more texts were in circulation in the Samarqand school than those named above, given the number of students and scholars affiliated with it.[162] Moreover, texts were not the only educational tools used in the madrasa. Kāshī's account suggests that practical astronomy was also a subject of discussion, as the astrolabe was often used in class to explain issues in the texts.[163] Therefore, we can surmise that the

[159] The fact that Molla Jāmī, who stayed in Samarqand in the 1430s and 1440s "became familiar with Aḍud al-Dīn al-Ījī's (d. 756/1355) theological work, *Mawāqif* through Qāḍīzada-yi Rūmī's discussion of it" is another important witness for the circulation of the *Mawāqif* literature among scholars at the Samarqand school. See, Ökten, "Jāmī (817-898/1414-1492)," 66.
[160] Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 47–48.
[161] Sadreddin Gümüş, "Cürcânî, Seyyid Şerîf," in *TDV İslâm Ansiklopedisi*, vol. 8 (Istanbul: TDV Yayınları, 1993), 135.
[162] Indeed, Fazlıoğlu gives more titles in mathematics and astronomy than the ones mentioned by Kāshī and Shirwānī. See, Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 55–58.
[163] Bagheri, "A Newly Found Letter of al-Kāshī," 245.

accounts of Kāshī and Shirwānī show how the intellectual vibrancy Ulugh Beg wanted for his city was reflected in the wide range of texts used for studies in the madrasa. It is also clear from this picture that Qūshjī's intellectual formation took place in a very rich scholarly environment.

Like many biographical sources that include Qūshjī's biography, Ṭāshkubrīzāda also writes that Qūshjī studied with the scholars of Samarqand and that he was trained in the mathematical sciences by Ulugh Beg and Qāḍizāda.[164] It is not surprising that these two leading figures of the Timurid intellectual scene are mentioned. However, what is striking is that we are not informed of any other figures who might have been Qūshjī's teachers. Is it because Ṭāshkubrīzāda did not know them? Ṭāshkubrīzāda was a student of Mīrim Chalabī, a leading scholar of the late fifteenth and early sixteenth century, who was a descendant of Qūshjī,[165] and therefore it can be safely assumed that Ṭāshkubrīzāda received oral information regarding Qūshjī from Mīrim Chalabī. The mention of only Ulugh Beg and Qāḍīzāda might be a matter of priority: he listed the most important or famous teachers in the limited space assigned to Qūshjī's biography in his work. There is also another complementary explanation. Historical sources generally highlight Ulugh Beg and Qāḍīzāda for their remarkable accomplishments in the mathematical sciences, especially with reference to their role in establishing the Samarqand observatory. Within this context, Ṭāshkubrīzāda might have preferred to specifically emphasize Qūshjī's solid scientific background he received from being their student.

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164 Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 159.
165 Aḥmad b. Muṣṭafā Ṭāshkubrīzāda, *Miftāḥ al-saʿāda wa-miṣbāḥ al-siyāda fī mawḍūʿāt al-ʿulūm*, vol. 1 (Beirut: Dār al-Kutub al-ʿIlmiyya, 1985), 349.

2.1.2.3. The Making of Qūshjī's Intellectual Personality (2): The Samarqand Observatory

The second institution which had a decisive role in shaping Qūshjī's career as a leading astronomer is the Samarqand observatory. According to Sayılı, this observatory "seems to represent the highwater mark of Islamic achievement in this field of activity."[166] Moreover, when we consider the major production of the Observatory, the *Zīj-i Ulugh Beg*, which Ṭāshkubrīzāda calls "the best and most accurate among the astronomical tables (*aḥsan al-zījāt wa-aqrabuhā min al-ṣiḥḥa*),"[167] and the wide circulation it received in Euroasia during the early modern period, the Observatory's importance should be understood on global scale. Having functioned for more than 30 years, the Observatory had a profound role in the production of mathematical and astral knowledge in Samarqand. Equally important, the relationship between the Samarqand madrasa and Observatory is remarkable. Along with the fact that some of the figures played roles in both the institutions, a number of texts that were in circulation in the madrasa are also relevant to the activities in the Observatory. Both institutions seem to have been established to complement each other's function. Of course, I do not want to give an impression that these institutions were some kind of "modern scientific research centers." However, I believe that the simultaneous founding and construction of the madrasa and Observatory had to do with the fact that Ulugh Beg and his scholars paid particular attention to the investigation of nature through the mathematical and astral sciences.[168]

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166 Sayılı, *The Observatory in Islam*, 259.
167 Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 160.
168 Fazlıoğlu has traced major figures in Islamic intellectual history with attention to their understanding of the relationship between nature and mental objects, making references to some of the Samarqand scholars including Qāḍīzāda Rūmī and Qūshjī. See, Fazlıoğlu, "Between Reality and Mentality," 1–39.

Contemporary sources do not agree as to when the construction of the Observatory and observations started. Generally speaking, the dates range from 823/1420 to 830/1427.[169] In Sayılı's opinion, the construction started in 823/1420. Additionally, in his letter, Kāshī reports that most of its construction had been completed. Thus, Sayılı argues that it must have been completed in a very short period of time, presumably in the year 824/1421-1422.[170] According to Fazlıoğlu, however, it is safer to assume that the construction might have started in 824/1421, and activities in the Observatory started in 827/1424.[171] In summary, it is hardly possible to make a conclusive decision, but the Observatory site is more likely to have been completed in the first half of 1420s.[172]

As far as the people who were involved in the activities of the Observatory are concerned, Ulugh Beg is credited with proposing the construction of the Observatory and with serving as its Director (*ṣāḥib al-raṣad*). Kāshī relates that Ulugh Beg was actively involved in the observations.[173] Furthermore, the Introduction of *Zīj-i Ulugh Beg* mentions the names of three other astronomers who conducted observations: Kāshī, Qāḍīzāda, and Qūshjī.[174] From his letters, Kāshī seems to have been highly regarded by Ulugh Beg, such that the observatory was built in accordance with his suggestions. He worked closely with astronomers, builders and instrument-makers in order for the project to go smoothly.[175] Though his service in the Observatory was short-lived, cut short by his death in 1429, his crucial role in the beginning of the project makes it important to examine his scholarship

[169] For comparisons of the dates given in various sources, see Giahi Yazdi and Rezvani, "Chronology of the Events," 149–50; Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 15–16.
[170] Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 35–36.
[171] Fazlıoğlu, "The Samarqand Mathematical-Astronomical School," 16.
[172] The construction story also has an astrological aspect. It is reported that well-known astrologers cast a horoscope for constructing the observatory; Giahi Yazdi and Rezvani, "Chronology of the Events," 159.
[173] Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 67, 103.
[174] Uluğ Bey, *Uluğ Bey'in Astronomi Cetvelleri (Zîc-i Uluğ Bey)*, 24.
[175] Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 98–99, 102.

related to the Observatory. As mentioned earlier, Kāshī's *Zīj-i Ḥāqānī* was dedicated to Ulugh Beg, and therefore comparing *Zīj-i Ḥāqānī* and *Zīj-i Ulugh Beg* might be fruitful for understanding the extent of Kāshī's influence on the outcome of the observatory's project.[176]

After Kāshī, Qāḍīzāda assumed the responsibility for the observations, followed by Qūshjī.[177] To what extent was Qūshjī involved in the Observatory? Given the fact that *Zīj-i Ulugh Beg* is said to have been completed in 1437, and Qāḍīzada was still alive in 1440, as Shirwānī's teaching license suggests, Qūshjī's role is unclear.[178] As mentioned earlier, Ulugh Beg in the *Zīj* mentions Qūshjī by name. Furthermore, in his *Fatḥiyya*, Qūshjī calls the Samarqand observations "our observations (*raṣaduna*)." These serve as convincing evidence that he was affiliated with the activities in the Observatory. Moreover, Qūshjī personally observed the comet that appeared in 837/1433.[179] Barthold's approach regarding the activities in the observatory, with reference to L-A Sédillot (d. 1875), the French translator of the *Zīj,* is that Ulugh continued to work on the *Zīj* even after its first release, eventually finalizing it in 853/1449.[180] When Qāḍīzāda died, Qūshjī must have taken the main responsibility to help Ulugh Beg in revising the *Zīj*.[181] That being said, one

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[176] Sayılı, *The Observatory in Islam*, 52.
[177] Sayılı prefers not to call this responsibility for observations equivalent to being the director of the observatory on the ground that Ulugh Beg was himself occupied with the observatory and its director. Ṭāshkubrīzāda recounts that Ulugh Beg appointed (*tawallā*) these three astronomers to the observatory (*mawḍiʿ raṣad*). Sayılı contends that this Arabic word does not stand for "the direction of an observatory." His point is understandable but the fact that these three names are specifically mentioned should point to their special positions in the Observatory. There is no doubt that Ulugh Beg was the head of the Project. They may be deemed to be its "executive managers," anachronistically speaking. Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 159–60; Sayılı, *The Observatory in Islam*, 266.
[178] Fazlıoğlu, "Ali Kuşçu," 2017.
[179] F. J. Ragep, "Ṭūsī and Copernicus," 150.
[180] V. V. Barthold, *Ulugh-Beg*, 133.
[181] In this respect, Heiderzadeh's observation is notable. A copy of the *Zīj-i Ulugh Beg* (Heiderzadeh only gives the catalog number of this copy (MS 2693); I have identified it as Ayasofya MS 2693) suggests that some

should also note that the extent of Qūshjī's role in preparing the *Zīj* would be better understood only after an extensive study of his own commentary on the *Zīj*.

As Kāshī points out, in the Ulugh Beg circle, there were numerous scholars who taught various subjects. A number of them were "occupied with the mathematical sciences."[182] As a result, one can conveniently assume that apart from the figures mentioned above, there were a number of astronomers, astrologers, and mathematicians who were engaged with the observatory. Among the most prominent, Muʿīn al-Dīn al-Kāshī, a different scholar from the aforementioned Ghiyāth al-Dīn Jamshīd al-Kāshī but apparently came from the same city, had a major role in initiating the observatory project. It is reported that he was the one who "prepared the plan for the observatory."[183] We do not know much about his life and activities in Samarqand, but his role in the observatory should not be underestimated, as his son Manṣūr ibn Muʿīn al-Dīn al-Kāshī was also a staff member of the observatory. In fact, Birjandī, one of the most notable astronomers of the sixteenth century, was a student of Manṣūr. The father and son seem to have had an important role in the transmission of the Samarqand scientific tradition to the next generation. In addition, the observatory also hosted people who designed and made instruments needed for various astronomical and mathematical applications. It is related that a certain Jalāl al-Dīn al-Usṭurlābī designed the instruments of the observatory.[184] Another name mentioned with respect to the Observatory is the "master Ibrahim." Ghiyāth al-Dīn al-Kāshī mentions only a few people in his letters; Master Ibrahim, a coppersmith,

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corrections were made by Qūshjī with the permission of Ulugh Beg. Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 44; Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 278.

182 Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 95.

183 Sayılı, *The Observatory in Islam*, 264–65.

184 Takanori Kusuba, "Birjandī: ʿAbd al-ʿAlī Ibn Muḥammad Ibn Ḥusayn al-Birjandī," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 127; Sayılı, *The Observatory in Islam*, 267.

received this acknowledgment for the skill he displayed in making an armillary sphere in the presence of Kāshī.[185]

Zīj-i Ulugh Beg, one of the most important outcomes of the Samarqand Observatory, includes a chapter devoted to horoscopic astrology, and, as mentioned before, there were astrologers affiliated with the Observatory. Therefore, one might wonder if Qūshjī had an interest in astrology or the occult sciences. Over the last decade, new studies have started to emerge regarding the proliferation and increasing political importance of scholarly networks and religious movements that were linked to the cultivation of the occult sciences. Propagating various cosmological and metaphysical doctrines, these networks held political and social power-bases, which the Timurid rulers, especially Shāhrukh, attempted to eliminate. Evrim Binbaş calls these kind of groups "informal" networks, as opposed to the "formal" ones such as Sufis orders.[186] In order to point to the fact that Samarqand in the fifteenth century hosted scholars with various intellectual orientations, one can take Sharaf al-Dīn ʿAlī Yazdī (d. 858/1454), a leading Timurid historian famous for his book on Tīmūr entitled *Zafar-nāma*, and his teacher Ṣāʾin al-Dīn Ibn Turka (d. 835/1432), as two examples. They were part of an informal network based on the science of lettrism (*ʿilm al-ḥurūf*), which connected scholars in such regions as Persia, Egypt, and Anatolia. Moreover, Yazdī and Ibn Turka stayed for a while in Samarqand, meeting with Ulugh Beg and Qāḍīzāda Rūmī. The latter had a close relationship with Ibn Turka as they studied together with Sayyid Ḥusayn Akhlāṭī (d. 799/1397), an Egyptian scholar who was the center of this informal network in Cairo. It is interesting to note that upon receiving a

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[185] Sayılı, *Uluğ Bey ve Semerkanddeki İlim Faaliyeti*, 102. Kāshī also mentions several instruments to be used in the Observatory. Sayılı, *The Observatory in Islam*, 284.
[186] Binbaş, *Intellectual Networks in Timurid Iran*, 8.

copy of Ibn Turka's *Risālat al-basmala*, Qāḍīẓāda sent a letter to him as an expression of his "continuing appreciation of lettrism and admiration for Ṣāʾin al-Dīn's project."[187]

Given this context, was Qūshjī involved in these sciences? Presumably, he was aware of the occult-oriented scholarship that was circulating in the places he lived, and he might have even known some occult-oriented scholars in person. Besides this, as a major contributor to the *Zīj*, he should have been cognizant of astrology, at least theoretically. Having said this, one needs more evidence to claim that Qūshjī was intellectually interested in astrology and the occult sciences. Among his works available to us, none belongs to any of those fields. Nor do we have codicological or historical/biographical evidence, at least for the time being, that Qūshjī paid special attention to those disciplines.[188] As a consequence, one might conclude that Qūshjī's active engagement with astrology was limited to his involvement in the *zīj* project, at least until new evidence shows otherwise.

2.1.3. An Unclear Episode of Qūshjī's Life: Years in Kirman and Beyond

As summarized above, in his early Timurid years, Qūshjī seems to have occupied himself with study and teaching at the madrasa, contributing to the activities in the observatory, as well as enjoying a close friendship with Ulugh Beg. However, Qūshjī also faced intellectual and personal troubles during the same period, even if he was highly favored by the ruler. We shall see how, according to Ṭāshkubrīzāda, he decided to leave Samarqand for Kirmān, Iran, where he studied with local scholars. The striking aspect of

[187] Matthew S. Melvin-Koushki, "The Quest for a Universal Science: The Occult Philosophy of Ṣāʾin Al-Dīn Turka Iṣfahānī (1369-1432) and Intellectual Millenarianism in Early Timurid Iran" (PhD diss., Yale University, 2012), 440–42.
[188] Ahmet Tunç Şen, "Astrology in the Service of the Empire: Knowledge, Prognostication, and Politics at the Ottoman Court, 1450s-1550s" (PhD diss., University of Chicago, 2016), 39. Furthermore, in her survey of astronomy in the fifteenth century, Sally P. Ragep does not mention any astrological work attributed to Qūshjī. S. P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," 154.

the story is that he did not ask Ulugh Beg's permission for this trip. Moreover, Ṭāshkubrīzāda's account also leads one to assume that nobody in Samarqand was informed of his departure. Given the fact that Qūshjī had a very close relationship with Ulugh Beg, one wonders why Ṭāshkubrīzāda does not give the reason for Qūshjī's secret departure from Samarqand. Again, the sources are silent regarding this question. They seem to be less informed of Qūshjī's life outside of Samarqand.

Ṭāshkubrīzāda goes on to say that in Kirman Qūshjī wrote (*sawwada*) his well-known commentary on Naṣir al-Dīn al-Ṭūsī's *Tajrīd*, one of the most widely studied *kalām* texts in the postclassical madrasa.[189] However, one should be cautious about Ṭāshkubrīzāda's account, because, as will be elaborated below, Qūshjī dedicated his commentary to Abū Saʿīd, the Timurid ruler who came into power a few years after Ulugh Beg died. The secondary literature produced so far on Qūshjī's scholarship in *kalām* is not mature enough to answer our questions concerning Qūshjī's commentary and the context within which it was written. But Ṭāshkubrīzāda's account indicates that Qushjī might have written an earlier draft of his commentary during this period. However, if this is the case, why did Qūshjī dedicate his work to Abū Saʿīd instead of Ulugh Beg upon returning to Samarqand? Moreover, while Abū Saʿīd's name is explicitly in the introduction of the *Sharḥ al-Tajrīd*, one wonders why Ṭāshkubrīzāda did not mention this ruler's name in his entry on Qūshjī. His account that *Sharḥ al-Tajrīd* was written in Kirman when Ulugh Beg was still alive appears to be highly questionable, if not fully refutable.[190]

[189] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 159.

[190] An important detail that supports our doubts regarding Ṭāshkubrīzāda's story of the *Sharḥ al-Tajrīd* is that the Ottoman historian Muṣṭafā Ālī (d. 1008/1600) omits the story that the *Sharḥ al-Tajrīd* was compiled in Kirman in his famous world history book entitled *Kunh al-akhbār*, although his entry of Qūshjī heavily relies on Ṭāshkubrīzāda. Thus, one might attribute this omission to Muṣṭafā Ālī's scepticism towards

Ṭāshkubrīzāda continues that after "many years (*sinīn kathīra*)" of being away from Ulugh Beg, Qūshjī returned to Samarqand and begged Ulugh Beg's pardon for his secret departure "for the sake of seeking knowledge (*li-taḥṣīl al-ʿilm*)." Ulugh Beg accepted his apology and asked what gift Qūshjī brought for him. Qūshjī responded that he brought a treatise which solved the problems related to the Moon (*ishkāl al-qamar*) that perplexed the predecessors (*aqdamūn*). Such a gift should please an exceptional astronomer-cum-ruler like Ulugh Beg. The patron's response showed his interest in the present, but was also chastising at the same time: "Bring it to me, and let me see in which issue you are mistaken." If we believe Ṭāshkubrīzāda's account, Ulugh Beg read the treatise presented to him while standing and was left with an admiration of Qūshjī's work.[191]

George Saliba, in his article in which he publishes a critical edition and English translation of Qūshjī's treatise on his non-Ptolemaic Mercury model, dedicated to Ulugh Beg, problematizes Ṭāshkubrīzāda's account and casts doubt that, after returning back to Samarqand, Qūshjī presented to Ulugh Beg a treatise on the Lunar model. According to Saliba, since the Lunar and Mercury models are similar to one another, it is odd that the treatise on the Mercury model does not mention the Lunar model. Therefore Saliba opines that Ṭāshkubrīzāda's mistakenly identified the treatise Qūshjī presented to Ulugh Beg.[192] Furthermore, Saliba proposes that the treatise on the Mercury model should have been written between 1420 and 1449, probably around 1425.[193]

Ṭāshkubrīzāda's account on this particular issue. Gelibolulu Mustafa Ali, *Künhü'l-Aẖbār (C. II: Fātih Sultān Mehmed Devri 1451-1481)*, ed. M. Hüdai Şentürk (Ankara: TTK Yayınları, 2003), 197–98.
[191] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 159.
[192] Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury," 166–67.
[193] Ibid, 166.

The introduction of Qūshjī's treatise is significant in the sense that it provides insight into the reason behind his secret departure from Samarqand, as well as into his life during that period. Equally significant is the tone Qūshjī uses in the introduction, which was apologetic, perhaps on account of his secret departure from Samarqand. Additionally, Qūshjī's own words in the treatise invalidates Ṭāshkubrīzāda's story that Qūshjī left the city for the sake of knowledge. Qūshjī explains his reason of departure as such:

> I gained the most prodigious portion, in sum and in part. I then sought the answer to the difficult problems, and inquired about the awesome quests, from the very best who won the victories of diligent research. I participated with the brilliant ones who dived after the pearls in the seas of inquiry. As a result, I became the subject of envy, and the bird of happiness was chased away from my mind. I was cast by the storm of disappointments away from the court of the Khāqān, and deprivation slapped me across the face with bad luck.[194]

As understood from this passage, because of his close relationship and remarkable success among the people of learning at Ulugh Beg's court, Qūshjī seems to have attracted the jealousy of a number of courtiers who compromised Ulugh Beg's strong attachment to Qūshjī. Moreover, Qūshjī's expression leads one to think that Ulugh Beg might not have wanted Qūshjī to be part of his entourage anymore. The text does not reveal the circumstances surrounding this break. But one thing is obvious: what Qūshjī faced seems to have been so stressful that he decided to leave his homeland.

Ṭāshkubrīzāda also tells that Qūshjī went to Kirman, giving an impression that it was the only place Qūshjī stayed during those years. Yet, we learn from Qūshjī that he undertook continuous travel that was full of hardships and disappointments:

> I was enchanted by human devils with mischievous hearts, so that I set myself on continuous travel; and then they all dispersed. I continued to

[194] Ibid, 170.

> travel, crossing deserts and being tossed from one land to the next, and being raised and lowered until I saw catastrophes that were not seen in any tale of travel and calamities that were not ever recounted in any collection of books.[195]

Although Qūshjī does not go further to detail the kinds of problems he faced during his travel, his continuous travels indicate a need to find a more hospitable place to stay. But then, which places and cities did he visit during this period, and what did he do there? The introduction does not tell us anything related to the second question, but there are some hints for the first. Qūshjī writes that presenting this treatise as a gift to Ulugh Beg is like "bringing cinnamon to Kirman and mushrooms to Oman,"[196] the places where those products seem to have been abundantly found at the time. This expression may not be so formulaic as it seems, but might be factual: that Qūshjī mentions Kirman and Oman deliberately, to inform his patron through literary conventions of the places he visited during his travels.

The introduction also reveals that Ulugh Beg indeed expelled Qūshjī from his court, and that after a certain period of time the patron decided to forgive him and called him back to Samarqand. As a result, Qūshjī wrote the treatise in question to express his gratitude to Ulugh Beg, who gave him a chance to restore their relation:

> My wishes came true, and my dark night gave way to a new dawn. My Lord granted me an overpowering success, when I received the good tidings […] I set my face toward the seat of the caliphate, and the abode of the mercy and compassion. I asked myself: to that majesty, what could my offering possibly be, and what gift could I possibly bring to it?[197]

In summary, we are still far away from learning the details of Qūshjī's travel after his departure from Samarqand. Yet, the introduction of his treatise on the Mercury Model

[195] Ibid, 170.
[196] Ibid, 171.
[197] Ibid, 170–71.

reveals that the relationship between Ulugh Beg and Qūshjī did not seem to have always been perfect, as is generally assumed. We also learn from this that this travel was a continuous one. One wonders then whether Qūshjī embarked on this trip to find another patron; but it is not possible to answer this question based on the available information we have about this period of Qūshjī's life.

2.2) **The Late Timurid Period: Between Samarqand and Herat**

After the death of Shāhrukh in 850/1447, Ulugh Beg was able to take control of the country. However, he spent the rest of his life fighting other descendants of Tīmūr, including his own son ʿAbd al-Laṭīf, who wanted the throne. Ulugh Beg's story ended tragically, as he was defeated by his son, with whose permission he was executed in 853/1449.[198] Ṭāshkubrīzāda recounts that one of Ulugh Beg's sons (*baʿḍ awlādihi*), presumably ʿAbd al-Laṭīf, came into power; he did not "know [Qūshjī's] value, and [therefore] his heart turned away from him." Ṭāshkubrīzāda goes on to say that Qūshjī asked permission for pilgrimage and went to the Aq Qoyunlu court.[199] In the next section, I will deal with this pilgrimage story, Qūshjī's departure from Herat, and his engagement with Uzun Ḥasan, the reigning Aq Qoyunlu ruler. But one thing is important to note at this point: Ṭāshkubrīzāda's account leaves the reader with the impression that Qūshjī left the Timurid court right after the death of Ulugh Beg, though he does not say this explicitly. Equally important, he does not relate anything about Qūshjī's life between Ulugh Beg and Uzun Ḥasan. Ṭāshkubrīzāda's omission of more than two decades of Qūshjī's life between the killing of Ulugh Beg and his departure is perplexing, in particular given that

[198] Barthold, *Ulugh-Beg*, 141.
[199] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 160.

Ṭāshkubrīzāda was a student of Mīrim Chalabī who was a descendant of Qāḍīzāda Rūmī and Qūshjī.

The question of where Qūshjī lived after Ulugh Beg's execution appears to be linked to the escalation in hostilities arising from the struggles between the descendants of Tīmūr to monopolize political and territorial power across the Empire. The main target of these struggles was control over Samarqand and Herat, the two political centers of the Empire, which caused instability, insecurity, and restriction of daily life for the inhabitants of these cities for many years. During the very short reign of ʿAbd al-Laṭīf, who would in 854/1450 share the same fate as his father, one might expect that Qūshjī continued to live in Samarqand; he might even have enjoyed ʿAbd al-Laṭīf's interest, who "indulged in" such sciences as astronomy and history.[200] Mirzā ʿAbd Allāh, a grandson of Shāhrukh took control of Samarqand after ʿAbd al-Laṭīf, but he was replaced after just one year by Abū Saʿīd in 855/1451. Since Abū al-Qāsīm Bābur, another grandson of Shāhrukh, ruled over Herat and Khurasan, Abū Saʿīd only controlled Transoxania, including Samarqand, until the former's death in 861/1457, when Abū Saʿīd captured Herat. However, due to prolonged conflict, he was able to achieve full control over the city only in 15 Ṣafar 863/7 January 1459. Qūshjī's relationship with Abū Saʿīd would have developed during Abū Saʿīd's first years in power in Samarqand.[201]

Recent research over the last few decades shows that Qūshjī stayed for a considerable time in Herat. Even during the period of Ulugh Beg, who visited Herat on

[200] Barthold, *Ulugh-Beg*, 161.
[201] For a general account of Timurid history after the killing of Ulugh Beg, see Abbas Zaryab, "Abū Saʿīd Gūrakān," in *Encyclopaedia Islamica*, ed. Wilferd Madelung and Farhad Daftary, trans. Suheyl Umar, accessed May 18, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1875-9831_isla_COM_0133.

many occasions, Qūshjī might have accompanied him for at least some of these visits.[202] Consistent with this assumption, it is reported that Mullā Jāmī, a well-known Timurid scholar, Sufi, and poet that lived in Herat, studied with Qūshjī in the city, after which he went to Samarqand to study with Qāḍīzāda.[203] Yet one should note that the added information we now have regarding Qūshjī's life in Herat derives not from an increase of studies on Qūshjī *per se*, but largely from studies of contemporary scholars in the Timurid context, particularly the aforementioned Jāmī. As will be mentioned below, Ertuğrul İ. Ökten's dissertation, which constructs Jāmī's intellectual biography, includes a detailed account regarding Qūshjī's intellectual life in Herat, especially about how his scholarship was received by the local scholars. This is because biographers of Jāmī and other contemporary sources produced in the Naqshībandī tradition (in which Jāmī was involved) recount Qūshjī's relationship with Jāmī and other major figures of this tradition.

As for the date of Qūshjī's arrival in Herat, it is likely that it occurred after Abū Saʿīd assumed full control of Samarqand in 863/1459, inasmuch as the political instability in both Khurasan and Transoxania was still at stake up to this time; it would hardly have been possible for a famous scholar like Qūshjī to move freely between cities that were under the control of different rulers. This hypothesis is also compatible with the fact that a copy of Qūshjī's Persian *hay'a* work, *Risālah dar hay'ah*, suggests that the work was completed in Samarqand in late Dhū al-ḥijja 862/late October-early November 1458.[204] As a result, it is likely that Qūshjī arrived in Abū Saʿīd's new capital Herat at around 863/1459.[205] That

[202] Barthold, *Ulugh-Beg*, 180–82.
[203] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 5.
[204] ʿAlī al-Qūshjī, *Risālah dar hay'ah*, Istanbul, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2640, f. 24b.
[205] His departure for Herat from Samarqand is also mentioned in historical sources including Idrīs Bidlisī's *Hasht Bihisht*. For the details, see Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 7–8.

being said, it is also reported that some of Qūshjī's family lived in Samarqand.[206] Thus one might also assume that Qūshjī always had familial and intellectual ties to Samarqand, and probably regularly went back and forth between the two cities. Besides this, there seems to have been other reasons that might account for Qūshjī's move from Herat. For example, the plague came to Herat around 866/February-March 1462. Even Abū Saʿīd had to leave the city. Given the fact that the plague continued until Muḥarram 867/September 1462, it is not far-fetched to think that Qūshjī was somewhere else during this time, presumably together with Abū Saʿīd.[207]

As Ökten's study indicates, Qūshjī's *Sharḥ al-Tajrīd* was highly discussed among Herat scholars, including Jāmī, in both praising and critical manners. Since the primary sources used by Ökten on the subject are generally those written from the perspectives of Jāmī or his Naqshībandi tradition, we are more informed of the criticisms of Qūshjī's text. That being said, they are helpful to make sense of the extent to which Qūshjī in his late Timurid period had a profound role in intellectual life of the fifteenth century.

Regarding the *Sharḥ al-Tajrīd*, the first question that needs to be addressed is when and where it was composed. As mentioned earlier, Ṭāshkubrīzāda writes that it was compiled in Kirman. According to some modern historians, however, it was written in Herat.[208] The fact that Qūshjī's commentary was in high circulation in the city seems to lend credence to this assumption. While this issue can only be resolved with extensive research on the copies of the *Sharḥ al-Tajrīd*, along with studies on contemporary sources

206 Heiderzadeh, 14; Jāmī, *Abdur-Rahman Jami's Autograph Letters*, 147.
207 Zaryab, "Abū Saʿīd Gūrakān."
208 Fazlıoğlu, "Ali Kuşçu," 2009, 35.

mentioning this commentary, I will in the following advance a different hypothesis regarding the time and place of the work's composition.

It is reported that a group of scholars including Jāmī studied Qūshjī's *Sharḥ al-Tajrīd* in Herat with Mawlānā Shahāb al-Dīn Jājarmī, one of Taftāzānī's students, who died in 864/1459-60.[209] As mentioned above, due to the political instabilities at the time, Abū Saʿīd could only take full control of Herat in 863/1459. We should also remember that Qūshjī dedicated his *Sharḥ al-Tajrīd* to Abū Saʿīd.[210] Under these circumstances, it is my conviction that after spending a certain period of his life (*shaṭran min ʿumrī*) studying *kalām*[211]*,* Qūshjī is more likely to have completed the *Sharḥ al-Tajrīd* when he and Abū Saʿīd were still in Samarqand before 863/1459; or at least most of the text was completed there. In either case, Qūshjī's idea of writing his *kalām magnum opus* seems to have arisen in the Samarqand context.

Qūshjī's commentary on the *Tajrīd* was so well-received by the dedicatee, Abū Saʿīd, that he gave Qūshjī a remarkable award of 50,000 dinars to acknowledge his voluminous work.[212] It is not surprising that having been honored in such a way by the highest ranking of the Timurid ruling elite, the *Sharḥ al-Tajrīd* would attract enormous attention among contemporary and succeeding scholars in the Persianate region and beyond. In many historical sources, Qūshjī is introduced as the author of *Sharḥ al-Tajrid* or the commentator of the *Tajrīd*. In *his Tārīkh Ḥabīb al-siyar*, Khwāndamīr states that among Qūshjī's works, *Sharḥ al-Tajrīd* is the most famous one.[213] A more interesting example is in *Lubb al-*

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209 Hamid Algar, *Jami* (New Delhi: Oxford University Press, 2013), 16; Ökten, "Jāmī (817-898/1414-1492)," 57–58.
210 Al-Qūshjī, *Sharḥ Tajrīd al-ʿaqāʾid*, 1:69.
211 Ibid, 1:68.
212 Ökten, "Jāmī (817-898/1414-1492)," 234.
213 Khwāndamīr, *Tārīkh-i ḥabīb al-siyar*, 4:38.

tawārīkh, whose author, Yaḥyā b. ʿAbd al-Laṭīf Qazwīnī (d. 962/1555), introduces Qūshjī as "the commentator of the *Tajrīd* (*shāriḥ Tajrīd*)" when outlining the prominent figures of the Samarqand observatory.[214]

That being said, not all contemporary scholars were happy with Qūshjī's work. Many scholars in Herat criticized it harshly to the extent that "its presence in scholarly gatherings could make certain scholars leave that gathering."[215] Jāmī, who had been acquainted with Qūshjī since the 1430s and 1440s when the former went to Samarqand to study, was extremely critical of the *Sharḥ al-Tajrīd*. As a Sufi in the Naqshībandī tradition who endorsed the doctrine of the unity of being (*waḥdat al-wujūd*), Jāmī taught *kalām* texts including Jurjānī's *Sharḥ al-Mawāqif*, one of the most influential works in the field in the pre-modern period.[216] In his eyes, however, Qūshjī simply repeated the opinions of others, when he was supposed to articulate his own ideas. Furthermore, when Jāmī was asked to write an evaluation of *Sharḥ al-Tajrīd*, he answered that "if he were to do that [ʿAlī Qūshjī] would be not able to continue [his scholarly] activities in the usual manner and distress would follow." In spite of his sharp utterance, he is said to have written a short treatise on it, but he did not think that it was worth being surveyed more than that.[217]

Ökten remarks that a detailed view of the reception of *Sharḥ al-Tajrīd* in Herat is difficult to obtain. He speculates that the discussion surrounding the text must have involved various topics such as natural philosophy, metaphysics and Sufi knowledge.[218] His assumption makes sense given the fact that, for instance, Qūshjī proposes the radical

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[214] Quoted in Giahi Yazdi and Rezvani, "Chronology of the Events," 160.
[215] Ökten, "Jāmī (817-898/1414-1492)," 236.
[216] Ibid, 268.
[217] Ibid, 235–36.
[218] Ibid, 235.

position that astronomical studies should not rely on natural philosophy.[219] Jāmī's criticism also extends to Qūshjī's ideas of astronomy. He attributes Qūshjī's way of defending astronomy to Qāḍīzāda, who was a teacher of both Qūshjī and Jāmī in Samarqand. Jāmī had heard of "similar things" proposed by Qāḍīzāda, remarking that "if he expended a little effort, he could remember [Qāḍīzāda-yi Rūmī's] comments," but he neglected this.[220] Despite Jāmī's tendency to marginalize Qūshjī's position on the subject, this comment nonetheless confirms the strong intellectual connection between Qūshjī and Qāḍīzāda. Fazlıoğlu argues that the mathematical tradition of the Samarqand school as represented by these two figures advanced a new understanding of the interplay between mathematics and natural philosophy, which he calls "mathematical humanism."[221]

In order to understand Jāmī's criticism of Qūshjī, we must take into consideration two important intellectual debates of the period. First, while Taftāzānī and his tradition were generally opponents of *waḥdat al-wujūd*,[222] Jurjānī thinks that this concept can "be interpreted in such a way as to make it acceptable to reason."[223] Then, one might wonder if Qūshjī opposes *waḥdat al-wujūd* in his commentary. This question is quite significant given the fact that as some of the secondary literature on Qūshjī's *Sharḥ al-Tajrīd* highlights that Qūshjī benefits substantially from Taftāzānī's scholarship. The second is with respect to the figures of Khwāja ʿUbayd Allāh Aḥrār, arguably the most important Naqshī Sufi in his

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[219] F. J. Ragep, "Freeing Astronomy from Philosophy," 49–71.
[220] Ökten, "Jāmī (817-898/1414-1492)," 239. Interestingly, Jāmī's criticism of Qūshjī was not only at an intellectual level, but also at a personal level. According to him, Qūshjī's intellectual production was so patron-oriented that he did not want to write a work unless he received patronage. Ibid, 240–41.
[221] Fazlıoğlu, "Between Reality and Mentality," 34.
[222] Ökten, "Jāmī (817-898/1414-1492)," 61.
[223] Nicholas Heer, "Five Unedited Texts on the Sufi Doctrine of *waḥdat al-wujūd* by al-Sayyid al-Sharīf al-Jurjānī," NELC Faculty Papers (Seattle: University of Washington, 2013), 1, https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/22418/jurjani-texts.pdf?sequence=1&isAllowed=y. I am grateful to Robert Wisnovsky who noted that even though Jurjānī was inspired by some of Ibn ʿArabī's ideas, his explanation of the subject of existence (*al-wujūd*) was made in a philosophical-theological context.

period who had a huge influence on Abū Saʿīd's policies in Samarqand, as well as on Mullā Jāmī, who was the Khwāja's student. Accounts of these two figures show that they had a cool and distant relationship with Qūshjī. A striking example of this is when Qūshjī and his students visited Khwāja ʿUbayd Allāh Aḥrār's circle in Tashkent, Aḥrār made an excuse to leave that place in order to avoid Qūshjī.[224] This story is important because it also tells us that Qūshjī stayed for a while in Tashkent. Moreover, since he was together with a group of his students, one might assume that he also taught in this city.

2.3) Towards Pilgrimage or Istanbul? Qūshjī Emigrating Westward

As described above, it has been assumed that right after the killing of Ulugh Beg, Qūshjī asked the succeeding ruler for permission to go on the pilgrimage, as he did not want to be patronized by him. When he arrived in Tabriz, the then capital of the Aq Qoyunlu state, he received a warm reception from the Sultan Uzun Ḥasan. Qūshjī then stayed under his service before emigrating to Istanbul.[225] However, as mentioned above, recent research over the last two decades has conclusively shown that Qūshjī continued to live in Timurid lands for more than two decades after Ulugh Beg died. It is puzzling why Ṭāshkubrīzāda does not mention Qūshjī's long and intellectually significant life in Samarqand and Herat after Ulugh Beg. I find this even more puzzling given the fact that, as mentioned above, our biographer was a student of Mīrim Chalabī, a leading Ottoman scholar who was Qūshjī's descendant. It is very likely that Ṭāshkubrīzāda received first-

[224] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 8.
[225] Dizer, *Ali Kuşçu*, 5; Adıvar, "Ali Kuşçu," 321; Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 16; Salih Zeki, *Āthār-i Bāqiya*, 1:195. Indeed, although Ünver also says that Qūshjī went to Tabriz during the period of Ulugh Beg's successor, he also adds that Qūshjī went to Herat where he visited Jāmī. Ünver gives the impression that Qūshjī only visited Tabriz for a short period of time.

hand oral accounts about Mīrim Chalabī's grandfather. One explanation could be that the narrative in the *Shaqāʾiq* seems to be constructed so as to highlight Qūshjī's years as an Ottoman scholar without dwelling on the immediately preceding period. Ṭāshkubrīzāda seems to have privileged details of Qūshjī's life that had special significance in the Ottoman context. Although I am quite interested in these historiographical interventions, proper research on this issue will require a more comprehensive approach to the entirety of Ṭāshkubrīzāda's *Shaqāʾiq*.

The first question that needs to be asked is why Qūshjī decided to leave Herat, or his home country in general. As mentioned before, Ṭāshkubrīzāda recounts that Qūshjī asked permission to leave for pilgrimage. Heiderzadeh's thesis has pointed out to a number of different sources that shed light on the subject.[226] The intriguing part of this story of departure is partially illuminated by Mullā Jāmī's letters which were written to the Timurid vizier ʿAlī Shīr Nawāʾī on behalf of Qūshjī. In general, the collection of Jāmī's letters reveals his efforts to intercede with Timurid authorities on behalf of various people including friends, such as Qūshjī, scholars, and students. As far as those written for Qūshjī are concerned, in the first letter Jāmī asks ʿAlī Shīr Nawāʾī to provide Qūshjī with such a document that would guarantee security and access to wherever he may go.[227] The second letter, in turn, was written since Qūshjī had not received such a letter of guarantee. In this letter, Jāmī writes that Qūshjī was so disappointed that Jāmī asked that the requested letter be provided as quickly as possible.[228] From a third letter, we understand that these efforts seem to have brought about a positive conclusion. Accordingly, Qūshjī's relatives

[226] Heiderzadeh, "Ali Kuşçu," 421–30; Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri." 13-17.
[227] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 14; Jāmī, *Abdur-Rahman Jami's Autograph Letters*, 107.
[228] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 14; Jāmī, *Abdur-Rahman Jami's Autograph Letters*, 122.

(*mutaʿalliqān*) came from Samarqand to Herat and needed a guide who would help them join Qūshjī. The tone of the third letter indicates that Qūshjī might have left the city before his people came to Herat. Another important point this letter reveals is that although Qūshjī lived in Herat at the time, his connections to Samarqand remained strong.[229]

It is important to keep in mind that those letters do not state explicitly that Qūshjī's aim in leaving was to perform his pilgrimage. Interestingly, the fact that his people joined him casts more doubt on the pilgrimage story, which in turn becomes more doubtful when we consider an account of Qūshjī found in another contemporary source. Idrīs Bidlīsī (d. 926/1520), who worked as a chancellor at Aq Qoyunlu's court in Tabriz, emigrated to Istanbul when Shāh Ismāʿīl came to power with the dissolution of the Aq Qoyunlu state.[230] He wrote a famous book in Persian on Ottoman history from its beginning to the reign of Bāyazīd II, entitled *Hasht Bihisht*. In this work, we are informed of a different but quite remarkable story regarding Qūshjī's motivation to emigrate. According to Idrīs Bidlīsī, one of Qūshjī's former students, ʿAlī Chalabī Fanārī (d. ca. 903/1497), who served as the chief judge (*qāḍī-ʿaskar* or kazasker) during Meḥmed II's reign,[231] told the Sultan that despite the fact that Qūshjī was such an important scholar, his value was not acknowledged in Herat, which led to personal disappointment. Once he heard this, Meḥmed II sent a group of people to visit Qūshjī with "1000 dinars" as a gift and, more importantly, to invite him to Istanbul. Meḥmed II's intention in this, as Idrīs Bidlīsī recounts, was for Qūshjī to continue his astronomical observations in Istanbul and cultivate the astronomical science among

[229] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 14; Jāmī, *Abdur-Rahman Jami's Autograph Letters*, 147.
[230] For further details regarding Bidlīsī's life, see Vural Genç, *Acem'den Rum'a Bir Bürokrat ve Tarihçi İdris-i Bidlîsî (1457-1520)* (Ankara: Türk Tarih Kurumu Yayınları, 2019); Christopher Markiewicz, The Crisis of Kingship in Late Medieval Islam: Persian Emigres and the Making of Ottoman Sovereignty (Cambridge: Cambridge University Press, 2019).
[231] For his biography, Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 181–85.

Ottoman scholars. Eventually, Qūshjī was invited. As a matter of fact, he had a "natural inclination (*mayl ṭabīʿī*)" towards such an invitation. Once he received a "legal permission (*ruḥṣat sharʿī*)" to leave, he came to the lands of *Rūm.*[232]

Being compiled only a little more than three decades after Qūshjī's death and half a century before the *Shaqāʾiq* was written, *Hasht Bihisht* provides us with another story regarding the emigration of Qūshjī by a Persianate scholar who is more likely to have more information about Qūshjī's pre-Ottoman period. It is also important to note that the multiplicity of narratives concerning Qūshjī seems to have been a major historiographical feature of late fifteenth- and early sixteenth-century accounts of this figure's life.

One of the earliest examples of Ottoman historiography in Persian, Idrīs Bidlīsī's *Hasht Bihisht* has two versions, one presented to Sultan Bāyazīd II and the other to Sultan Salīm I. The second version is shorter than the first. Crucially, with respect to Qūshjī's entry, the story summarized above was not included in the second version. What is briefly mentioned about Qūshjī in the latter version is that Sultan Meḥmed II's courtesy (*iḥsān*) and benefaction (*inʿāmat*) attracted Qūshjī "with a magnetism (*miqnāṭīs vār*)," so great that together with his entire household (*jamīʿ aqwām wa khoyash wa tabār*), he left Khurasan and Transoxania for the lands of *Rūm*.[233] Setting aside the remarkable question of why Idrīs Bidlisī omits the previous account in the second version, both versions confirm the centrality of Meḥmed II's role in making Qūshjī's transition into a new intellectual landscape possible.

[232] Idrīs Bidlīsī, *Hasht bihisht*, Istanbul, Süleymaniye Manuscript Library, Esad Efendi Collection, MS 2198, ff 32b-34a. In his Turkish translation of the relevant parts of *Hasht bihisht*, Heiderzadeh uses this particular copy but without indicating which codex he used. Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 15.
[233] Idrīs Bidlīsī, *Hasht bihisht*, Istanbul, Süleymaniye Manuscript Library, Nuruosmaniye Collection, MS 3209, ff 344b. For Turkish translations of this section, see Muhammed İbrahim Yıldırım, "İdris-i Bitlisî'nin Heşt Behişt'ine Göre Fatih Sultan Mehmed ve Dönemi" (PhD diss., Mimar Sinan Güzel Sanatlar University, 2010), 27; Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 15.

Besides this, some of the contemporary Persian sources written in the Aq Qoyunlu and Safavid contexts do not mention that Qūshjī intended to underake the pilgrimage. Quoting *Kitāb-i Diyārbakriyya* of Abū Bakr-i Ṭihrānī (d. after 882/1478), a chancellor (*munshī*) who worked closely with the Aq Qoyunlu ruler Uzun Ḥasan, Ḥasan Beg Rūmlū (d. 985/1577), a prominent Safavid intellectual and history writer, wrote in his *Aḥsan al-tawārīkh* that Qūshjī met Uzun Ḥasan in a place called Alādāq (Aladağ), which seems to be close to Tabriz, where the ruler gave him a huge sum of around "20,000 *tanga-yi Shāhrukhī* and one roll of fabric (*yak dūqūz qumāsh*)." There is no mention of Qūshjī accepting entry into Uzun Ḥasan's service or of his possible pilgrimage or migration to Istanbul.[234]

Having said this, the pilgrimage story still matters given the reports in other important works of history. In his *Jāmiʿ al-Duwal,* Müneccimbaşı Aḥmed Dede (d. 1113/1702), a leading Ottoman chief astrologer and historiographer who also benefited from Abū Bakr-i Ṭihrānī's account, states that Qūshjī was on his way to pilgrimage when he met the Aq Qoyunlu ruler. The same account also adds that Qūshjī was honored by Uzun Ḥasan whose service Qūshjī would eventually enter. Interestingly enough, Müneccimbaşı Aḥmed Dede also reports that Uzun Ḥasan "sent him wherever he wanted to go." The context suggests that he helped Qūshjī continue his pilgrimage.[235]

I have so far dealt with the possibility that Qūshjī's departure from Herat had largely to do with his resentment with the intellectual and political environment he was engaged with at the time. One of Mullā Jāmī's letters suggests that Qūshjī's discontentment with his

[234] Həsən Bəy Rumlu, *Əhsənüt-təvarix (Tarixlerin Ən Yaxşısı)*, trans. Oqtay Əfəndiyev and Namiq Musalı (Kastamonu: Uzanlar, 2017), 280; Ebu Bekr-i Tihrani, *Kitab-i Diyarbekriyye*, trans. Mürsel Öztürk (Ankara: Türk Tarih Kurumu, 2014), 368; Abū Bakr-i Ṭihrānī, *Kitāb-i Diyārbakriyya (Ak-Koyunlular Tarihi)*, ed. Necati Lugal and Faruk Sümer, 2nd ed., vol. 2 (Ankara: Türk Tarih Kurumu Basımevi, 1993), 564.
[235] Tihrani, *Kitab-i Diyarbekriyye*, 368; Ṭihrānī, *Kitāb-i Diyārbakriyya (Ak-Koyunlular Tarihi)*, 2:564. The editors of Ṭihrānī's book quote the relevant section in Müneccimbaşı Aḥmed Dede's history book directly on the grounds that it is based on Ṭihrānī's account in this particular section.

homeland might have had a more serious and personal dimension. A certain Mawlānā ʿAlāʾ al-Dīn accused Qūshjī of having some object (*chīzī*) found in his house. Upon learning of that, Jāmī wrote a letter defending Qūshjī.

The letter seems to have been sent directly to Qūshjī so that he would use it in his case with the relevant people. In the letter, Jāmī reminds the recipient that Qūshjī's reliable personality (*ṣalāh-i khidmat-i Mawlānā ʿAlāʾ al-Dīn*) is witnessed by trustworthy people (*mardom ṣāliḥ*). As understood from the tone of the letter, since Jāmī believed that Qūshjī was innocent of the accusation he faced, without stating it explicitly, he kindly asked the recipient of the letter to command that Qūshjī be treated according to the "pure Divine Law" (*sharīʿat-i muṭahhara*) and that the law not be transgressed (*taʿaddī ne-konand*). The letter does not give further details on the issue and what that object was, but one thing seems to be clear: Qūshjī was going to face trial—though we are not informed whether that trial was realized—and Jāmī wanted to make sure that Qūshjī's dignity and innocence was secured. Considering these personal hardships, Qūshjī's radical decision to leave his country with his entire household when he was around 70 years old might have been due to this difficult affair.[236]

To summarize, the historical sources provides multiple narratives about Qūshjī's travels. Most sources were produced in the Persianate context, but one important source we have used above was Idrīs Bidlisī's biographical work. While it was produced in the

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[236] One might ask if this "Mawlānāʾ ʿAlāʾ al-Dīn" is our Qūshjī or might be another person. The first thing is that this naming was frequently used for Qūshjī in historical sources. Secondly, the editor of the letters, A. Urunbaev, indexes this letter under "Mawlānā ʿAlāʾ al-Dīn ʿAlī Qūshjī. Hence, it is not far-fetched to assume that the relevant person in this letter is our Qūshjī. Jāmī, *Abdur-Rahman Jami's Autograph Letters*, 87, 211. Importantly, Ökten, in his dissertation, remarks that "several examples in the sources show that individuals resorted to going on the pilgrimage at moments of crisis, especially when there was a life threatening situation at hand." We are far from making a conclusive comment on Qūshjī's situation, but Ökten's point deserves to be considered in the case of Qūshjī as well. Ökten, "Jāmī (817-898/1414-1492)," 150.

Ottoman context, and other Ottoman sources like Ṭāshkubrīzāda and Müneccimbaşı Aḥmed Dede mention that Qūshjī travelled to undertake the pilgrimage, Bidlisī was silent regarding Qūshjī's intentions. Therefore, these sources do not lead us to a conclusive answer as to whether Qūshjī told Uzun Ḥasan he was going on pilgrimage or to Istanbul.

As touched upon above, contemporary sources are almost unanimous on the fact that Qūshjī met Uzun Ḥasan in or around Tabriz.[237] I will deal with the political relevance of this meeting within the context of the increasing conflicts between the Ottomans and Aq Qoyunlus shortly, but here I will simply determine the possible dates of this meeting. We must also provide the date when Qūshjī might have departed from Herat and how long Qūshjī stayed in the Aq Qoyunlu state. Abū Bakr-i Tihrānī and Ḥasan Beg Rūmlū's account, both of which are among the most important sources for the history of the Aq Qoyunlu state, largely narrate events chronologically. They recount that Uzun Ḥasan celebrated the birth of the Prophet Muhammed on 12 Rabīʿ I 876 (29 August 1471) outside of Tabriz. On the same day, he was informed that the pilgrimage caravan was about to arrive in Tabriz, upon which he returned there to welcome it. He then left Tabriz again for a while for the circumcision ceremony of the Prince—most likely his own son—but later returned and spent the winter in Tabriz. When winter was over, he again departed Tabriz with his soldiers. The report goes on to say that when Uzun Ḥasan stayed for a few days in Ālādāq, he met Qūshjī.[238] If we assume Nowruz to be what is meant by "the end of winter," the meeting might have taken place after 9-10 Shawwal 876/20-21 March 1472.

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[237] Indeed, one might propose another scenario according to which both stories might be combined. Accordingly, Qūshjī might have wanted to leave on the pretext of a pilgrimage on account of the increasing military tension between Uzun Ḥasan and Meḥmed II, and his real intention was to go to Istanbul.
[238] Rumlu, *Əhsənüt-təvarix*, 280; Tihrani, *Kitab-i Diyarbekriyye*, 365–68; Ṭihrānī, *Kitāb-i Diyārbakriyya (Ak-Koyunlular Tarihi)*, 2:560–64.

Müneccimbaşı Ahmed Dede's narrative is as follows: In 876/1471-72, Uzun Ḥasan appointed his brother Oways Beg as the *amīr al-ḥajj* (commander of the pilgrimage), responsible for maintaining the caravan's security and leading ceremonies related to the pilgrimage in the country.[239] Many scholars and notable people passed by Tabriz, where Uzun Ḥasan treated them well. He departed Tabriz for Ālādāq to prepare for a campaign in Anatolia, where he apparently met Qūshjī "who was on his way to pilgrimage."[240] The sources seem to agree about the fact that they met in 876/1471-72. Considering both the narratives, I am inclined to accept that they met after the winter of the year, as it is more likely to think that the preparations for a campaign would have been done right after winter. Therefore, it is more likely that they met sometime between 9-10 Shawwal 876/20-21 March 1472 and 29 Dhū al-ḥijja 876/7 June 1472, the last day of that Ḥijrī year.

The following question that arises is when Qūshjī might have departed Herat. To determine this, one needs to know how long a trip between Herat and Tabriz took in the fifteenth century. Luckily, we have historically confirmed the dates in which Mullā Jāmī started his trip for pilgrimage from Herat and returned back home. In his way back home, he departed from Tabriz for Herat on 6 Jumādaʾ II 878/29 October 1473. He arrived in Herat on 18 Shaʿbān 878/ 8 January 1474. That is to say that Mullā Jāmī spent 72 days between Tabriz and Herat. This is likely comparable to Qūshjī's trip. In this respect, it is likely that Qūshjī left Herat sometime between 26 Rajab 876/8 January 1472 and 16 Shawwal 876/27 March 1472.

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[239] For the significance of this responsibility in Islamic history, see Jane Hathaway, "Amīr al-Ḥajj," in *Encyclopedia of Islam, THREE*, ed. Kate Fleet et al., accessed May 16, 2019. <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_24219>.

[240] Tihrani, *Kitab-i Diyarbekriyye*, 368–69; Ṭihrānī, *Kitāb-i Diyārbakriyya (Ak-Koyunlular Tarihi)*, 2:564.

2.4) Qūshjī as a Diplomatic Mediator between the Ottomans and Āq Qoyūnlūs

We have thus determined that Qūshjī met Uzun Ḥasan around Tabriz, presumably sometime between 9-10 Shawwal 876/20-21 March 1472 and 29 Dhū al-ḥijja 876/7 June 1472, and that Qūshjī finally came to Istanbul where he would live until his death. However, before dealing with Qūshjī's short period of time under Ottoman patronage, we must first address the following intertwined questions: how long did Qūshjī stay in the Aq Qoyunlu territory before leaving for Istanbul and when did he arrive in the Ottoman capital? How relevant was Qūshjī's trip from Tabriz to Istanbul to the increasing conflict between Meḥmed II and Uzun Ḥasan at the time, which would lead to war no later than one year after his departure from Tabriz? Relevant to this question, did Qūshjī play any role in this political instability in Anatolia?

The Persian sources I have addressed earlier do not give information about that part of Qūshjī's life. The generally accepted narrative about this comes again from Ṭāshkubrīzāda. When Qūshjī came to Tabriz, Uzun Ḥasan treated him well, as mentioned above, and "sent him to the Sultan Meḥmed Khān as an envoy so that he would make peace between them."[241] When he arrived in Istanbul, the Sultan received Qūshjī in a more honorable manner than Uzun Ḥasan and asked him to stay in Istanbul. Qūshjī's response was positive on the condition that he would first fulfill his mission for Uzun Ḥasan and then come to the Ottoman capital. Indeed, Qūshjī returned to Uzun Ḥasan, but, as he promised, he came back to Istanbul to settle there.[242]

[241] "[…] *wa-arsalahu bi-ṭarīq al-risāla ilā al-Sulṭān Muḥammad Khān li-yuṣāliḥ baynahumā.*" Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 160.
[242] Ibid.

Before continuing Ṭāshkubrīzāda's story regarding Qūshjī's second trip after fulfilling his mission for Uzun Ḥasan, I will deal with the story that has so far been told with reference to the questions raised above. Unlike Idrīs Bidlisī's narrative, according to which Qūshjī was invited by the Sultan when the former was still in Herat, Ṭāshkubrīzāda suggests that the invitation took place only when Qūshjī came to Istanbul as the envoy of Uzun Ḥasan at a time of political tension between the two rulers. That is to say, if one assumes Ṭāshkubrīzāda's story, then the pilgrimage story still matters, according to which, on his way to pilgrimage through Tabriz, Qūshjī met Uzun Ḥasan who took advantage of the opportunity to send a well-known figure to resolve the conflicts between him and his Ottoman counterparts. Having said this, the issue of different reports regarding Qūshjī's trip presents a challenge for both modern and premodern historians. In his partial commentary on Qūshjī's arithmetic work entitled *al-Risāla al-Muḥammadiyya*, even a rigorous bibliophile and historian like Kātib Chalabī would resort to relating both scenarios, namely those proposed by Ṭāshkubrīzāda and Idrīs Bidlisī, without making any choice between them.[243]

Despite the historiographical challenges confronting us, I still think that both these two seemingly different narratives might be true when one considers the political conflicts between the two sultans when Qūshjī departed from Herat. Before explaining how, let me briefly give a history of the rivalry between the Ottomans under Meḥmed II and the Aq Qoyunlus under Uzun Ḥasan, which will, I think, contextualize Qūshjī's trip to Istanbul.

[243] "[…] *madʿū aw rasūlan min al-Sulṭān Ḥasan al-Ṭawīl ka-mā thabata fī al-tawārīkh*." For an edition of this partial commentary and a study on it, see Fazlıoğlu, "Ali Kuşçu'nun El-Risâlet El-Muhammediyye Fi El-Hisâb Adlı Eserine," 121.

Coming into power in their respective lands almost at the same time, Uzun Ḥasan (r. 856-82/1452-78) and Meḥmed II (r. 855- 886/1451-1482) were constant rivals as both tried to consolidate power by expanding their territories in Anatolia. Their conflict was played out on several fronts, which sometimes caused minor battles; but they generally made use of diplomacy in resolving their conflicts. Earlier both rulers had undergone a number of successful military campaigns, such as the conquest of Constantinople and territorial expansions in both Anatolia and the Balkans, in the case of Meḥmed II, and the consolidation of power in Persia as a result of defeating both Qara Koyunlu and the Timurid states, in the case of Uzun Ḥasan. On top of that, the conflict between them heightened, especially when it came to issues such as controlling the Empire of Trebizond and principalities in Anatolia, especially the Karamanoğulları, which was located in the region around Konya and Karaman. Eventually, some elites of Karamanoğulları requested help from Uzun Ḥasan against Meḥmed II. As a result, Uzun Ḥasan sent his troops to Karaman to help them retake control of the territory from the Ottomans. Though they were able to take control of the territory temporarily, Ottoman troops soon arrived and defeated them. This battle, which was a preview for a larger conflict, took place in Rabīʿ I 877/August 1472, around which Qūshjī met Uzun Ḥasan in the Aq Qoyunlu territory.[244]

It is reported that when these developments occurred, Uzun Ḥasan sent a letter to Meḥmed II to seek peace under some conditions. Yet, Meḥmed II's response was quite harsh; he declared to his counterpart that he would start a campaign against him in the

[244] Erhan Afyoncu, "Otlukbeli Savaşı," in *TDV İslâm Ansiklopedisi*, vol. 34 (Istanbul: TDV Yayınları, 2007), 4–6; Remzi Kılıç, "Fatih Devri (1451-1481) Osmanlı-Akkoyunlu İlişkileri," *Erciyes Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* 14, no. 1 (2003): 95–118.

upcoming spring (Shawwāl 877/March 1473).[245] Given the fact that Qūshjī's trip from Tabriz to Istanbul happened concurrently with all the aforementioned developments and diplomatic shutdowns between the two rulers, Ṭāshkubrīzāda's account that the first coming of Qūshjī to Istanbul was to convey Uzun Ḥasan's peace message to Meḥmed II makes sense. But when did this diplomatic visit happen?

We have two known dates at hand: 1) an approximate date for Qūshjī's arrival in Tabriz (sometime between 9-10 Shawwal 876/20-21 March 1472 and 29 Dhū al-ḥijja 876/7 June 1472); 2) the composition date of his *al-Risāla al-Muḥammadiyya* presented to Meḥmed II when Qūshjī is said to have come to Istanbul for a second time to stay permanently (Ramaḍān 877/February 1473).[246] If we also know how long a trip took between Istanbul and Tabriz during that period, we can infer an approximate date for Qūshjī's first arrival. In his master's thesis, Samet Balta demonstrates that in his ʿIrāqayn campaign, the Ottoman Sultan Süleyman I went from Istanbul to Tabriz in three to four months (940-41/1534).[247] Since Qūshjī probably went with a special and smaller caravan on behalf of Uzun Ḥasan, which should be considered faster than troops in a royal campaign, the duration of his trip might be safely assumed to be three months. Thus Qūshjī's first arrival in Istanbul seems to have occurred in late summer or early fall of 1472. Given that, we may also assume that he came to Tabriz in late 1472 to complete his duty as an envoy of Uzun Ḥasan, followed by his final trip to Istanbul which ended, as mentioned

[245] Afyoncu, "Otlukbeli Savaşı," 5.
[246] İhsan Fazlıoğlu, "Er-Risâletü'l-Muhammediyye," in *TDV İslâm Ansiklopedisi*, vol. 35 (Istanbul: TDV Yayınları, 2008), 129–30.
[247] Samet Balta, "XVI. Yüzyılda Osmanlı-Safevî Tarihi Açısından İstanbul-Tebriz Hattı ve Anlamı" (MA Thesis, Istanbul University, 2017), 64–66. I am grateful to Samet Balta for kindly sharing his thesis with me.

above, in Ramaḍān 877/February 1473. From this assumption, it seems that Qūshjī stayed in Tabriz for a very short period of time.

The theory I have proposed also coincides with the dating of the letter sent by Meḥmed II to Uzun Hasan, in which he declared that he would start his campaign against him in early spring (Shawwāl 877/March 1473).[248] Furthermore, considering that around the proposed time for Qūshjī's first arrival the Ottomans had already been in preparation for the campaign, one may be tempted to speculate whether this particular letter was brought by Qūshjī to Uzun Ḥasan.

Qūshjī's difficulties related to the Aq Qoyunlu-Ottoman tension continued even after his settlement. As I mentioned before, he arrived at Istanbul in Ramaḍān 877/February 1473. A month later or so Meḥmed II started his campaign against Uzun Ḥasan in Üsküdar on the Anatolian side of present-day Istanbul. Qūshjī also accompanied the Sultan on this campaign. The inevitable war, which is known as Otlukbeli war in the literature, took place on 16 Rabīʿ I 878/11 August 1473 in a place called Tarjān in Eastern Anatolia. It ended with the victory of Meḥmed II.[249] The completion of Meḥmed II's campaign coincided with the completion of one of Qūshjī's last works, *al-Risāla al-Fatḥiyya,* which is the subject of this dissertation. The colophon of its autograph copy gives this context clearly:

> The writing of this [copy] was completed by the servant, the author, in the middle of Rabīʿ al-Awwal in 878. These muddled lines were written by the mendicant and miserable ʿAlī b. Muḥammad al-Qūshjī, who is the author and copyist of this copy, on the day of the Great Sultan Abū al-Fatḥ Sulṭān Muḥammad Khān's victory, May God perpetuate his sovereignty forever,

[248] Afyoncu, "Otlukbeli Savaşı," 5.

[249] For a brief account of Otlukbeli war, see John E. Woods, *The Aqquyunlu: Clan, Confederation, Empire* (Salt Lake City: The University of Utah Press, 1999), 117–20. Mo'āli, an Ottoman writer, presented his history book in Persian entitled *Khonkār-nāme* to the Ottoman court in 1474, only eight months after the war. The importance of this work with respect to our topic is that it devotes a section to Meḥmed II's campaign over Uzun Ḥasan, which resulted in Otlukbeli war. Sara Nur Yıldız, "Ottoman Historical Writing in Persian, 1400-1600," *Persian Historiography*, ed. Charles Melville (London: I.B. Tauris, 2012), 451.

over Uzūn Ḥasan around Tarjān, in the location [called] Ūt Bīlikay [Otlukbeli], which is close to Qubāsivrī.[250]

2.5) Qūshjī under Ottoman Patronage: Science and Education in Istanbul

2.5.1. Qūshjī's Final Years in Istanbul

After completing his duty as an envoy of Uzun Ḥasan, Qūshjī embarked on his final travel to Istanbul. Meḥmed II sent Qūshjī some of his servants (*min khuddāmihi*) who would accompany and serve him. His entourage reportedly included around 200 people during their final travel to Istanbul. The Sultan ordered 1000 dirhams to be spent for each day of this journey (*marḥala*).[251]

Ṭāshkubrīzāda reports that Qushji and his entourage arrived in Istanbul "with lavish decorum (*bi-al-ḥashma al-wāfira*) and numerous benefits (*al-niʿam al-mutakāthira*)" in Ramadān 877/February 1473. They were welcomed on the Anatolian side of Istanbul by Istanbulite scholars including Khojāzāda (d. 893/1488), one of the most prominent figures in Ottoman intellectual life at the time and who had taught Mehmed II. Khojāzāda and Qūshjī took a boat to cross to the European side of the city, during which they discussed scientific topics, such as the high and low tides in the Persian Gulf, as well as the intellectual debate that took place between Jurjānī and Taftāzānī, the two leading scholars of the late fourteenth and early fifteenth-centuries, which took place in front of Tīmūr in Samarqand in 791/1388. Qūshjī mentioned that he preferred Taftāzānī's position. Khojāzāda, in turn, states that he had originally sided with Taftāzānī, but after closely examining the matter, he decided that Jurjānī was right in the debate. Khojāzāda also added that he wrote glosses on

[250] ʿAlī al-Qūshjī, *al-Risāla al-Fatḥiyya*, Istanbul, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2733, f. 70a.
[251] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 160.

his book copy, the title of which Ṭāshkubrīzāda did not mention. He asked one of his servants to bring the copy, which Qūshjī examined after getting off the boat. Qūshjī expresses his appreciation acknowledgement (*istiḥsānahā*) of the significance of Khojāzāda's gloss.[252]

Afterwards, he was warmly welcomed by Sultan Meḥmed II. Being pleased that Qūshjī accepted his invitation to come to Istanbul, the Sultan asked how Qūshjī found Khojāzāda intellectually. We do not know whether Qūshjī's answer was his real opinion or polite statement, but it was something the Sultan would expect to hear: "There is none like him, whether in Persia or in the lands of *Rūm*." The Sultan's response is also interesting, demonstrating his intellectual ambition: "There is none like him even in the Arab lands."[253] For the Sultan, Qūshjī presented his arithmetic work entitled *Risālat al-Muḥammadiyya fī ʿilm al-hisāb* as a gift. Ṭāshkubrīzāda describes this work as "such an elegant treatise that no work is more beneficial than it in this discipline."[254]

An appointment decree issued by Meḥmed II reveals that a scholar named Efḍālzāde was appointed as a *mudarris* at Ṣaḥn-i Thamān Madrasa, after Qūshjī left it on Shawwal 877/March 1473. This suggests that Qūshjī was appointed to the Ṣaḥn-i Thamān Madrasa as soon as he arrived in Istanbul and that after one month he left this position to join the Sultan's campaign against Uzun Ḥasan. Ṭāshkubrīzāda recounts that Qūshjī was appointed as a *mudarris* in the Ayasofya madrasa, with a daily salary of 200 *akçes*. With respect to his short tenure at Ṣaḥn-i Thamān before the war, the appointment for the Ayasofya Madrasa would have taken place after the war. Moreover, the Sultan's favor towards Qūshjī also

[252] Ibid, 161.
[253] Ibid.
[254] Ibid, 160.

extended to his family and his entourage (*tawābaʿahu*), each of them being appointed to positions.[255]

ʿAlī al-Qūshjī died in Istanbul on Saturday, 7 Shaʿbān 879/17 December 1474 and was buried in the Eyüp Sultan Cemetery.

2.5.2. Qūshjī's Intellectual Production and Teaching Activities

Qūshjī's life in Istanbul was quite short, but his intellectual activities, such as composing new works, teaching, as well as contributing to the institutionalization of education in Istanbul, were remarkably productive. Meḥmed II's invitation to Qūshjī took place during a period in which the Sultan had embarked upon a wide range of intellectual, architectural, political, bureaucratic and economic enterprises after he conquered the city in 1453. This was part of a larger attempt of consolidating the new capital as heart of a "universal empire."[256] Consequently, Meḥmed II made large investments in political, social, and educational institutions and encouraged the Ottoman elite to do so as well. On the intellectual level, a new madrasa was established next to the Hagia Sophia (Ayasofya) after it was converted into a mosque, followed by the construction of other new madrasas.[257] The Sultan was aware that these new schools needed proficient scholars from abroad who would educate students and produce new works. He therefore invited many prominent scholars from various Islamic intellectual centers, primarily Persia and Egypt, to serve

[255] Ibid.
[256] Abdurrahman Atçıl, *Scholars and Sultans in the Early Modern Ottoman Empire* (Cambridge & New York: Cambridge University Press, 2017), 55.
[257] Çiğdem Kafesçioğlu, *Constantinopolis/Istanbul: Cultural Encounter, Imperial Vision, and the Construction of the Ottoman Capital* (University Park: Pennsylvania State University Press, 2009), 21.

under his patronage.[258] His efforts led to the migration of many scholars during his reign. Some of them were hired at madrasas established by the royal family and other ruling elites.[259] For instance, the Sultan wrote a letter of invitation to the astronomer and mathematician Fatḥallāh al-Shirwānī (d. 1486), a student of Qāḍīzāde in Samarqand, expressing his desire to see Shirwānī in Ottoman lands.[260] During the astronomer's stay in Kastamonu, which was then controlled by the Anatolian principality called Candaroğulları, he educated many students who would continue teaching those sciences in the Ottoman realms.[261]

Equally important to these institutions was the fact that the Sultan embarked on a program of establishing a hierarchical system for scholarly education and bureaucracy that "not only provided scholars with a lifetime career in the administration, but also created career expectations and caused an ever-increasing number of them to offer their services to the dynasty."[262]

Within the context described above, Qūshjī wrote at least three new works, all of which are dedicated to Meḥmed II. As mentioned above, upon his arrival in Istanbul, he presented his arithmetic book the *Muḥammadiyya*. In theoretical astronomy, the *Fatḥiyya*,

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258 A. Süheyl Ünver, *Fatih Devri İlim, San'at ve İçtimai Tekamül Hamlelerine Umumi Nazar* (Istanbul: İstanbul Fethi Derneği Neşriyatı, 1953), 6. One should point out that the flow of scholars continued from the beginning of the Ottoman state to the seventeenth century: Ertuğrul Ökten, "Scholars and Mobility: A Preliminary Assessment from the Perspective of Al-Shaqāyiq Al-Nuʿmāniyya," *Osmanlı Araştırmaları Dergisi/The Journal of Ottoman Studies*, no. 41 (2013): 55–70; Tofigh Heiderzadeh, "Patronage, Networks and Migration: Turco-Persian Scholarly Exchanges in the 15th, 16th and 17th Centuries," *Archives internationales d'histoire des sciences* 55, no. 155 (2005): 419–34.

259 Abdurrahman Atçıl, "Mobility of Scholars and Formation of a Self-Sustaining Scholarly System in the Lands of Rūm during the Fifteenth Century," in *Islamic Literature and Intellectual Life in Fourteenth- and Fifteenth-Century Anatolia*, ed. A. C. S. Peacock and Sara Nur Yıldız (Würzburg: Ergon Verlag in Kommission, 2016), 316.

260 Atçıl, *Scholars and Sultans in the Early Modern Ottoman Empire*, 64.

261 İhsan Fazlıoğlu, "Shirwānī: Fatḥallāh Ibn Abū Yazīd Ibn ʿAbd al-ʿAzīz Ibn Ibrāhīm al-Shābarānī al-Shirwānī al-Shamāhī," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 1055–56.

261 Atçıl, *Scholars and Sultans in the Early Modern Ottoman Empire*, 64.

262 Ibid, 59.

the main subject of this dissertation, was completed right after the Otlukbeli War in which Meḥmed II defeated Uzun Ḥasan.[263] Another work Qūshjī wrote upon the request of Meḥmed II is *ʿUnqūd al-zawāhīr* in Arabic linguistics. Given the fact that those works are basically textbooks intended for students at the Ottoman madrasa, it can be safely said that Qūshjī contributed to the consolidation of the madrasa education in Istanbul. With reference to the *Muḥammadiyya* and *Fatḥiyya,* it is also worth noting that Qūshjī's scholarship in the mathematical sciences was warmly welcomed by the Sultan. The fact that these textbook works were dedicated to Meḥmed II indicates the strong interplay between the Sultan's invitation of Qūshjī and the large-scale educational projects in the capital.

An interesting aspect of Qūshjī's writing activities in Istanbul is reflected in the *Fatḥiyya*. As will be shown later, my critical edition takes into consideration the fact that the *Fatḥiyya* circulated in three versions. Being part of a dynamic pedagogical context, Qūshjī continued to revise it until his death. Equally notable, these three versions emerged only within 16 months. It is a remarkable example that Qūshjī's writing process was not a one-time experience, but something that evolved in accordance with the author's pedagogical and scientific concerns, as well as with in-class dynamics.

In parallel with his compilation of new works in the Ottoman context, Qūshjī was involved in intense teaching activities until his death. It seems that as soon as he arrived in Istanbul, he was appointed to a position at Ṣaḥn-i Thamān madrasa, which had been built by the Sultan. Presumably starting in Ramaḍan 877/February 1473, his occupation of the

[263] In addition to theoretical astronomy, Qūshjī is also said to have dealt with some practical astronomical activities in Istanbul. He recalculated Istanbul's longitude and designed a sundial on the wall of the Fatih Mosque. Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 58–61.

chair ended after a very short period of time on Shawwal 877/March 1473[264], since Qūshjī accompanied the Sultan in his campaign against Uzun Ḥasan. After returning from the campaign, Qūshjī was appointed to the Ayasofya madrasa. The fields which he taught include theoretical and observational astronomy, mathematics, Arabic linguistics, and *kalām*. In terms of Qūshjī's role during the institutionalization of the madrasa system in Istanbul, it is also reported that Qūshjī was one of those who contributed to the preparations of the educational programs for the newly established Ṣaḥn-i Thamān madrasas.[265]

In his commentary on the *Fatḥiyya*, Ghulām Sinān, one of Qūshjī's students in Istanbul, gives numerous evidential anecdotes regarding Qūshjī's teaching of *hayʾa* and mathematics in Istanbul. Along with his *Fatḥiyya* and *Muḥammadiyya*, many other texts including commentaries written on the *Tadhkira* and the *Mulakhkhaṣ* were subject of discussions in class. More specifically, Ghulām Sinān, in his *Fatḥ al-Fatḥiyya*, a commentary on the *Fatḥiyya*, states that he studied Jurjānī's commentary on the *Tadhkira* with Qūshjī.[266] A personal note sent by Qūshjī to his student named ʿUmar Dimashqī, in turn, reveals that Dimashqī studied *Zīj-i Ulugh Beg* under the supervision of Qūshjī.[267] That he wrote a pedagogically-oriented text in Arabic linguistics, the aforementioned *ʿUnqūd al-zawāhīr*, one can safely assume that Qūshjī also taught in this field. Considering Qūshjī's fame in *kalām* as a commentator on the *Tajrīd*, one wonders if Qūshjī also taught in this field. In this

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[264] Meḥmed II appointed Efḍālzāde to the position Qūshjī had held at Ṣaḥn-i Thamān madrasa on 3 Shawwal 877/3 March 1473. Ünver, "Fâtih Sultan Mehmet Zamanında Tedris Berâtları Vesilesiyle Ali Kuşcu ve Efdal-zâde," 352. According to İsmail Hakkı Baltacıoğlu, the exact date on which Qūshjī left his position is 23 Shawwal 877/23 March 1473. Uzunçarşılı, *Osmanlı Devletinin İlmiye Teşkilâtı*, 231.
[265] Uzunçarşılı, *Osmanlı Devletinin İlmiye Teşkilâtı*, 7.
[266] Şükrü Özen, "Sahn-i Semân'da Bir Atışma: Gulâm (Köle) Sinan'ın Mektubu," *Osmanlı Araştırmaları Dergisi/The Journal of Ottoman Studies* 38 (2011): 167.
[267] Arslan, "A Fifteenth-Century Mamluk Astronomer in the Ottoman Realm," 123–24.

respect, a remarkable example is that a copy of Jurjānī's gloss on Shams al-Dīn al-Iṣfaḥānī's commentary on the *Tajrīd* was completed at Qūshjī's house in Istanbul exactly one month after his death. This copy includes a number of marginalia with an expression "it was heard by Qūshjī (*sumiʿa alā Qūshjī*)," which is an important indication that Qūshjī taught this work in the Ottoman context.[268] This makes more sense given the fact that Jurjānī's work was one of the basic texts that was taught at the Ottoman madrasas.[269]

2.5.3. <u>Qūshjī's Networks of Scholars in Ottoman Lands: A Preliminary Observation</u>

Qūshjī's encounter with Ottoman scholars went back to his early years as a student. Before emigrating to Samarqand during Tīmūr's reign, Qūshjī's teacher Qāḍīzāda had received education in Ottoman Bursa in the Fanārī circle, a scholarly group formed around Mullā Fanarī (d. 834/1431), the first Ottoman *shaykh al-Islām* (the chief legal authority).[270] Besides this, over the course of years, many Ottoman scholars went to Timurid lands to continue their education; one of them was Fanārī-zāda ʿAlī Chalabī, a student of Qūshjī, who would ascend to such higher positions as chief judge after returning to Ottoman lands.

Thanks to his fame as an eminent scholar across the Islamic East who worked with Ulugh Beg at the Samarqand Observatory and who wrote his widely circulated *Sharḥ al-Tajrīd*, Qūshjī was received by Ottoman scholars with great interest. Our current knowledge of Qūshjī's engagement with local scholars is not extensive enough to identify

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[268] Al-Sayyid al-Sharīf al-Jurjānī, *Ḥāshiyat al-Tajrīd*, Istanbul, Süleymaniye Manuscript Library, Hekimoğlu Collection, MS 833, f. 271b. I am grateful to Muhammet Ali Koca who shared with me this important detail.
[269] Uzunçarşılı, *Osmanlı Devletinin İlmiye Teşkilâtı*, 24–25.
[270] F. Jamil Ragep, "Astronomy in the Fanārī-Circle: The Critical Background for Qāḍīzāde al-Rūmī and the Samarqand School," in *Proceedings of the International Symposium on Molla Fanârî (4-6 December 2009 Bursa)*, ed. Tevfik Yücedoğru et al. (Bursa: Bursa Büyükşehir Belediyesi Yayınları, 2010), 165–76.

all those associated with him; nor can we evaluate, in a substantial way, the intellectual subjects that received increased study as a result of Qūshjī's arrival. Nevertheless, the available information is still helpful to get a sense of Qūshjī's stimulating presence among Ottoman scholars.

While Qūshjī's arrival was a profound step in advancing many disciplines including theoretical astronomy in Istanbul, it should be noted that theoretical astronomy was already a subject of learning among the Ottomans.[271] We have seen above how Qāḍīzāde Rūmī received his first education of astronomy in Bursa in the Fanārī Circle. Among the works studied in this circle was Maḥmūd al-Jaghmīnī's *Mulakhkhaṣ*, arguably the most widely-used elementary level astronomical textbook in pre-modern Islamic history; this thirteenth-century treatise became the subject of an extensive number of commentaries and glosses, a huge number of which were written by Ottoman scholars.[272] These examples underscore the fact that rather than creating a sphere of astronomical education in the Ottoman intellectual milieu *ex nihilo,* Qūshjī contributed to the institutionalization of the education of astronomy in the new Ottoman capital.[273] He also contributed to the integration of the mathematical sciences into the Ottoman world that had already been produced and was circulating at the Samarqand School. According to Salih Zeki (d. 1921), a leading Ottoman historian of science of the late nineteenth and early twentieth centuries, Qūshjī, as a representative of the Samarqand mathematical tradition, stimulated the

[271] For a list of the theoretical astronomy works used among Ottoman scholars, see Cevad İzgi, *Osmanlı Medreselerinde İlim*, 1:370-412.

[272] For a list of commentaries and glosses on *Mulakhkhaṣ*, see S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 284-91.

[273] It should be noted that the institutionalization of the mathematical sciences in Islamic societies started especially from the thirteenth century onwards. For a historiographical discussion of this institutionalization, see Sally P. Ragep, "The Teaching of Theoretical Astronomy in Pre-Modern Islam: Looking Beyond Individual Initiatives," in *Schüler und Meister*, ed. A. Speer and T. Jeschke (Berlin: De Gruyter, 2016), 557–68.

dissemination of theoretical astronomy "for a while" in the Ottoman lands.[274] Another leading historian of science among the Ottomans, Adnan Adıvar paralleled Salih Zeki's view by emphasizing that Qūshjī's arrival marked a bright period for the Ottomans with respect to the mathematical sciences.[275]

Contemporary sources provide us with some striking examples about the extent to which Qūshjī's teaching and writing activities in Istanbul stimulated a vigorous interest in theoretical astronomy among Ottoman scholars, as well as about the fact that Mehmed II encouraged Ottoman scholars to attend Qūshjī's classes. For instance, it is reported that the Sultan asked Sinān Pasha (d. 891/1486), an Ottoman scholar and bureaucrat, to attend Qūshjī's classes so that he would improve his knowledge in the mathematical sciences. Interestingly, rather than attending the classes himself, Sinān Pasha sent his brilliant student Mullā Luṭfī (d. 900/1495). By listening to what Mullā Luṭfī learned from Qūshjī during the classes, Sinān Pasha indirectly fulfilled the Sultan's request. Moreover, a few years after the death of Qūshjī, Sinān Pasha wrote a gloss on Qāḍīzāde al-Rūmī's famous commentary on Jaghmīnī's *Mulakhkhaṣ*, revealing his capability in this field.[276] He states in his gloss that Meḥmed II was very interested in the mathematical sciences, especially in theoretical astronomy, and encouraged people to study these sciences. This is a clear indication that the Sultan wanted theoretical astronomy to flourish among Ottoman scholars, and that his invitation to Qūshjī seems to be strongly linked to the vision he had for the cultivation of astronomy in the Ottoman intellectual milieu.[277]

[274] Salih Zeki, *Āthār-i Bāqiya*, 1:197.
[275] Adıvar, *Osmanlı Türklerinde İlim*, 32.
[276] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:46–47.
[277] Fazlıoğlu, "Ali Kuşçu'nun Bir Hendese Problemi," 93.

As another dimension of Qūshjī's engagement with local scholars, Qūshjī was involved in scholarly discussions that took place in front of the Sultan. These meetings were not conducted solely for the purpose of exchanging ideas; some of them demonstrated the existence of intellectual rivalry around specific questions. For instance, the aforementioned Sinān Pāsha wrote a geometrical treatise as a response to a question regarding the magnitude of angle, which had been posed by Qūshjī to a group of Ottoman scholars in front of the Sultan.[278] That Sinān Pāsha wanted to write a treatise as an answer to this question speaks to the fact that some Ottoman scholars were eager to conduct their intellectual discussion with Qūshjī at a higher level.

That being said, despite the Sultan's high regard for Qushjī and the good reputation he enjoyed among Istanbul's scholarly elite, not all the local scholars were happy with Qūshjī. His presence in their intellectual environment seems to have led some scholars to be jealous of him. In one of his letters to his homeland, Qūshjī expresses his dissatisfaction with the "Istanbulite *ʿulamā*'s jealousy" towards him.[279] What is more interesting is that Jāmī also describes the Ottoman intellectual milieu in similar terms, by reporting how "in the Ottoman realm they put newcomers aside. If one was favored by the ruler, others formed a party and started discrediting him."[280] One might be surprised by Jāmī's opinion given the considerable number of scholars coming to the Ottoman lands over the centuries, but it is important to see that Qūshjī's uneasiness in the Istanbul circle also resonated in the intellectual circle in his homeland.

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[278] Ibid, 85–106.
[279] Adıvar, "Ali Kuşçu," 322.
[280] Ökten, "Jāmī (817-898/1414-1492)," 247.

As previously stated, Qūshjī's life as an Ottoman scholar was short, but his strategic steps in establishing strong networks with established Ottoman scholars in intellectual and bureaucratic positions were remarkable. In this respect, Ṭāshkubrīzāda's account is interesting. Meḥmed II ordered that the *Tahāfut* debate be re-evaluated by Ottoman scholars. This tradition of discussion had originated from al-Ghazālī's (d. 505/1111) *Tahāfut al-falāsifa*, in which he explains his criticisms of Peripatetic philosophy especially on metaphysical issues, and Ibn Rushd's (d. 595/1198) response to these criticisms. The aforementioned Khojāzāda and ʿAlāʾ al-Dīn ʿAlī al-Ṭūsī (d. 887/1482), a prominent Persian scholar who had received education in Samarqand and later come to the Ottoman lands, were asked to write treatises to evaluate al-Ghazālī's and philosophers' positions. The treatises they produced were highly acknowledged by the Sultan, but Khojāzāda's was preferred.[281] Disappointed, ʿAlī al-Ṭūsī decided to leave the Ottomans lands, and went first to Tabriz and then to Samarqand. Reportedly, on his way, he came across Qūshjī who was on his way to Istanbul. When ʿAlī al-Ṭūsī learned that Qūshjī was going to the "lands of *Rūm*," meaning to the Ottoman lands, he suggested Qūshjī to establish a good relationship with Khojāzāda. Qūshjī adopted ʿAlī al-Ṭūsī's advice and married his daughter to Khojāzāda's son. Khojāzāda also married his daughter to Qūshjī's grandchild whose name is al-Mawlā Quṭb al-Dīn, who was also Qāḍīzāda's grandchild.[282]

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[281] For further details regarding Khojāzāda's opinions, see Muhammet Fatih Kılıç, "An Analysis of the Section on Causality in Khojazāda's *Tahāfut*," *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 3, no. 1 (2016):43-76; Ayman Shihadeh, "Khojazāda on al-Ghazālī's Criticism of the Philosophers' Proof of the Existence of God," in *Uluslararası Hocazâde Sempozyumu (22-24 Ekim 2010 Bursa): Bildiriler* [*International Symposium on Khojazāda (22-24 October 2010 Bursa): Proceedings*], eds. Tevfik Yücedoğru et al. (Bursa: Bursa Büyükşehir Belediyesi Yayınları, 2011), 141-60; Lambertus Willem Cornelis van Lit, "Two Ottoman Intellectuals on the Issue of God's Knowledge: Khojazāda and ʿAlāʾ al-Dīn al-Ṭūsī" (MA thesis, McGill University, 2011).

[282] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 161.

Equally important, Qūshjī and his descendants seem to have taken the advantage of Qāḍīzāda's networks in the Ottoman lands, which he had established before leaving for Samarqand. Indeed, Qūshjī was Qāḍīzāda's student, but at the same time they were relatives, since the former's daughter was married to the latter's son. One of the most prominent networks of scholars with which Qūshjī seems to have had good relations in the Ottoman context was the Fanārī family. As mentioned above, Qāḍīzāda was also a student of Mullā Fanārī in Bursa. Besides this, Qūshjī's student Fanārī-zāda ʿAlī Chalabī was a member of this family. Considering that Khojāzāda was also originally from Bursa, connections of Qūshjī's family to the Bursa circle deserves further attention.

Members of Qūshjī's family continued to sustain their ties with the intellectual circle in Bursa. Qūshjī's descendants, Qūṭb al-Dīn, Mīrim Chalabī, and Mīrim Kösesi (d. 957/1550) taught in Bursa during a certain period of time. Jāmī, who thought that migrating to Ottoman lands was a bad idea, wrote that he received news that Qūshjī was appointed to a position in Bursa.[283] This quite interesting detail is not supported by the available Ottoman sources, but it is still significant to think about why Qūshjī was associated with Bursa in the news Jāmī received. Another important implication is that members of the Qūshjī family continued to live in the old capital, i.e. Bursa. As Ünver remarks, many historically significant manuscript copies associated with Qūshjī and his descendants are currently located in the libraries in Bursa.[284] In terms of the Qūshjī effect in Ottoman bureaucracy, there are other examples to consider. Mīrim Chalabi and his nephew Mīrim Kösesi both served as the chief judge in Anatolia, whereas Abū al-Suʿ ūd Afandī (ö. 982/1574), whose father was Qūshjī's nephew, became one of the most influential *Shaykh al-Islām* in Ottoman

[283] Ökten, "Jāmī (817-898/1414-1492)," 248.
[284] Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 31, 40.

history.[285] Thus it can be said that the Qūshjī family deserves to be studied further in terms of its impact on Ottoman intellectual and bureaucratic life during the early modern period.

2.6) Concluding Remarks

This chapter aimed to cover Qūshjī's life from his early age in Timurid Samarqand to the end of his life in Ottoman Istanbul. It covered his intellectual background, networks of scholars and rulers, and the trajectory of his travels that ended in Istanbul. Though this chapter considerably benefited from Ṭāshkubrīzāda's account of Qūshjī, my narrative also used other relevant historical sources to make a better sense of Qūshjī's life, especially those that are not covered by Ṭāshkubrīzāda. Following a chronological narrative, the chapter tries to reveal the link between Qūshjī's life and the changing conditions in the Islamic East during that period. My classification of Qūshjī's life was based on major transformations he underwent. In this respect, let me summarize the basic points that have been made in the chapter:

1) Qūshjī was raised in a vibrant intellectual environment in the Timurid Empire, especially in his homeland Samarqand. In this decisive period, he studied with Ulugh Beg and Qāḍīzāda, among others, and became a close friend of the former. In a similar vein, the Samarqand madrasa and observatories were influential in his intellectual background, particularly with reference to the mathematical sciences. In addition, the Timurid Empire in his time included various intellectual currents.

[285] Nev'îzâde Atâî, *Hadaiku'l-hakaik fî tekmileti'ş-Şakaik*, ed. Abdülkadir Özcan (Istanbul: Çağrı Yayınları, 1989), 83.

2) Qūshjī was involved in major intellectual circles in cities of his homeland such as Samarqand, Herat, and Kirman as well as other major cities farther afield, such as Bukhara, Tashkent, Tabriz, and Istanbul. His works, especially the *Sharḥ al-Tajrīd* in the science of *kalām*, attracted much attention among the scholars of the Islamic East.
3) His departure from Herat and arrival in Istanbul through Tabriz are intertwined with the political and intellectual controversies that were taking place in the Ottoman, Aq Qoyunlu and Timurid states. He was placed in the role of being a mediator between the Ottomans and Aq Qoyunlus.
4) His life in Istanbul was very short, a little more than one year. Yet, historical sources convincingly indicate that he taught *kalām*, theoretical and observational astronomy, mathematics, and linguistics in Istanbul, and that he assumed positions at the Ṣaḥn-i Thamān and Ayasofya madrasas. Another important detail is that he seems to have established good relations with some major Ottoman scholars and bureaucrats.

CHAPTER 3

HISTORICAL AND SCIENTIFIC CONTEXTS OF THE *FATḤIYYA*

In the "Astronomy" section of the literature review chapter, I briefly presented modern scholarship on Qūshjī's non-Ptolemaic models, his non-Aristotelian approach to astronomical research that proposes to exclude natural philosophy from theoretical astronomy, his role in the Samarqand observatory, his teaching activities in Istanbul, and the significance and cross-cultural circulation of his *hayʾa* works. My review also showed that although Qūshjī's *hayʾa* works have attracted some attention, we are still lacking critical editions and detailed textual studies.[286]

This chapter will focus not only on the *Fatḥiyya*, but also its derivative texts and other *hayʾa* works insofar as these are relevant to the evolution of the *Fatḥiyya*. It is divided into two main sections. The first offers introductory information regarding the *Fatḥiyya*, along with its commentaries and translation, and Qūshjī's other *hayʾa* works. The second section of this chapter will focus on the historical, local, and scientific contexts within which the *Fatḥiyya* was written. Here, I argue that the *Fatḥiyya* was the product of the changing intellectual milieu and linguistic context of Qūshjī's intellectual career. Additionally, it will aim to reveal that while Qūshjī's engagement with the earlier *hayʾa* literature manifests itself in the *Fatḥiyya*, he also makes significant interventions by reorganizing the information he acquired from earlier *hayʾa* works and by adding new information in this work.

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[286] In addition to the review, one can consult the following works for the list of Qūshjī's astronomical corpus. Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 285–87; Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri"; İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:27–38; Cunbur, *Ali Kuşçu Bibliyografyası*; Ünver, *Ali Kuşci (Hayatı ve Eserleri)*.

3.1) Qūshjī as a *Hay'a* Writer

Qūshjī wrote three *hay'a* works: one in Persian, *Risālah dar hay'ah*; and two in Arabic, *Sharḥ al-Tuḥfa al-shāhiyya* and *al-Risāla al-Fatḥiyya*. Other *hay'a*-related works are also attributed to Qūshjī, but since the authenticity of these attributions are not yet verified, I prefer to leave them aside in this dissertation. [287] A brief presentation of these three works and their significance follows.

3.1.1. *Sharḥ al-Tuḥfa al-shāhiyya*

Qūshjī wrote an incomplete commentary in Arabic on *al-Tuḥfa al-shāhiyya*, one of the authoritative works in the field, written by Quṭb al-Dīn al-Shīrāzī (d. 710/1311). Süheyl Ünver remarks that there is no evidence within the text to attribute it to Qūshjī.[288] However, the Bāyazīd II inventory, prepared around 908/1502-3, which includes a list of codices located in the Topkapı Palace Library at the time of Bāyazīd II, is strong evidence of this attribution. It lists a copy of Qūshjī's commentary on the *Tuḥfa* in his handwriting.[289] Rather than a full commentary that covers the entire text, Qūshjī's *Tuḥfa* commentary includes only selections of the original text followed by Qūshjī's explanations.

The interesting aspect of this commentary is that it directly starts with Qūshjī's explanations without an incipit and ends with an incomplete sentence. The text contains no clues as to when and where it might have been written. Therefore, one can safely suppose that the commentary at hand is a draft. Qūshjī's commentary on the *Tuḥfa* deserves further

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[287] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:37–38; Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 287.
[288] Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 38.
[289] F. Jamil Ragep et al., "Astronomical and Other Mathematical Sciences in ʿAṭūfī's Inventory of Bāyezīd II's Library," in *Treasures of Knowledge: An Inventory of the Ottoman Palace Library (1502/3-1503/4) (2 Vols)*, ed. Gülru Necipoğlu, Cemal Kafadar, and Cornell H. Fleischer (Leiden: Brill, 2019), 846.

study, even if it is in draft format. Perhaps one can discover possible connections between this commentary and Qūshjī's other *hay'a* works. This is more likely since, as I will elaborate later, Qūshjī benefited from Shīrāzī's *hay'a* works, especially the *Tuḥfa*, in his *Fatḥiyya* project.

3.1.2. ***Risālah dar hay'ah***

Considering the number of copies of *Risālah dar hay'ah* that have come down to us, it seems that it is the most widely-studied of Qūshjī's *hay'a* works. It is also one of the most popular *Persian* astronomical works of the early modern period. The oldest extant copy was produced in the final days of Dhū al-Ḥijja in 862/late October-early November 1458 in Samarqand.[290] Curiously enough, unlike his other major works such as *Sharḥ al-Tajrīd* and the *Fatḥiyya*, the *Risālah* does not seem to have a dedicatee, as far as the copies I have examined are concerned. Represented by more than 100 copies in libraries across the world[291], the *Risālah* was widely used in the teaching of astronomy in most of the Islamic East. Its influence extended to a wider audience through its many commentaries and translations into such languages as Arabic[292], Turkish[293], Sanskrit[294], Judeo-Persian[295], and Latin.[296] The *Risālah* was also studied in the madrasa context, which is one of the main reasons for its wide circulation. For instance, the madrasa curriculum known as *Dars-i*

[290] ʿAlī al-Qūshjī, *Risālah dar hay'ah*, Ayasofya, MS 2640, f. 24b.
[291] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 37.
[292] Muḥammad b. Nāṣir Al-ʿAjamī, *Al-Rasā'il al-mutabādila bayna Jamāl al-Dīn al-Qāsimī wa-Maḥmūd Shukrī al-Alūsī* (Beirut: Dār al-Bashā'ir al-Islāmiyya, 2001), 35.
[293] An Ottoman scholar and bureaucrat, Parwīz ʿAbd Allāh (d. 987/1579), translated the *Risālah* into Turkish under the title of *Mirqāt al-samā'* in 934/1527-28. Parwīz ʿAbd Allāh, *Mirqāt al-samā'*, Istanbul, Süleymaniye Manuscript Library, Halet Efendi Collection, MS 533, f.41a. For further details about the author, see İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi,* 1:189–91.
[294] Pingree, "Indian Reception of Muslim Versions of Ptolemaic Astronomy," 471–85.
[295] ʿAlī al-Qūshjī, *Rasalah dar hayat* (*רסאלה דר היאת*), British Library, Collection of Judeo-Persian works, Add MS 7701, 38r-81v (Online access: http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Add_MS_7701).
[296] De Young, "John Greaves' Astronomica Quaedam," 467–510.

Niẓāmī, which was prepared by Mullā Niẓām al-Dīn al-Sihālawī (d. 1161/1748) in India, listed the *Risālah* as one of the works to be studied.[297] In Iranian madrasas, it was studied until the end of the twentieth century.[298] Many *Risālah* copies were produced in the Ottoman Empire, implying that it was part of the education system in many parts of the Empire.[299]

While the *Risālah* drew the attention of many commentators,[300] Muṣliḥ al-Dīn al-Lārī (d. 979/1572), a prolific scholar who composed a number of works in various fields of the madrasa disciplines, wrote its most famous commentary, which received wide circulation in the early modern Islamic world. Dedicated to the Mughal ruler Humāyūn Shāh (d. 963/1556), this commentary was responsible for the dissemination of Qūshjī's astronomy across the three major Islamic Empires of the period, namely the Mughals, the Safavids, and the Ottomans. Since Lārī emigrated to the Ottoman Empire after being in the service of the Mughal court, his work attracted the attention of Ottoman scholars. He taught in such Ottoman cities as Aleppo, Istanbul, and Diyarbakir until his death in Diyarbakir.[301]

With respect to the main subject of this dissertation, another important aspect of the *Rīsālah* is its strong connection to the development of the *Fatḥiyya*, which I will deal with in more detail in the second part of this chapter.

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297 Abdülhamit Birışık, "Hint Alt Kıtasında Medrese," in *TDV İslam Andiklopedisi*, vol. 28 (Ankara: TDV Yayınları, 2003), 334.
298 Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 37.
299 İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:30–33.
300 For a list of its commentaries, see Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 38–40.
301 For further details about his life and scholarship, see Baki Tezcan, "Muslihiddin Lari (d. 1572): The Fate of an Immigrant Polymath in the Sixteenth Century Ottoman Empire," in *History from Below: A Tribute in Memory of Donald Quataert*, ed. Selim Karahasanoğlu and Deniz Cenk Demir (Istanbul: Istanbul Bilgi University Press, 2016), 615–28; Reza Pourjavady, "Muṣliḥ Al-Dīn al-Lārī and His Samples of the Sciences," *Oriens* 42 (2014): 292–322; İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:179–83.

3.1.3. ***Al-Risāla al-Fatḥiyya***

In the previous chapter on Qūshjī's intellectual biography, I provided a brief outline of the political environment in which the *Fatḥiyya* was written. Qūshjī accompanied Meḥmed II on his campaign against the Āq Qoyūnlū state and completed an early draft of the text during this period. He presented his work to the Sultan to honor his victory over Uzun Ḥasan in the Otlukbeli war that took place on 16 Rabīʿ I 878 (11 August 1473), a historical event alluded to by the title *al-Risāla al-Fatḥiyya* ("The Treatise of Conquest"). In conformity with the date of war, the colophon of the autograph copy presented to the Sultan gives the completion date of the work as mid-Rabīʿ I 878 (August 1473).[302] The compilation story of the *Fatḥiyya* indicates that Qūshjī continued his intellectual activities even during the war campaign.

Apart from being presented to the Ottoman Sultan, there are also other characteristics that make the *Fatḥiyya* an Ottoman *hayʾa* work. As one can observe in the "Description of the Manuscripts," the available copies of the *Fatḥiyya* are produced almost entirely in an Ottoman context. To put it differently, unlike his *Risālah dar hayʾah,* which circulated across various geographies, the *Fatḥiyya* was written, studied, commented, and translated in the Ottoman context. Moreover, the number of available copies for the *Fatḥiyya* is far less than that of the *Risālah* or Qāḍīzāda's *Sharḥ al-Mulakhkhaṣ*, which was also widely studied at Ottoman madrasas. I will return to this intriguing situation later. But since the derivative textual tradition of the *Fatḥiyya*, in both commentary and translation forms, was also produced in the Ottoman context, it is important to make sense of the text's

[302] ʿAlī al-Qūshjī, *Risālat al-Fatḥiyya*, Istanbul, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2733, f. 70a. Ghulām Sinān, Qūshjī's Ottoman student, gives a slightly different reason for the naming of the treatise. According to him, Qūshjī completed it near the time of the conquest of the Karahisar castle that had been kept by Uzun Ḥasan, which took place right after the Otlukbeli war. Özen, "Sahn-i Semân'da Bir Atışma," 168.

trajectory in this intellectual environment. As such I will briefly introduce them in the following sections. Particularly, one needs to introduce the commentaries on the *Fatḥiyya*, since I will benefit from them in my commentary chapter. The second part of this chapter is entirely devoted to historical, local, and scientific contexts of the text.

The Commentaries on the *Fatḥiyya*

a) *Fatḥ al-Fatḥiyya*: This commentary was written by Sinān al-Dīn Yūsuf, better known as Ghulām Sinān, one of Qūshjī's students in Istanbul, in 890/1485.[303] He dedicated it to the Sultan Bāyazīd II, expressing his hope that this treatise is a foreshadow of Sultan's conquests in the near future. Thus he named the commentary *Fatḥ al-Fatḥiyya* (The Conquest of the [Treatise] of Conquest).[304] Ghulām Sinān was a prominent scholar who taught at higher Ottoman madrasas in Bursa and Istanbul, such as the Ṣaḥn-i Thamān established by Sultan Meḥmed II. In *Miftāḥ al-saʿāda*, a well-known book on the classification of sciences, Ṭāshkubrīzāda introduces Ghulām Sinān as "not being proficient in this discipline [i.e. *hayʾa*] (*mā kāna māhiran fī hādhā al-ʿilm*)," presumably by comparing him with his own teacher Mīrim Chalabī, another commentator of the *Fatḥiyya*. On the other hand, it was also Ṭāshkubrīzāda who described Ghulām Sinān's commentary as being "extremely useful (*nāfiʿ fī al-ghāya*)," in his *Shaqāʾīq*.[305] Kātib Chalabī also reiterates both Ṭāshkubrīzāda's opinions.[306]

303 For the copies of the text see, İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:68.
304 Özen, "Sahn-i Semân'da Bir Atışma," 168.
305 Ṭāshkubrīzāda, *Miftāḥ al-Saʿāda wa-miṣbāḥ al-siyāda fī mawḍūʿāt al-ʿulūm*, 1:349; Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 277.
306 Kâtib Çelebi, *Kashf al-ẓunūn*, ed. Şerafettin Yaltkaya and Rifat Bilge, vol. 2 (Istanbul: Maarif Matbaası, 1941), 1236.

Nonetheless, from a historical point of view, the significance of this commentary stems from the fact that as a student of Qūshjī, Ghulām Sinān adds to his commentary numerous notes he took in Qūshjī's classes. Indeed, he points out that his aim in writing his commentary is to explain unclear parts of the text by using Qūshjī's lecture notes, adding that he also offers his own opinions and criticisms if needed. In addition, he makes references to other important works, such as *Mulakhkhaṣ* commentaries written by Qāḍīzāda and Jurjānī, commentaries on the *Tadhkira* compiled by Jurjānī and Nīsābūrī, and *Sharḥ al-Mawāqif*, *Ḥāshiyat al-Tajrīd*, and *Sharḥ al-Miftāh* by Jurjānī, among others. Şükrü Özen, in his article on a letter written by Ghulām Sinān to another Ottoman scholar regarding the personal and intellectual tension between them, also discusses the significance of Ghulām Sinan's *Fatḥ al-Fatḥiyya*, informing us that Ghulām Sinān studied Jurjānī's *Sharḥ al-Tadhkira* in Istanbul under the supervision of Qūshjī.[307]

In my study, I consulted a copy of this text in the Fatih Collection (MS 5396, ff. 78b-188a), which is an extremely interesting example of how *hay'a* was studied in the Ottoman context. There are numerous marginal notes from a rich set of astronomical, mathematical, theological, and linguistic sources. Equally important, it includes a number of *minhu* notes that can be attributed to Ghulām Sinān and probably recorded by one of his students.[308] It contains many figures, apart from those included in the original *Fatḥiyya* text. From codicological and pedagogical points of view, this copy deserves further investigation.[309]

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[307] Özen, "Sahn-i Semân'da Bir Atışma," 167–69.

[308] For the significance of *minhu* (also known as *minhīyāt*) notes in Islamic manuscript studies, see Rosemarie Quiring-Zoche, "Minhīyāt- Marginalien des Verfassers in arabischen Manuskripten," *Asiatische Studien - Études Asiatiques* LX, no. 4 (2006): 987–1019.

[309] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Istanbul, Süleymaniye Manuscript Library, Fatih Collection, MS 5396, ff. 78b-188a.

b) *Sharh al-Fatḥiyya*: This commentary was written by Maḥmūd b. Muḥammad b. Qāḍīzāda, better known as Mīrim Chalabī, who was a descendant of both Qūshjī and Qāḍīzāda Rūmī. He was one of the most prominent figures in the mathematical sciences in the early sixteenth-century Ottoman Empire. His scholarship was also acknowledged by Bāyazīd II, who was not only his close friend, but also studied the mathematical sciences with him. Under the Sultan's patronage, Mīrim Chalabī wrote works in various fields including the astral sciences, such as observational and theoretical astronomy, astronomical instruments, and astrology.[310]

In the *Miftāḥ al-saʿāda*, Ṭāshkubrīzāda states that Mīrim Chalabī wrote this commentary when Ṭāshkopruzāda was studying the *Fatḥiyya* with him.[311] Both the autograph copy and the copy copied by Ṭāshkopruzāda when studying it are extant. According to the colophon of the autograph copy, the work was completed on 23 Muḥarram 925/25 January 1519 and was copied (*tamma tarkīm hādhā al-kitāb*) on 13 Dhū al-Ḥijja 925/6 December 1519. The work was presented to the Sultan Salīm I as a "gift (*tuḥfa*)."[312] In turn, Ṭāshkoprīzāda, who gives his full name as Aḥmad b. Muṣṭafā b. Khalīl in the copy, copied the commentary from the autograph copy and collated it in 926/1519-20 in Istanbul. One can understand from this information that Ṭāshkoprīzāda studied Qūshjī's *Fatḥiyya* along with Mīrim Chalabi's commentary on it when he was around 25 years old, as he was born in 901/1495.[313] Compared to Ghulām Sinān's commentary, Mīrim Chalabi's

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[310] Ṭāshkubrīzāda, *Al-Shaqāʾiq al-nuʿmāniyya*, 327–28. For a summary of Mīrim Chalabi's activities at Bāyazīd II's court, see Şen, "Astrology in the Service of the Empire," 188–93.
[311] Ṭāshkubrīzāda, *Miftāh al-saʿāda*, 1:349.
[312] Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Istanbul, Millet Manuscript Library, Feyzullah Efendi Collection, MS 1347, ff. 2a, 186b.
[313] Regarding the copy place, Ṭāshkoprīzāda uses this phrase: "[…] *karramahu al-shāmil fī madīnat Qusṭanṭiniyya* (…it was granted to be completed in the city of Constantinople) […]" Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Bursa, Inebey Manuscript Library, Hüseyin Çelebi Collection, MS 755, f. 177b.

seems to have less explicit references to other sources, whereas one finds implicit quotations from various sources in the former, including Shīrāzī's *Nihāyat al-idrāk*. As one of the leading Ottoman astronomers of the period,[314] Mīrim Chalabī's commentary deserves further study to help establish the level of theoretical astronomy education in early sixteenth century Istanbul. Besides this, as I will elaborate further in the "Editorial Procedures" section, Ghulām Sinān and Mīrim Chalabī use different versions of the *Fatḥiyya*, which is obviously relevant for the development and reception of the *Fatḥiyya* text. This differentiation is more intriguing given the fact that in his commentary, Mīrim Chalabī, like Ghulām Sinān, also claims to have used an autograph copy of the *Fatḥiyya*.[315]

The Translation of the *Fatḥiyya*

Mir'āt al-ʿālam: The *Fatḥiyya* was translated into Turkish and published in 1824 in Istanbul. The translator was Sayyid ʿAlī Pāsha (d. 1262/1846), who was the chief instructor at the Ottoman Imperial School of Land Engineering. An official document ordering that a translation of the *Fatḥiyya* be published and that 250 copies be sent to the School's library summarizes why this text was chosen for translation. It notes that teachers of the School had been compiling or translating works in the mathematical and engineering sciences (*fann-i handasa*). Since *hay'a* was one of the required courses in the curriculum, and the available copies at hand were either in Arabic or Persian, it was decided that the *Fatḥiyya*

[314] For a general overview of his astronomical scholarship, see İhsan Fazlıoğlu, "Mīram Čelebī: Maḥmūd Ibn Quṭb Al-Dīn Muḥammad Ibn Muḥammad Ibn Mūsā Qāḍīzāde," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 788–89.
[315] Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Feyzullah Efendi, MS 1347, f. 8a.

should be translated into Turkish so that all the engineers at the School could understand it. The translation was presented to Sultan Maḥmūd II (d. 1255/1839).[316]

As discussed in the Editorial Procedures Section, there are two copies of the *Fatḥiyya* copied in the Engineering School context (Konya, Koyunoğlu Museum and Library, Koyunoğlu Collection, MS 11359; ff. 21b-54b; Istanbul, Istanbul Technical University Library, Rare Manuscripts Collection, 7094; ff. 1a-42b). Notably, the first copy was copied by Ḥusayn Rifqī, who was the chief instructor at the Engineering School before the translator, Sayyid ʿAlī Pāsha, assumed that position. Given the fact that they were copied more than 15 years before the publication of the translation, it is likely that the *Fatḥiyya*'s text was already studied at the Engineering School. Generally speaking, Sayyid ʿAlī Pāsha produced a literal translation of the *Fatḥiyya*, but he made occasional additions to secure its clarity. In my view these clarifications are based on Mīrim Chalabi's commentary.

3.2) Writing *Hayʾa* in the Ottoman Context: The Evolution of the *Fatḥiyya*

This section aims to examine the background of the *Fatḥiyya* by explaining the historical, local and scientific contexts within which Qūshjī wrote his work. In fulfilling this aim, I will first present a general history of the science of *hayʾa* up to the *Fatḥiyya* before offering a survey of theoretical astronomy education in pre-Ottoman Anatolia and Ottoman lands before Qūshjī's arrival. I will then discuss the relationship between three interrelated texts: the *Fatḥiyya*; the *Risālah dar hayʾah*; and *Khulāṣat al-hayʾa*, the last of which is an expanded Turkish rendition of the *Risālah* by an Ottoman scholar named Saydī ʿAlī Raʾīs. Finally, I will present the general characteristics of the *Fatḥiyya*, and contextualize it in the

[316] BOA, HAT 922/40090. See also, Seyyid Ali Paşa, *Mirʿâtü'l-ʾÂlem (Evrenin Aynası)*, 25.

history of *hay᾿a* literature, especially in reference to its significance and reception in the Ottoman milieu.

3.2.1. The Historical Context: *Ḥay᾿a* up to the *Fatḥiyya*

The aim of this part is to present a brief history of the science of *hay᾿a* up to the *Fatḥiyya* in order explore the context within which it was written in 1473. I will show that while Qūshjī's effort in writing a new *hay᾿a* work should be understood from the perspective of the *longue durée*, namely in reference to major figures of the tradition and their works in the preceding four centuries, equally influential are the immediate intellectual and social contexts of the *Fatḥiyya*. This includes the history of Ottoman intellectual life up to the late fifteenth century and the personal intellectual development of Qūshjī himself. In addition, I will also take into account the study of *hay᾿a* in Anatolia during the same period, since the Ottoman intellectual system emerged in Anatolia and evolved with reference to the networks of scholars and texts that flourished in this peninsula.

My account will largely rely on the available secondary literature. My concern here is not to provide a comprehensive account, which would require the examination of a number of primary sources written and disseminated up to the late fifteenth-century. For the time being, this is not a feasible undertaking given the current state of research. Although studies on *hay᾿a* have expanded both quantitatively and qualitatively over the last few decades, many of the primary works have not yet been edited, let alone been subjected to in-depth examination. I should also note that my survey of the literature will be largely selective in the sense that I will refer to the *hay᾿a* works that are generally considered pioneering or authoritative in this genre or those that are related to Qūshjī's astronomical background. I already mentioned some of them in the previous chapter under the sections entitled “The Making of Qūshjī’s Intellectual Personality (1): The Samarqand Madrasa” and “The Making of Qūshjī’s Intellectual Personality (2): The Samarqand Observatory.” Since there is no evidence, at least for the time being, that Qūshjī used the *hayʾa* literature that was produced in the Islamic West, I will not deal with it here. Apart from them, I will also discuss works studied by Anatolian scholars by the late-fifteenth century.

Before dealing with the history of *hayʾa*, we must begin with a definition of the discipline. Naṣīr al-Dīn al-Ṭūsī (d. 672/1274) defines it in the *Tadhkira* as follows:

> The subject of astronomy is the simple bodies, both superior and inferior, with respect to their quantities, qualities, positions, and intrinsic motions. Those of its principles that need proof are demonstrated in three sciences: metaphysics, geometry, and natural philosophy. Its problems aim at gaining knowledge of these bodies in and of themselves, of their shapes, of the manner of their arrangement and motions, of the amounts of their motions and distances, and of the reasons for changes in position.[317]

F. Jamil Ragep discusses at length the main characteristics of *hayʾa* in his Introduction to the *Tadhkira*, which might be summarized as follows. First, this genre deals with the World as a whole by considering both the sublunary and celestial bodies. Second, unlike the *Almagest*, it aims to introduce the configuration and motions of the celestial bodies without any geometrical proofs. Third, it takes its principles from such sciences as metaphysics, natural philosophy and geometry.

The interplay between *hayʾa* and natural philosophy would be one of the central issues of debate for the astronomers, philosophers, and *mutakallimūn* of the following centuries. More importantly, Qūshjī’s *hayʾa* works, especially the *Fatḥiyya*, introduced major interventions into this discussion, which we will discuss later. According to Ṭusī,

[317] F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī’s Memoir on Astronomy*, 1:90–91.

hay'a primarily concerns the question of "how." In this regard it has a different scope than Aristotle's physical work on the heavens, *De Caelo*, whose primary concern is to answer the question of "why." A *hay'a* work deals, for instance, with the directions and quantities of the motions of the orbs, but it does not concern itself with the question of why they move circularly and uniformly. This distinction of how and why was known in the literature as the *innī-limmī* problem.[318]

The discipline of *hay'a* emerged in Islamic culture as a distinct field of astronomy after the eleventh-century by distinguishing itself from astrology. It eventually became an umbrella term for the astronomical disciplines.[319] However, one should note that this genre originated from Islamic and pre-Islamic astronomical texts. Sally P. Ragep's study of Jaghmīnī's *Mulakhkhaṣ*, which was written in the early thirteenth century, offers a succinct history of the discipline and surveys the practice of writing elementary-level astronomical textbooks in pre-modern Eurasia. She contextualizes the emergence and development of *hay'a* with reference to many prominent figures, texts, as well as scientific and philosophical currents of the pre-Ptolemaic, Ptolemaic and Islamic periods. As a consequence, she convincingly argues that the genre of *hay'a* did not emerge *ex nihilo*, but from a particular historical and intellectual context. This context includes the astronomical works of Aristotle and Ptolemy, as well as those written by several Islamic scholars such as Yaʿqūb b. Ṭāriq (2nd-3rd/8th- 9th c.), al-Farghānī (fl. 3rd/9th c.), Thābit b. Qurra (d. 288/901), Ibn Sīnā (d. 428/1037), and Bīrūnī (d. ca. 441/1050) among others.[320]

[318] For further elaboration of *hay'a* see, Ibid., 1:24–53.
[319] For further examination of this demarcation process, see George Saliba, "Islamic Astronomy in Context: Attacks on Astrology and the Rise of the Hay'a Tradition," *Bulletin of the Royal Institute for Inter-Faith Studies* 4, no. 1 (2002): 25–46.
[320] For Sally Ragep's history of *hay'a* in the by the early thirteenth century, see S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 26–67.

The post-twelfth-century deserves particular attention when considering the development of *hayʾa*. Nevertheless, due recognition should be accorded to Ibn al-Haytham's (d. ca. 431/1040) role in identifying the genre's basic principles and delineating its subject-matter. His account of the World was a "pioneering inspiration" for his successors in the field.[321] Generally speaking, Ibn al-Haytham has been duly recognized as a pre-eminent scientist with his *magnum opus* in optics, entitled *Kitāb al-manāẓir*; yet his two works in theoretical astronomy are no less significant. In his *al-Shukūk ʿalā Baṭlamyūs* (Doubts concerning Ptolemy), Ibn al-Haytham criticized specific issues covered in Ptolemy's three works: *Almagest*, *Planetary Hypotheses*, and *Optics*. As far as Ptolemy's astronomical works are concerned, Ibn al-Haytham criticized them for violating Aristotelian natural philosophical principles. To give an example, Ptolemy proposed the equant, an eccentric point that equalizes the motion of the epicyclic orb along the deferent. Mathematically speaking, this assumption was an efficient device for calculating the motions of the planets, but it does not conform to the Aristotelian principle that a celestial body only moves uniformly about its own center.[322]

In terms of the formation of *hayʾa*, Ibn al-Haytham's *Maqāla fī hayʾat al-ʿālam* (On the Configuration of the World) is extremely important.[323] He proposes a three-dimensional structure of the celestial orbs, which are represented as circles in the *Almagest*, and explains the physical principles of the planetary motions in a non-technical way. For this reason, he is credited with being the first scholar in Islamic history who put

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[321] F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:33.
[322] Ibn al-Haytham, *al-Shukūk ʿalā Baṭlamyūs*.
[323] For its critical edition and English translation, see Y. Tzvi Langermann, *Ibn al-Haytham's On the Configuration of the World* (New York: Garland, 1990).

an effort to "physicalize the mathematical constructs of Ptolemaic astronomy."[324] Apart from this, Ibn al-Haytham's work can be regarded as a significant step in the production of pedagogical texts in the mathematical sciences. That is to say, unlike the *Almagest*, which requires an extensive amount of knowledge in mathematics and astronomy, Ibn al-Haytham's *Maqāla* was generally accessible if one knew basic geometrical entities such as point, circle, and spheres. In this respect, it addressed a wide, non-professional but educated audience, primarily those having a philosophical background.[325]

As pointed out above, Ibn al-Haytham's work represents a new approach in the Islamic context, but one should acknowledge that it was not a complete departure from the Ptolemaic corpus. Rather, they were "appropriated into the Islamic world," followed by many revisions and additions that were made in the *hayʾa* tradition over the following centuries.[326] More specifically, Ibn al-Haytham's project resonates with Ptolemy's larger project of astronomy. On the one hand, we have the *Almagest*, which was primarily interested in providing mathematical proofs of the celestial motions. On the other, we have the *Planetary Hypotheses*, which focuses on the physical structure of the celestial bodies in a way that pre-figures the content of *hayʾa* literature. Thus, as far as the aim and scope of *hayʾa* are concerned, one might say that these two texts complement each other to produce "a unified celestial and sublunar cosmography fundamental for any *hayʾa* work."[327]

Despite the fact that Ibn al-Haytham's *Maqāla* played a crucial role in specifying the general structure and contents of *hayʾa*, it was during the twelfth and thirteenth centuries that it gained its final form as a well-defined discipline. For instance, *hayʾat al-arḍ* was

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[324] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 58–59.
[325] Y. Tzvi Langermann, "Arabic Cosmology," *Early Science and Medicine* 2, no. 2 (1997): 189.
[326] F. J. Ragep, "Astronomy."
[327] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 36.

introduced into the structure of *hayʾa* works during this period. Furthermore, several works in the genre that would be widely studied in the following centuries were compiled during this period. Qaṭṭān al-Marwazī's (d. 548/1153) *Gayhānshenākht* (Knowledge of the Cosmos) is one of the first examples of this genre. Written in Persian, Marwazī's work aims to provide "a coherent and unified" summary of *hayʾa*. Given the fact that Marwazī's intellectual lineage goes back to Ibn Sīnā, *Gayhānshenākht*'s main audience seems to be those who had some philosophical education, as was the case with Ibn al-Haytham's *Maqāla*.[328] Its importance also stems from the fact that it was one of the earliest *hayʾa* works written in Persian that was influential for the development of the discipline.[329]

Another *hayʾa* writer who flourished in the twelfth-century is ʿAbd al-Jabbār al-Kharaqī (d. 533/1138-39). His works, *Muntahā al-idrāk fī taqāsīm al-aflāk*[330] and its abridged version *al-Tabṣira fī ʿilm al-hayʾa*, were decisive for "the crystallization of the genre."[331] He also contributed to the *hayʾa* literature in Persian with his work *ʿUmdah li-ūlī al-albāb*.[332] It would not be an exaggeration to say that it was Kharaqī who established the link between Ibn al-Haytham and the *hayʾa* tradition that flourished in the post-classical

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328 Behnaz Hashemipour, "Qaṭṭān al-Marwazī: ʿAyn al-Zamān Abū ʿAlī Ḥasan Ibn ʿAlī Qaṭṭān al-Marwazī," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 943–44.
329 S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 63.
330 For a critical edition, study and Persian translation of this works, see Hanif Ghalandari, "A Survey of the Works of 'Hayʾa' in the Islamic Period with a Critical Edition, Translation and Commentary of the Treatise Muntaha al-idrāk fī taqāsim al-aflāk Written by Bahāʾ al-Dīn al-Kharaqī (d. 553 AH/1158 AD)" (PhD diss., University of Tehran, 2012).
331 Langermann, "Arabic Cosmology," 197.
332 Sally Ragep stresses that the *ʿUmdah* resembles the *Muntahā* remarkably, highlighting the intertextual aspect of producing a *hayʾa* text. S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 62–63. As a matter of fact, notably, this pattern, namely the interplay between *hayʾa* works in Arabic and Persian written by the same scholar awaits detailed scrutiny as it can be observed in such prominent figures as Ṭūsī (*Tadhkira* in Arabic, *Risāla-yi Muʿīniyya* and *Ḥall-i mushkilāt-i Muʿīniyya* in Persian), Shīrāzī (*Nihāyat al-idrāk* and *al-Tuhfa al-shāhiyya* in Arabic, *Ikhtiyārāt-i Muẓaffarī* in Persian) and Qūshjī (*Al-Risāla al-Fatḥiyya* in Arabic and *Risālah dar hayʾah* in Persian). I will deal with the Qūshjī case shortly.

period.[333] His direct reference to Ibn al-Haytham indicates that he was inspired by the latter's approach in assuming the solidity of the spheres, instead of imaginary and mathematical figures.[334] As far as his influence on the subsequent literature is concerned, Ṭūsī, who, as we shall, is one of the authoritative writers of *hayʾa*, explicitly makes reference to Kharaqī. Furthermore, Ṭūsī's *Tadhkira* and *Muʿīniyya* follow a similar structure to the one found in Kharaqī's corpus.[335] Concerning the audience of Kharaqī's scholarship, Y. Tzvi Langermann claims that Kharaqī's definition of some technical terms like a point (*al-nuqṭa*) "almost automatically conjures up the atomism of *kalām*."[336] This observation is in line with the fact that in the *Muntahā*, Kharaqī emphasizes that, like *kalām*, *ʿilm al-hayʾa* is also a rational approach to "standing and nobility in showing God's wisdom."[337] Although it is hardly possible to make a clear-cut determination of the intellectual backgrounds of the readers of *hayʾa* works in the post-classical period, Kharaqī's scholarship shows how the *mutakallimūn* participated in the production and study of this discipline during the crucial period of its development.

None of the *hayʾa* texts written in Islamic history attracted more attention than Jaghmīnī's (d. ca. 618/1221) *Mulakhkhaṣ*. Written in 602-3/1205-6, it was studied across almost all of the Islamic world until as late as the twentieth century. Its popularity is attested by the fact that Sally Ragep, who prepared its critical edition, identified more than 60 derivative works in various languages, including Arabic, Persian, Turkish, and

333 In the *Tabṣira*'s Introduction, Kharaqī makes an explicit reference to Ibn al-Haytham. See Hanif Ghalandari, "ʿAbd Al-Jabbār Kharaqī wa āthār ū dar hayʾat," *Āyina-yi Mīrāth* 51 (1391): 162–63.
334 S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 60.
335 F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:33.
336 Langermann, "Arabic Cosmology," 195.
337 S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 60, 67.

Hebrew.[338] Considering that the *Mulakhkhaṣ* was largely studied in the madrasa context, one of its most remarkable achievements is pedagogical. While Jaghmīnī benefits from several sources from the pre-Islamic and Islamic periods, he overcame what he considered to be their drawbacks, such as "complex explanations", "longwinded discussions", "oversimplifications", "additional literary references", and "incorrect statements and depictions."[339] Thanks to being a concise and simple text, the *Mulakhkhaṣ* fulfilled one of the most crucial objectives of *hayʾa*, which was to reach a wider, educated, but non-professional audience. As far as Qūshjī's engagement with this text is concerned, as pointed out in the previous chapter, his teacher Qāḍīzāda wrote the most widely studied commentary on the *Mulakhkhaṣ* in Samarqand. This is strong evidence that Qūshjī studied it with Qāḍīzāda.

After the composition of the *Mulakhkhaṣ* in the early-thirteenth century, the *hayʾa* literature witnessed a remarkable development during the rest of the century, which can be called the expansion period of the tradition of *hayʾa*. This expansion indicates an increase not only in the number of works written in the genre, but also in their length. In other words, unlike the *Mulakhkhaṣ,* which aims to be concise, the major *hayʾa* texts written in the later part of the thirteenth-century cover a vast amount of knowledge in a variety of subjects. More importantly, some of these works differ from earlier ones, as their authors also discussed non-Ptolemaic models. To put it another way, they wanted to make their readers more engaged with the problems and their possible solutions associated with the Ptolemaic system, especially those concerning the violation of the natural philosophical principles to save celestial phenomena. In this respect, among the *hayʾa* writers who

[338] Ibid., 284–91.
[339] Ibid., 66.

flourished in this post-*Mulakhkhaṣ* period, those who distinguished themselves include: Muʾayyad al-Dīn al-ʿUrḍī (d. ca. 664/1266), Naṣīr al-Dīn al-Ṭūsī (d. 672/1274), and Quṭb al-Dīn al-Shīrāzī (d. 710/1311).

A prominent astronomer, engineer, and instrument maker, ʿUrḍī is best known for his involvement in the Maragha Observatory project. Invited by Ṭūsī, the director of the Observatory, ʿUrḍī contributed to the building of the Observatory site and made several instruments that would be used there. In addition to his remarkable competence in practical astronomy and engineering, he made major contributions to theoretical astronomy. A commentary on Kharaqī's *al-Ṭabṣira fī ʿilm al-hayʾa* is attributed to ʿUrḍī. Another of his works, entitled *Kitāb al-hayʾa*, is a major contribution in the history of theoretical astronomy in the premodern period.[340] In this work, ʿUrḍi differs from Ptolemy on issues pertaining to the planetary models and sizes, proposing a device known as the *ʿUrḍī Lemma*, which helped transform the eccentric models into epicycle ones. As remarked above, this intervention aims to revise the Ptolemaic system in order to be consistent with Aristotelian natural philosophical principles.[341]

Ṭūsī was one of the distinguished scholars in theoretical astronomy during this period. Generally speaking, Kharaqī's aforementioned works, especially *Muntahā al-idrāk*, had a profound influence on the structure of Ṭūsī's studies in *hayʾa*. Like ʿUrḍī, he also incorporated non-Ptolemaic models into his *hayʾa* works. In his *Ḥall-i mushkilāt-i Muʿīniyya*, a supplement to his earlier *hayʾa* work written in Persian, entitled *Risāla-yi Muʿīniyya*, and

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[340] For a critical edition of this work, see Saliba, *The Astronomical Work of Muʾayyad al-Dīn al-ʿUrḍī (Kitāb al-Hayʾa).*

[341] Petra G. Schmidl, "ʿUrḍī: Muʾayyad (Al-Milla Wa-) Al-Dīn (Muʾayyad Ibn Barīk [Burayk]) Al-ʿUrḍī (Al-ʿĀmirī Al-Dimashqī)," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, ed. Thomas Hockey et al. (New York: Springer, 2007), 1161–62.

later in his *Tadhkira*, Ṭūsī introduced his "Ṭūsī Couple" which he uses in his Lunar and other planetary models. By proposing two circles, the smaller one internally tangent to the larger one, and rotating at different speeds, an oscillating rectilinear motion for a given point on the smaller circle could be sustained.[342] This device served to maintain the compatibility between the mathematical modeling and physical principles, primarily the one that supposes uniform motion for the celestial bodies. Another extremely significant aspect of Ṭūsī's *hayʾa* works, especially the *Tadhkira*, is that although Ṭūsī's aforementioned *hayʾa* works in Persian enjoyed some pedagogical attention, it was the *Tadhkira* that would be the subject of many commentaries and glosses during the centuries to come. In line with the number of extant copies of the *Tadhkira* and its derivative texts, representative encyclopedic works also suggest that it was one of the most widely used textbooks in *hayʾa*. To give an example, in his *Miftāḥ al-saʿāda*, Ṭāshkubrīzāda lists the *Tadhkira* and Jaghmīnī's aforementioned *Mulakhkhaṣ* among the popular elementary level textbooks in this genre.[343]

In terms of the expansion of the knowledge of *hayʾa*, Ṭūsī's student, Quṭb al-Dīn al-Shīrāzī, played a substantial role with his most voluminous works in this genre. *Nihāyat al-idrāk* and *al-Tuḥfa al-shāhiyya* in Arabic and *Ikhtiyārāt-i Muẓaffarī* in Persian were written in Sivas, a city in middle Anatolia, between 1281-1285, when Shīrāzī was a judge of the region. He later wrote a supercommentary on the *Tadhkira*, entitled *Faʿalta fa-lā talum*. Notwithstanding his differences of opinion with Ṭūsī, Shīrāzī's scholarship relies heavily on

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[342] For an explanation and account of the transmission of the "Ṭūsī Couple" across cultures, see F. Jamil Ragep, "From Tūn to Toruń: The Twists and Turns of the Ṭūsī-Couple," in *Before Copernicus: The Cultures and Contexts of Scientific Learning in the Fifteenth Century*, ed. Rivka Feldhay and F. Jamil Ragep (Montreal: McGill-Queen's University Press, 2017), 161–97.
[343] Ṭāshkubrīzāda, *Miftāḥ al-saʿāda*, 1:348–49.

his teacher's works—especially on the *Tadhkira*—for their structure and organization. In his *Nihāyat al-idrāk*, Shīrāzī expresses this point clearly:

> … that I follow the linguistic style of the *Tadhkira*, which nothing before has surpassed and nothing after has overtaken, and that I incorporate it in the course of the exposition if it is clear, and expound upon it if something in it is obscure… since this book does not leave anything small or large without enumerating it, nor the shunned or rejected without turning it to account and bringing it closer, so as to include the utmost thoughts of the foremost Ancients and contain the paramount ideas of the uppermost of the Moderns as well as sublime benefits and fine singularities from us—and even though they are not greater or larger than what they have stated neither are they lesser or smaller—I have called it the Utmost Attainment in Comprehending the Orbs, so that its name will indicate its connotation and its literal sense will inform its signification.[344]

As this passage reveals, Shīrāzī aims to write a work that relies on "the linguistic style of the *Tadhkira*" and explains issues that are unclear. Although Shīrāzī does not call his work a commentary on the *Tadhkira*, Fateme Savadi, who prepared a critical edition of the Book on the Configuration of the Earth in the *Nihāya*, describes it as a "mixed commentary," which seems to include notes taken when he was studying the *Tadhkira* with Ṭūsī.[345] Another remarkable aspect of the *Nihāya* is that his project is far more extensive than that of the *Tadhkira*, to such a degree that, as Shīrāzī expresses it, he "does not leave anything small or large without enumerating it." As far as the history of *hayʾa* is concerned, Shīrāzī's motivation seems to be different from Jaghmīnī in the *Mulakhkhaṣ,* whose main concern is to be concise. Another point to be highlighted is that like ʿUrḍī and Ṭūsī, Shīrāzī

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[344] F. Jamil Ragep, "Shīrāzī's Nihāyat al-Idrāk: Introduction and Conclusion," *Tarikh-e Elm: Iranian Journal for the History of Science* 11 (2013): 54.
[345] Savadi, "The Historical and Cosmographical Context of *Hayʾat al-arḍ*," 38.

also presents non-Ptolemaic planetary theories in his *hayʾa* works. His engagement with proposing new models is so intense that he revised them several times.[346]

Before moving into the development of *hayʾa* in the fourteenth century, let me point out that the works written in the eleventh through thirteenth centuries served as models for writing *hayʾa* works and were extensively referenced in later works. However, we should differentiate the *Mulakhkhaṣ* and the *Tadhkira* from the works written at the end of the thirteenth century, as the former two were more widely consulted *hayʾa* works, as attested by the number of extant copies and their derivatives. All in all, I refer to the period between the eleventh and thirteenth centuries as the *formative period of the authoritative texts in hayʾa*.

The fourteenth and fifteenth centuries witnessed an increased interest in commenting on *hayʾa* texts that were written in the *formative period*. Despite this, it would not be true to say that the commentary tradition in *hayʾa* started from the fourteenth century; as pointed out previously, a commentary on Kharaqī's *Tabṣira* is attributed to ʿUrḍī who died sometime after the middle of the thirteenth-century. While acknowledging that further examination is needed in order to contextualize when and under which circumstances the commentary tradition in the genre of *hayʾa* started, we might still conclude based on the available sources that the earliest commentary on the *Tadhkira* emerged in the late thirteenth- or early fourteenth-centuries, whereas the earliest commentary on the *Mulakhkhaṣ* was written in the fourteenth-century. Although a few commentaries on Kharaqī's works were written

[346] As examples, see Gamini, "Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century," 165–203; Kaveh Niazi, *Quṭb al-Dīn Shīrāzī and the Configuration of the Heavens: A Comparison of Texts and Models* (Dordrecht: Springer, 2014).

in this period, it was the *Mulakhkhaṣ* and *Tadhkira* that were the main vehicles through which the genre of *hayʾa* was transmitted across generations. Accordingly, a number of commentaries and glosses on these two texts were produced by leading figures. Shīrāzī's student Niẓām al-Dīn al-Nīsābūrī (d. 711/1311) wrote a widely studied commentary on the *Tadhkira* entitled *Tawḍīḥ al-Tadhkira*.[347] Qāḍīzāda's *Sharḥ al-Mulakhkhaṣ* became arguably the most widely studied commentary on the *Mulakhkhaṣ*. Other scholars of the fourteenth- and fifteenth-centuries who wrote commentaries or glosses on both the texts include Faḍl Allāh al-ʿUbaydī, al-Sayyid al-Sharīf al-Jurjānī, and Fatḥ Allāh al-Shirwānī. These authors were associated with the *hayʾa* traditions of Jaghmīnī and Ṭūsī and the textual tradition that emerged in their wake. The composition of these commentaries and glosses is strong evidence that the teaching of theoretical astronomy started to reach an increasingly wider audience, for whom the *Mulakhkhaṣ* and *Tadhkira* became acknowledged as authoritative texts in the discipline. Therefore, I call this period *the consolidation period of the authoritative texts with their derivative textual tradition*.

Let me conclude this section by raising the following problem. Qūshjī was active at a time in which *hayʾa* was already an established field with its standard set of problems, principles, and authorities. However, unlike many leading scholars from the earlier or the same period, Qūshjī decided against writing a commentary on the *Mulakhkhaṣ* and *Tadhkira*, but as mentioned, he did write a partial commentary on Shīrāzī's *Tuḥfa.* Rather than commentaries, his major *hayʾa* contributions were two original compositions, *Risālah dar hayʾah* and the *Fatḥiyya*. What motivated this

[347] For an extensive account of this commentary, see Robert G. Morrison, *Islam and Science: The Intellectual Career of Niẓām al-Dīn al-Nīsābūrī* (New York: Routledge, 2007).

attempt to contribute original compositions instead of participating in the commentary tradition? In order to understand Qūshjī's *hay'a* project, I will first briefly present the Anatolian and Ottoman context of the emergence of the *Fatḥiyya*.

3.2.2. The Local Context: *Ḥay'a* in Anatolia and the Ottoman Lands up to the *Fatḥiyya*

The Ottomans emerged as a northwestern Anatolian principality neighboring the Byzantines in the late-thirteenth century.[348] Notwithstanding the political instability in the region on the eve of the establishment of the Ottoman state, a number of scholars specializing in various disciplines visited Anatolian cities and stayed either for a certain period of time or permanently to teach at madrasas or to hold bureaucratic positions. Likewise, many local students and scholars went to major intellectual centres in Persia, the Levant, and Egypt to further their studies. This cosmopolitan environment of intellectual exchange brought together diverse networks of scholars, texts, and ideas in Anatolia and contributed to the flourishing of institutions of education in the region. For instance, around 80 madrasa buildings that were established in Anatolia before the sixteenth-century still survive today. It is also reported that just in Sivas, a historically significant city in the heart of Anatolia, at least 13 madrasas were active in the thirteenth-century. As a parallel development, new hospitals were established in various cities of Anatolia during the same period.[349]

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[348] For an account of the early Ottoman period, see Cemal Kafadar, *Between Two Worlds: The Construction of the Ottoman State* (Berkeley: University of California Press, 1995).
[349] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:LII, LIV, LVII–LIX.

The secondary literature on science education and that of astronomy in particular during the pre-and early-Ottoman period is not mature enough to offer a full account of its development. Yet, available sources convincingly suggest that many *hay'a* texts were either written or studied in Anatolia by the time Qūshjī came to Istanbul. In this respect, the most remarkable astronomer was Quṭb al-Dīn al-Shīrāzī, who wrote *Nihāyat al-idrāk*, *al-Tuḥfa al-shāhiyya*, and *Ikhtiyārāt-i Muẓaffarī* in Sivas when he was serving as a judge of the region during the Ilkhanid period.[350] His works were among the most advanced in the *hay'a* literature, and there is evidence that they started to circulate in Anatolia as soon as they were penned.[351] Given the fact that in order to study these texts, the student must first be knowledgeable of a number of mathematical and philosophical texts, the institutionalization of science education in Anatolia must be understood within the context of a widespread integration of the mathematical and philosophical sciences in the madrasa system during the post-classical period.[352]

The existence of several *hay'a* works that were copied in Anatolia by the early fifteenth-century also shows their dissemination among the scholars in Anatolia. The texts

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[350] For Shīrāzī's life in Anatolia, see Niazi, *Quṭb Al-Dīn Shīrāzī and the Configuration of the Heavens*, 61–84; Savadi, "The Historical and Cosmographical Context of *Hay'at al-arḍ*," 22–37.

[351] For example, several copies of Shīrāzī's *hay'a* works that were copied in Sivas have come down to us. İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:LXXVIII.

[352] There has been an ongoing discussion in the literature as to whether science education in Islamic history had an institutional basis or relied solely on the student-teacher relationship without any need of institutional support. While some scholars propose a well-structured madrasa model, others defend that education could occur any place, not necessarily at the madrasa, since the main agent of the transmission of knowledge was the student-teacher relation. George Makdisi, *The Rise of Colleges: Institutions of Learning in Islam and the West* (Edinburgh: Edinburgh University Press, 1981); Jonathan P. Berkey, *The Transmission of Knowledge in Medieval Cairo: A Social History of Islamic Education* (Princeton, New Jersey: Princeton University Press, 1992); Michael Chamberlain, *Knowledge and Social Practice in Medieval Damascus, 1190-1350* (Cambridge ; New York: Cambridge University Press, 1994); Daphna Ephrat, *A Learned Society in a Period of Transition: The Sunni "ulama" of Eleventh Century Baghdad* (Albany: State University of New York Press, 2000). For a succinct critical evaluation of those tendencies, see S. P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," 154–56. For a number of examples regarding science education in various contexts, see Sonja Brentjes, *Teaching and Learning the Sciences in Islamicate Societies (800-1700)* (Turnhout: Brepols, 2018).

that attracted attention were among the most widely studied in major intellectual localities in Islamic East. For instance, in addition to Shīrāzī's aforementioned voluminous works, among the works that were copied in Anatolia are Ṭūsī's *Taḥrīr al-Majisṭī*, *Tadhkira*, and *Zubdat al-idrāk*, Nīsābūrī's *Tawḍīh al-Tadhkira*, Jurjānī's *Sharḥ al-Tadhkira*, Jaghmīnī's *Mulakhkhaṣ* and its commentaries by Mubārak-shāh (d. 741/1341), Faḍl Allāh al-ʿUbaydī (d. 751/1350), Kamāl al-Dīn al-Turkmānī (d. 758/1357), and ʿAbd al-Wājid (d. 838/1435).[353]

As for the *hayʾa* works used by Ottoman scholars before Qūshjī's arrival in Istanbul, the situation of astronomy education was not so different. A text attributed to Dāʾūd al-Qayṣarī (d. 751/1350) who was considered to be the first Ottoman *mudarris* (professor of a madrasa), and dedicated to Ottoman Sultan Orhan's son Sulayman Pāshā, entitled *al-Itḥāf al-Sulaymānī fī al-ʿahd al-Ūrkhānī*, covers several subjects treated in various disciplines including *hayʾa*. His topic from this field is the relative positions of the Sun and Moon, a typical topic one can find in *hayʾa* works.[354] In a similar vein, Qāḍīzāda al-Rūmī, one of the most distinguished scholars of the Samarqand school, was originally from Ottoman Bursa where he received his early education in astronomy. He was a member of the Fanārī circle that emerged around the first Ottoman *shaykh al-Islām*, Mullā Fanārī. It is evident that the *Tadhkira* and the *Mulakhkhaṣ* were studied in this circle. In his encyclopaedic work entitled *Unmūdhaj al-ʿulūm*, Muḥammad Shāh Fanārī, Mullā Fanārī's son, treats several issues drawn from the *Tadhkira*. ʿAbd al-Wājid, in turn, wrote a commentary on the *Mulakhkhaṣ*,

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[353] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:LXXVIII–LXXIX, 24. Cevad İzgi's lists of the *hayʾa* worksthat circulated in Ottoman lands can also be consulted in the same vein. İzgi, *Osmanlı Medreselerinde İlim*, 1:370–412.

[354] İhsan Fazlıoğlu, "What Happened in Iznik? The Shaping of Ottoman Intellectual Life and Dāwūd Qayṣarī," trans. Taha Yasin Arslan, *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 4, no. 1 (2017): 30, 54.

presumably presented to Ottoman Sultan Murad II. The pedagogical aspect of this commentary clearly speaks of its madrasa context.[355]

As mentioned previously in my chapter on Qūshjī's intellectual life, after establishing Constantinople as his new capital, Sultan Meḥmed II embarked on large-scale investments in education by establishing new institutions as well as by inviting scholars from inside and outside of Ottoman lands to the city. Again we are not well-informed regarding the place of astronomy education in post-conquest Istanbul, but some evidence attests to the growing interest in the mathematical sciences in the city. Upon the invitation of the Sultan, Fatḥ Allāh Shirwānī, a member of the Samarqand School, spent many years in Anatolia including Ottoman lands. He wrote his two important *hayʾa* works, entitled *Ḥāshiya ʿalā Sharḥ al-Mulakhkhaṣ fī al-hayʾa* and *Sharḥ al-Tadhkira fī ʿilm al-hayʾa* during this period. Likewise, we have a manuscript of Jurjānī's *Sharḥ al-Tadhkira* that was copied in Istanbul in 868/1463, namely around ten years before Qūshjī's arrival into the city.[356] One should also add that Muslim scholars were not the only community that studied theoretical astronomy in Istanbul during this period. A Hebrew translation of Jaghmīnī's *Mulakhkhaṣ*, entitled *Sefer Mezuqqaq*, was completed by Moses ben Elijah around 1459, only six years after the Ottomans took over Constantinople.[357]

To summarize, if one considers the *hayʾa* texts that were studied in pre-Ottoman and early Ottoman Anatolia, it is clear that Qūshjī's *Fatḥiyya* emerged in an environment wherein a great deal of the works used in the Samarqand school and before were known by

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[355] Ragep, "Astronomy in the Fanārī-Circle," 165–76.
[356] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi,* 1:LXXIX.
[357] Robert G. Morrison, "The Role of Oral Transmission for Astronomy Among Romaniot Jews," in *Texts in Transit in the Medieval Mediterranean*, ed. Y. Tzvi Langermann and Robert G. Morrison (University Park: Pennsylvania State University Press, 2016), 13.

Ottoman scholars. This increasing interest in *hayʾa* and other astral sciences would continue after Qūshjī died.[358] This trend is also compatible with the fact that a number of the *hayʾa* works originated from Persia and Anatolia, the places where Qūshjī's astronomy would flourish.[359]

3.2.3. The Scientific Context: The Content, Sources and Evolution of the *Fatḥiyya*

3.2.3.1. From the *Risālah* to the *Fatḥiyya*: Translating, Revising and Rewriting a Text

In order to understand the evolution of the *Fatḥiyya*, one should also take into consideration its relation to Qūshjī's earlier *hayʾa* work, the *Risālah dar hayʾah*. Qūshjī compiled these works in two different intellectual settings, namely in the Ottoman and Timurid Empires, respectively, and in two different languages. Of course, having *hayʾa* works in both languages was not unique to Qūshjī. For instance, Ṭūsī wrote his Persian astronomical works, namely *Risāla-yi Muʿīniyya* and *Ḥall-i mushkilāt-i Muʿīniyya*, before writing his Arabic work, namely the *Tadhkira*. Another scholar who exhibited this kind of writing practice is Shīrāzī. Recent studies have clearly shown that Shīrāzī makes cross-references across his texts.[360] These examples show the importance of the Persian *hayʾa*

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[358] For example, many valuable copies of significant works in *hayʾa* found their way into the palace library, as evidenced by the catalog of the palace library prepared during the reign of Sultan Bāyazīd II. Ragep et al., "Astronomical and Other Mathematical Sciences in ʿAṭūfī's Inventory of Bāyezīd II's Library," 823-55. As a matter of fact, generally speaking, there was an increasing interest in astral sciences at his court. For the details see, A. Tunç Şen and Cornell H. Fleischer, "Books on Astrology, Astronomical Tables, and Almanacs in the Library Inventory of Bayezid II," *Treasures of Knowledge: An Inventory of the Ottoman Palace Library (1502/3-1503/4)*, ed. Gülru Necipoğlu, Cemal Kafadar, and Cornell H. Fleischer (Leiden: Brill, 2019), 768-821; Şen, "Astrology in the Service of the Empire."
[359] S. P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," 148.
[360] Savadi, "The Historical and Cosmographical Context of *Hayʾat al-arḍ*," 32-33.

corpus and its intimate relationship with the Arabic compositions, but the literature is not yet mature enough to propose extensive claims as to why an author wrote *hayʾa* works in different languages, as well as in what ways they were connected to each other.

In this section, I will address how three *hayʾa* works in three languages, namely Arabic, Persian, and Turkish, associated with Qūshjī's astronomy are connected to each other in terms of their inception and development. These texts are Qūshjī's aforementioned works and Saydī ʿAlī Raʾīs' *Khulāṣat al-hay'a*, an expanded Turkish rendition of Qūshjī's *Risālah*. My main concern will be twofold: First, I will demonstrate that both the *Fatḥiyya* and *Risālah* were revised by Qūshjī over the years, and that the latter Persian text was influential in the formation of the Arabic *Fatḥiyya*. To put it differently, the development of the latter text is better understood when one compares the content of the two texts. I argue that despite important similarities, their divergences have to do not only with the language, content, and audience, but also with Qūshjī's changing intellectual, scientific and pedagogical concerns over the years.

My second focus is Saydī ʿAlī Raʾīs' *Khulāṣat al-hayʾa*. I argue that the adaptation of Qūshjī's astronomical corpus to a Turkish-speaking audience in the mid-sixteenth-century shows how the *Risālah* and the *Fatḥiyya*—and the relationship between them—were received by an Ottoman reader and writer. Yet, I will not look into this interesting case in depth. Rather, I focus on showing how this reception sheds light on the development of Qūshjī's astronomy from the *Risālah* to the *Fatḥiyya*.

First of all, I shall elaborate on how the *Risālah* has at least two versions. The most obvious evidence for the revision of the *Risālah* is in the section on the distances and sizes of the planets. In some copies, the discussion is presented in the 12th chapter of Part 2 on the configuration of the Earth.[361] This is an unconventional ordering, since this subject is covered as a separate Part in many authoritative texts of the discipline, including the *Tadhkira*, *Nihāyat al-idrāk*, and the *Tuḥfa*. Because of this unconventional feature, some copies of the *Risālah* label this chapter as the "Conclusion (*khātimah*)."[362] Among the copies I have examined, two of them entitle this chapter as Part (*maqāla*) 3, which parallels the structure of the aforementioned works.[363] I have not found any proof in the copies themselves that may indicate whether the changes were made by Qūshjī himself. However, the most significant change with respect to this subject is that this chapter is not included in the earliest extant copy of the *Risālah* (Ayasofya, 2640), and many other copies do not include it either.[364] The lack of the chapter in question in the important Ayasofya copy and other copies was also pointed out by Tofigh Heiderzadeh in his master's thesis on Qūshjī's astronomical works.[365]

In my view, Qūshjī's concern in the first version of the *Risālah* was the same as Jaghmīnī's in the *Mulakhkhaṣ*. As Qāḍīzāda points out in his *Sharḥ al-Mulakhkhaṣ*, Jaghmīnī does not cover the distances and sizes of the planets since it is a difficult topic to cover in depth in a pedagogical text.[366] Likewise, Qūshjī's initial intention for the *Risālah* seems to also have been pedagogical. However, as I have mentioned before, the lack of this subject

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361 ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hay'ah,* Beyazıt Manuscript Library, Veliyyüddin Efendi Collection, MS 2306, ff. 37a-38a.

362 For instance, see, ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hay'ah*, British Library, Oriental Manuscripts, MS 23569, ff. 44b-46a; Oxford University Bodleian Library, Oriental Manuscripts, MS Greaves 21, ff. 32b-65a. The following copy, in turn, writes it as "Supplement (*tatimmah*)." Beyazıt Manuscript Library, Veliyyüddin Efendi Collection, MS 2307, ff. 20b-21a.

363 ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hay'ah*, Süleymaniye Manuscript Library, Esad Efendi Collection, MS 2023, ff. 129a-130b; Kütahya Vahid Paşa Manuscript Library, Vahid Paşa Collection, MS 797, f. 28b.

364 ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hay'ah,* Ayasofya, MS 2640, ff. 1b-24b; Süleymaniye Manuscript Library, Ayasofya Collection, MS 2639, ff. 2b-84a; Süleymaniye Manuscript Library, Nuruosmaniye Collection, MS 4913, ff. 304b-331a.

365 Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 36.

366 F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:500.

was not compatible with the post-Ṭūsī *hayʾa* literature, whose outline was based on a four-part structure that includes the distances and sizes of the planets. Therefore, when revising the *Risālah*, Qūshjī seems to have decided to follow this precedent by adding this subject. Yet it should be noted that his treatment thereof is quite simple and short compared to the same section in the *Fatḥiyya*, let alone to that of other *hayʾa* works.[367] This is consistent with the assumption that his aim in the *Risālah* was pedagogical.

Given these possible motivations for the revision, is it possible to speculate when he might have written the *RIsālah*? It goes without saying that this can be answered conclusively only after examining all of its extant copies in an extensive and comparative manner. Yet, in order to promote further research on the *Risālah*, I shall propose a tentative date on the assumption that the sources I have used can yield a viable and defensible hypothesis.

The first thing to be noted is that the first version of the *Risālah*, namely the one without the chapter on the distances and sizes of the planets, seems to have been in wide circulation, since it was this version that Muṣliḥ al-Dīn al-Lārī most likely used in his commentary, which was completed sometime between 1530 and 1556 at the Mughal court of Humāyūn (d. 963/1556). This is because this commentary also lacked the pertinent chapter. For this reason, in some later copies of this commentary, this chapter was appended to the text without commentary.[368] Given the fact that the intellectual connection between the Timurid and Mughal intellectual settings was strong, and that al-Lārī used the

[367] See the Third Part in my commentary chapter for a comparison of the relevant chapters in the *Risālah* and *Fatḥiyya*.
[368] For example, see, Muṣlih al-Dīn al-Lārī, *Sharḥ-i Risālah dar hayʾah*, Süleymaniye Manuscript Library, Ragıp Paşa Collection, MS 926, ff. 61a-61b; Beyazıt Manuscript Library, Veliyyüddin Efendi Collection, MS 2307, ff. 84b-85a.

first version, it is possible that Qūshjī made the revision after he left Timurid lands. In line with this argument, a copy in the first version was copied in Shiraz in Ramaḍān 878/January-February 1474 when Qūshjī was in Istanbul.[369]

More curiously, there is also evidence drawn from some *Risālah* copies that leads us to consider the possibility that this revision was made in the Ottoman context. A copy of the *Risālah* (Ayasofya, 2639) does not include the chapter in question. The importance of this copy stems from the fact that it was held in the palace library in the late fifteenth-century, as it was stamped with Bāyazīd II's seal on the cover page. A beautifully painted medallion is also seen on the cover page, which has the following phrase: "This treatise in *hayʾa* was written by our Master ʿAlī al-Qūshjī, May God the Exalted protect him (*Hādhihi al-risāla fī al-hayʾa allafahu mawlānā ʿAlī al-Qūshjī sallamahu Allāh taʿālā*)."[370] The important clue here is that by stating "May God protect him" instead of "May God have mercy upon him (*raḥimahu Allāh*)," the phrase suggests that during the preparation of this medallion, Qūshjī was still alive. In other words, this copy seems to have found its way into the palace library during the reign of Sultan Meḥmed II, presumably as a gift by Qūshjī upon his arrival in Istanbul. Equally important, there is a copy, based on the second version of the *Risālah*, that was copied almost at the same time as the compilation of the *Fatḥiyya*.[371] Thus it is clear that when Qūshjī was alive under Ottoman patronage, both versions were in circulation. The fact that the volume presented to the royal library is a copy of the first version leads us to hypothesize that the text was revised around the time of the compilation of the *Fatḥiyya*.

[369] ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hayʾah*, Nuruosmaniye, MS 4913, f. 331a.
[370] ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hayʾah*, Ayasofya, MS 2639, f. 2a.
[371] ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hayʾah*, Esad Efendi, MS 2023, f. 130b.

In fact, the writing process of his Arabic *hayʾa* work might have stimulated Qūshjī's revision of the Persian *Risālah*.

I have presented evidence for the possible revision of the *Risālah* during Qūshjī's life under the Ottomans. However, I should also add that there is one puzzling situation that challenges my hypothesis. As one can consult in my commentary chapter, the parameters used in the *Risālah* for the distances and sizes of the planets are based on Kāshī's *Sullam al-Samāʾ*, whereas those in the *Fatḥiyya* are completely different, apparently drawn from his own calculations. If we assume that the *Risālah*'s second version was prepared during almost the same period as the *Fatḥiyya*, why are their parameters different? Again, without an extensive study of all the *Risālah* copies, it is hardly possible to answer this question.

One of the most striking differences between the *Risālah* and *Fatḥiyya* is related to Qūshjī's patronage relations. While the *Fatḥiyya* was dedicated to Sultan Meḥmed II, all of the *Risālah* copies I examined, including the earliest one that bears the date of 862/1458, do not have a dedication section. It is quite intriguing given the fact that Qūshjī dedicated his *Sharḥ al-Tajrīd* to the Timurid Sultan Abū Saʿīd around the same period. Moreover, we know that Qūshjī dedicated several other works to his patrons including Ulugh Beg, Abū Saʿīd, and Meḥmed II. An extensive study of the *Risālah* is needed to resolve the dedication issue; but the possibility that the *Risālah* does not have a dedicatee should stimulate further questions regarding the nature of his patronage relationships, as well as intellectual and political circumstances within which the text was produced in Timurid lands.

As for the relation between the *Risālah* and *Fatḥiyya*, according to Adnan Adıvar, the author of the first book on Ottoman science, the latter work is nothing but the Arabic translation of the former. According to him, the only difference is that the *Fatḥiyya* includes a Part on the distances and sizes of the planets.[372] As mentioned before, the *Risālah* has at least two versions, the latest of which covers that subject as well. Thus it is likely that the copy Adıvar consulted was a copy of the first version, which misled him in his conclusion regarding the outline of the *Risālah*. That being said, Adıvar rightly points out that Qūshjī benefitted from the *Risālah* extensively while preparing the *Fatḥiyya*. In the following lines, I will present three major processes through which the *Risālah* was used in the service of composing the *Fatḥiyya*, namely translation, revision, and rewriting the text. Given the fact that a critical edition of the *Risālah* has yet to be prepared, rather than embarking on an extensive comparison of these works, my concern here is to present a general picture regarding their interplay so that one can make more sense the development of the *Fatḥiyya*.

Among the three processes I have listed, the most obvious one is that Qūshjī translated a great deal of the *Risālah* when compiling the *Fatḥiyya*. A quick glance at the titles of the chapters in both of the works confirms this. That is to say, Qūshjī drew on the general structure of the *Risālah* in his Arabic *hayʾa* project. As I have shown in the "Editorial procedures" section of this dissertation, there are three versions of the *Fatḥiyya* upon which my critical edition is based. In addition to this, as far as Qūshjī's astronomy in general is concerned, we must consider the various *Risālah* versions as part of the development of the *Fatḥiyya*. As a result, in my commentary chapter, I make references to the *Risālah* quite a few times to explicate the *Fatḥiyya*. Nevertheless, one should keep in mind that a comprehensive comparison is possible only after a critical edition of the *Risālah* is established.

[372] Adıvar, "Ali Kuşçu," 321–23.

There are examples that indicate the *Fatḥiyya* was more than a mere translation of the *Risālah*. Qūshjī made many revisions to the content and structure of the *Risālah* while adapting it to the Arabic corpus. The most obvious example of these revisions is found in the Introduction. While the *Risālah*'s Introduction includes two chapters, one pertaining to geometry and the other to natural philosophy, the *Fatḥiyya*'s Introduction comprises only geometry. The meaning of this omission will be treated later, but for the time being it can be stated that it has to do with how Qūshjī understands the role of natural philosophy in a *hayʾa* work. Moreover, the geometry section of the *Fatḥiyya* is broader in that it also introduces topics that are not covered in the *Risālah*, such as the cone and basic trigonometric terms. Equally important, he changes the definition of some terms such as the point.[373] We also observe that in the *Fatḥiyya*, Qūshjī excludes some figures found in the *Risālah* or adds new ones.[374] Apart from these, Qūshjī also changes the order of presentation. The chapters in the *Risālah* such as "On an Explanation of the Co-ascendant (*maṭāliʿ al-burūj*) [II.6]," "On the Degrees of Transit of the Stars [II.7]," "On Dawn and Dusk [II.8]," "On Epochs, Months, Years and Their Parts [II.9]," "On Shadows [II.10]" are reorganized in the *Fatḥiyya*. Qūshjī also revises their contents either by shortening or expanding them.

As mentioned above, one of the most striking differences between the *Risālah* and the *Fatḥiyya* is on the subject of the distances and sizes of the planets. The values given in each text are completely different. While the *Risālah* relies mostly on Kāshī's *Sullam*, the *Fatḥiyya*'s values are different from both the *Sullam* and *Tadhkira*, although its structure in this Part is taken from the latter. More curiously, , Qūshjī replaces values he calculated in

[373] See Intro.[1] in the commentary chapter.
[374] As examples, see II.1.[3] and II.6 in the commentary chapter.

the first version of the *Fatḥiyya* with new ones in the other versions.[375] This is a good example of how Qūshjī would rewrite entire sections. The result of this is that the *Fatḥiyya*'s account of the same topic is completely different, not only in terms of structure, which relies heavily on *Tadhkira*, but also in terms of the parameters used.

Another significant example of the relation between the *Risālah* and *Fatḥiyya* is seen in the case of the *Khulāṣat al-hayʾa*, an expanded Turkish translation of "Qūshjī's work" by Saydī ʿAlī Raʾīs (d. 970/1562), an Ottoman admiral who produced works on theoretical, practical and naval astronomy. Written in 955/1548 in Aleppo, it was presented to Sultan Süleyman (d. 974/1566). Saydī ʿAlī Raʾīs explains his motivation for preparing this work in the introduction, which is quite interesting in view of the development of *hayʾa* literature in the Turkish language. Saydī ʿAlī Raʾīs participated in one of Sultan Süleyman's campaigns. When the army was spending the winter in Aleppo, Saydī ʿAlī Raʾīs studied astronomy with a local scholar named Ḥamd Allāh b. Shaykh Jamāl al-Dīn.[376] This scholar suggested that he translate "Qūshjī's work" in *hayʾa* into Turkish. Saydī ʿAlī Raʾīs neither gave the title of Qūshjī's work, nor did he reveal which texts he studied with this scholar.[377] Yet, given the fact that this scholar mentioned Qūshjī's work, it is likely that the suggested work was in circulation in Aleppo and its surrounding intellectual milieus. Now Saydī ʿAlī Raʾīs seems to suggest that his *Khulāṣat al-hayʾa* was the first work in Turkish in this genre; but we know that this is not the case, since the catalog of books in the palace library completed in

[375] For further details, see Part III in the commentary chapter.
[376] This campaign should be the one against the Safavids, during which the Sultan spent his winter in Aleppo. For the details see, Feridun Emecen, "Süleyman I," in *TDV İslâm Ansiklopedisi*, vol. 38 (Istanbul: TDV Yayınları, 2010), 68–69.
[377] Saydī ʿAlī Raʾīs, *Khulāṣat al-hayʾa*, Süleymaniye Manuscript Library, Aşir Efendi Collection, MS 223, 2a.

909/1503-4 lists a Turkish translation of Jurjānī's *Sharḥ al-Mulakhkhaṣ*.[378] Moreover, Qūshjī's *Risālah* was earlier translated into Turkish by Parwīz ʿAbd Allāh under the title of *Mirqāt al-samāʾ* in 934/ 1527-28.[379]

There has been an assumption in the literature that Saydī ʿAlī Raʾīs' work is a translation of the *Fatḥiyya*.[380] However, a general comparison of the outline of this work to that of the *Fatḥiyya* and *Risālah* shows that this expanded translation was based on the latter. This is attested by Süheyl Ünver in his monograph on Qūshjī, where he also implies that Saydī ʿAlī Raʾīs' work is based on Qūshjī's Persian *hayʾa* text. But in what seems to be puzzling, he introduces this text as a translation of the *Fatḥiyya*. Ünver's study shows that he grasped the differences between the *Fatḥiyya* and *Risālah* as well as their relationship; however, he seems have occasionally used the title *Fatḥiyya* for both works, under the assumption that it is a general title for Qūshjī's scholarship on *hayʾa*. For example, he calls the *Risālah* the "Persian [version] of the *Fatḥiyya*." However, such an assumption makes it difficult to follow his account.[381]

In my opinion, this misunderstanding regarding the *Khulāṣat al-hayʾa* and the *Fatḥiyya* was never rectified because of three main reasons. First, as mentioned above, Adnan Adıvar in his *Osmanlı Türklerinde İlim*, the first comprehensive work on Ottoman

378 Ragep et al., "Astronomical and Other Mathematical Sciences in ʿAṭūfī's Inventory of Bāyezīd II's Library," 835.

379 For further details about this author, see İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:189–91.

380 Adıvar, *Osmanlı Türklerinde İlim*, 72-73; Fazlıoğlu, "Qūshjī: Abū Al-Qāsim ʿAlāʾ Al-Dīn ʿAlī Ibn Muḥammad Qushči-zāde," 946–48; Mahmut Ak, "Seydi Ali Reis," in *TDV İslâm Ansiklopedisi*, vol. 37 (Istanbul: TDV Yayınları, 2009), 22. In her master's thesis dealing with the *Khulāṣat al-hayʾa*, Uymaz also assumes it to be a translation of the *Fatḥiyya* and evaluates it accordingly. See, Uymaz, "Seydî Ali Reis'in Hülâsa El-Hey'e," 13.

381 Ünver, *Ali Kuşci (Hayatı ve Eserleri)*, 45–48. A similar case is seen in the *History of Astronomy Literature During the Ottoman Period* (OALT). While it presents the *Khulāṣat al-hayʾa* as the translation of the *Risālah* in its introductory chapter that provides general observations on Ottoman astronomy based on the data drawn from its catalog, it is introduced as the translation of the *Fatḥiyya* under its entry on Qūshjī. İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:CXXXIII, 34–35. On the other hand, *Khulāṣat al-hayʾa* is introduced as "the revision of" the *Risālah* in the catalog published by Rosenfeld and İhsanoğlu. Rosenfeld and İhsanoğlu, *Mathematicians, Astronomers, and Other Scholars*, 325.

science, presents *Khulāṣat al-hayʾa* as the translation of the *Fatḥiyya*. Subsequent historians seem to have taken this assumption for granted. Second, since the *Fatḥiyya* was written in the Ottoman context, there has been a tendency to link any derivative text produced in the Ottoman context to the *Fatḥiyya*. To put it differently, the *Fatḥiyya*'s popularity in modern scholarship on Ottoman science has overshadowed the significance of the *Risālah* even for Ottoman astronomy. Third, as discussed above, the relationship between the *Risālah* and *Fatḥiyya* has yet to be examined in detail in the literature.

As Saydī ʿAlī Raʾīs states in his introduction, the *Khulāṣat al-hayʾa* is not a word-by-word literal translation of "Qūshjī's work" but an expanded one, drawing on several works including Qāḍīzāda's *Sharḥ al-Mulakhkhaṣ*, Shīrāzī's *Nihāya*, and Jurjānī's *Sharh al-Tadhkira*. However, another aspect of his translation is more intriguing. As I will discuss shortly, *Khulāṣat al-hayʾa* is a reconstructed work that also uses the *Fatḥiyya* through Mīrim Chalabī's commentary. In other words, Saydī ʿAlī Raʾīs not only translated the Persian text, but also revised and expanded it substantially using these additional works. As a result, it leaves no doubt that Saydī ʿAlī Raʾīs was aware of the difference between the *Fatḥiyya* and *Risālah*. Equally important, this Ottoman scholar preferred to use the Persian *hayʾa* work as the basis of his text, instead of the Arabic one which was written in the Ottoman context. Although we don't know why the *Risālah* was chosen, the decision strongly indicates that by the sixteenth-century it was studied in Aleppo and other parts of the Ottoman Empire. Consistent with this statement is the striking fact that the number of available *Risālah* copies in Turkish collections—not to speak of the collections in former Ottoman territories—is twice the total number of all available *Fatḥiyya* copies.[382]

Saydī ʿAlī Raʾīs follows three methods in rendering Qūshjī's *Risālah* into Turkish: First, he translated a great deal of the *Risālah* literally. Second, by using other *hayʾa* sources including Mīrim Chalabī's commentary on the *Fatḥiyya*, he explains parts of the original text and adds new content. In this respect, Saydī ʿAlī Raʾīs behaves like a commentator of the *Risālah*. To give an example, at the end of his commentary, Mīrim Chalabī adds Kāshī's tables for the sizes and distances of the planets in the *Sullam*; Saydī ʿAlī Raʾīs appends these tables to his work, explicitly referencing Mīrim Chalabī as his source. Likewise, *Khulāṣat al-hayʾa*'s chapter on the distances and sizes of the planets is much longer than that of the *Risālah*, relying mostly on Kāshi's parameters. One should be reminded that these tables are not included in the *Fatḥiyya* and the *Risālah*.[383]

The third and most interesting methodology is that he revises the text if he thinks that the information given in the *Riṣālah* should be omitted or replaced by that in the *Fatḥiyya*. For instance, in the *Risālah*, the difference between the numbers of daytime and night beneath the northern pole is given as seven days, as is the case in *Tadhkira*. However, Saydī ʿAlī Raʾīs adopts the value in the *Fatḥiyya*, which is nine days.[384] As I have pointed out in the commentary chapter, Ṭūsī's value is generally regarded "as a slip of the pen" by the *Tadhkira* commentators, and Qūshjī corrected the value included in the *Risālah* when

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[382] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*, 1:30–35. See also the "Editorial Procedures" for further information about the available *Fatḥiyya* copies.
[383] Saydī ʿAlī Raʾīs, *Khulāṣat al-hayʾa*, Aşir Efendi, MS 223, 38b-40b.
[384] Ibid, 28b.

writing the *Fatḥiyya*.[385] Saydī ʿAlī Raʾīs was aware of this issue thanks to Mīrim Chalabī's commentary and took the *Fatḥiyya* as its source for this value.

Generally speaking, the case of *Khulāṣat al-hayʾa* reveals that both the *Risālah* and *Fatḥiyya* with its commentary by Mīrim Chalabī were in circulation in the Ottoman context, although they attracted varying attention. Additionally, *Khulāṣat al-hayʾa* also indicates that Ottoman scholars like Saydī ʿAlī Raʾīs were cognizant of the relationship between Qūshjī's writings. This is also evidenced by the inter-linguistic practice in the study of Qūshjī's astronomy in the early modern period. A *Fatḥiyya* copy might include marginal notes from Lārī's commentary on the *Risālah*, whereas a *Risālah* copy might include marginal notes from Ghulam Sinān's commentary on the *Fatḥiyya*.[386] In conclusion, one should emphasize again that the development and reception of the *Fatḥiyya* are better understood in relation to Qūshjī's other astronomical works as well as their derivative texts produced or used in the Ottoman context and beyond.

3.2.3.2. The Content and Sources of the *Fatḥiyya*

This section aims to present briefly the content and sources of the *Fatḥiyya* and contextualize its intervention into the *hayʾa* literature. I argue that this will give insight into Qūshjī's intention in compiling this new work. I aim to demonstrate that while Qūshjī benefits greatly from his predecessors, his elementary-level textbook brings about a new synthesis of the earlier authoritative and contemporaneous astronomical works.

[385] See my translation and commentary for the relevant passage in II. 5.[2].
[386] ʿAlī al-Qūshjī, *Risālat al-Fatḥiyya*, Süleymaniye Manuscript Library, Halet Efendi Collection, MS 538, 1b-69b; ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hayʾah*, Beyazıt Manuscript Library, Veliyyüddin Efendi Collection, MS 2306, ff. 1b-38a.

In the previous section, I have dealt with the *Risālah* as one of the main sources of the *Fatḥiyya*. It is important then to first identify the sources of the former work. In his thesis, Tofigh Heiderzadeh argues that when composing the *Risālah*, Qūshjī benefited extensively from Ṭūsī's *Risāla-yi Muʿīniyya*. Additionally, he offers an assertion based on a linguistic criterion: the Persian *Risālah* is connected to the Persian *Muʿīniyyah*, just as the Arabic *Fatḥiyya* is influenced by the Arabic *Tadhkira*.[387] While this observation is a good starting point for establishing the *Fatḥiyya*'s connections to earlier texts, there are other works that are influential in the making of the *Fatḥiyya*.

First of all, the *Fathiyya*'s composition is motivated by a similar concern as that of the *Mulakhkhaṣ* and the *Tadhkira*. Qūshjī defines his work as "small in words, large in meaning, diminutive in volume, great in signification."[388] In other words, he wanted to write a concise textbook, unlike, for instance, Shīrāzī's *Nihāya* which was intended as an advanced work. As discussed earlier, the *Tadhkira* and the *Mulakhkhaṣ* were by far the most widely studied works in theoretical astronomy during the pre-modern period. Thus, it would not be an exaggeration to say that these two texts with their derivative works formed two main clusters in astronomy education.[389] Some scholars such as Jurjānī wrote a commentary on each of them. Given the central function of commentaries in post-classical education, it is likely that Jurjānī taught both of the texts during his career.

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[387] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 26–38.
[388] See the Preface in the translation of the *Fatḥiyya*. In line with Qūshjī's concern, Jaghmīnī wanted his book to be "both an abridgement and exposition, and combining a succinctness of words with an elucidation of meanings," S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 84–85. Ṭūsī expresses a similar approach as follows: "The scientific exposition that we wish to undertake will be a summary account of this presented in narrative form." F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:92–93.
[389] Sally Ragep's observation is also in the same direction: "Both the *Mulakhkhaṣ* and the *Tadhkira* undoubtedly played key roles in disseminating the teaching of theoretical astronomy throughout Islamic lands for generation of scholars." S. P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," 153.

When I say the *Mulakhkaṣ* and *Tadhkira* represent two clusters in the education of *hayʾa*, I do not deny their overlapping characteristics in terms of structure and content. My point is that their diverging aspects played a central role in the formation of what I prefer to call their clusters. Robert Morrison has identified an intriguing characteristic of their respective textual traditions that can be described as forming clusters of astronomical research. According to him, commentaries and glosses on the *Mulakhkhaṣ* do not deal with the non-Ptolemaic models proposed by the astronomers affiliated with the Maragha Observatory, although some works in the *Mulakhkhaṣ* tradition "pointed out the problems with Ptolemaic astronomy that led to the production of new models."[390] Relying on Morrison's observation, it can be said that the *Fatḥiyya*'s approach is closer to the *Mulakhkhaṣ* in the sense that while Qūshjī proposes non-Ptolemaic models in his separate treatises, he does not incorporate them into his *Risālah* or *Fatḥiyya*. That being said, one should also note that he aims to make his reader aware of the controversial issues in the Ptolemaic system. In Chapter 6 entitled "On What Occurs to the Planets," Qūshjī writes the phrase, "this is among the difficulties in this discipline," several times after explaining contentious issues in the Ptolemaic system.

Moreover, I argue that the making of the *Fatḥiyya* has strongly to do with Qūshjī's selective approach to the *Tadhkira*, *Mulakhkhaṣ*, and Shīrāzī's works, especially the *Tuḥfa*, in accordance with his astronomical background and understanding of *hayʾa*. That being said, along with the large role the *Tadhkira* and *Mulakhkhaṣ* played in the formation of the *Fatḥiyya*, Qūshjī also benefitted from the astronomical literature that was produced after Ṭūsī. In this respect, one might ask about the role of the commentaries written on the

[390] Morrison, "The Role of Oral Transmission for Astronomy Among Romaniot Jews," 14.

Mulakhkhaṣ and *Tadhkira* in the formation of the *Fatḥiyya*. As mentioned in the previous chapter, a number of other astronomical and mathematical texts were used in the Samarqand school. Thus, a more nuanced examination of the debt the *Fatḥiyya* owes to the earlier *hayʾa* literature must also take into consideration the major commentaries belonging to the *Mulakhkhaṣ* and *Tadhkira* clusters. This is particularly relevant since Qūshjī studied and taught many of these texts. Although I do not dismiss possible influences of these commentaries on the development of the *Fatḥiyya*, except for a few references to the commentary tradition, I focus largely on the main texts. Despite possible connections the *Fatḥiyya* may have to various commentaries, the main purpose of the composition is to present scientific content in the structure and limits of an original *hayʾa* composition.[391] Therefore, within the scope of this dissertation, I prefer to compare the *matn*s in the first place.

Before starting my comparison of the *Fatḥiyya* with other texts, we must note the important fact that only around 16 months separated the compilation of the first version of the *Fatḥiyya* and Qūshjī's death. It is during this relatively short period that the *Fatḥiyya* underwent constant revisions that took the form of the three versions of the text we now have. My critical edition relies heavily on this fact. I argue that by showing the differences between the versions, we will be able to infer Qūshjī's motivations in revising the text.

As far as the nature of these revisions is concerned, there are various reasons for them, such as correcting grammatical errors or wrong information, adding further information, rewriting for the clarification of obscure statements, cleaning up redundant

[391] For various functions of commentaries with respect to Ibn Sīnā's *Ishārāt* and its commentaries, see Robert Wisnovsky, "Avicennism and Exegetical Practice in the Early Commentaries on the Ishārāt," *Oriens* 41 (2013): 349–78.

phrases, reordering chapters, and changing parameters. One can consult the critical edition and translation for Qūshjī's revisions, but in order to highlight the dynamic process of writing and teaching a *hayʾa* text in the fifteenth-century, I shall describe one example of such revision. In the Third Part, which is on the sizes and distances of the planets, Qūshjī uses the values he calculated himself, instead of borrowing from earlier texts. Despite this, Qūshjī revises those found in the first version of the *Fatḥiyya* substantially, and as a result Qūshjī used two sets of parameters in that Part. I have not been able to detect the possible source of this revision, but it is definitely worth investigating to better understand how a *hayʾa* writer compiled his work.

Like the *Tadhkīra*, the *Fatḥiyya* follows the four-part outline. It includes an Introduction, three Parts devoted respectively to the configuration of the celestial bodies, configuration of the Earth, and distances and sizes of the celestial bodies and the Earth. In contrast to this, the *Mulakhkhaṣ* does not cover the last subject. This is a major difference between the *Mulakhkhaṣ* and *Tadhkira* traditions. Now the first version of Qūshjī's *Risālah* follows the structure of the *Mulakhkhaṣ* as it does not cover the distances and sizes of the celestial bodies. However, this section makes an appearance in the *Risālah*'s second version, albeit in shorter form, and in the *Fatḥiyya*. This indicates that Qūshjī decided to follow the *Tadhkira* tradition of *hayʾa* books at a later point in his life.

As far as the Introduction of the *Fathiyya* is concerned, it is remarkably different from both the *Tadhkira* and *Mulakhkhaṣ*. On the one hand, unlike the Introductions of the *Tadhkira* and Qūshjī's *Risālah*, which cover two sections, one for geometry and the other for natural philosophy, the *Fatḥiyya*'s Introduction only includes an explanation of geometrical terms related to *hayʾa*. On the other hand, this approach also diverges from the *Mulakhkhaṣ*, which does not cover geometrical principles in its introduction. The *Mulakhkhaṣ* addresses only selected issues in natural philosophy. Later in this chapter, I will address the significance of Qūshjī's omission of the section on natural philosophy in the *Fatḥiyya* and how radical it is compared to his *Risālah*. But one thing to note here is that the *Fatḥiyya*'s Introduction is Qūshjī's major intervention in the history of *hayʾa* literature, which has largely included an introductory section on natural philosophy.

The number of chapters in Part 1 ("On an Explanation of the Circumstances of the Celestial Bodies Comprising Six Chapters") in the *Fathiyya* (i.e. six chapters) shows that its general structure is closer to the *Mulakhkhaṣ* (which has five chapters, compared to the *Tadhkira*'s 14). Despite this, the *Tadhkira*'s influence can be seen in some chapters. For instance, the naming and ordering of Chapter 2 and 3 in the *Fatḥiyya* ("On the Well-Known Great and Small Circles, and the Well-Known Arcs" and "On Explaining the Configuration of the Ninth and Eighth Orbs, Their Motions, and the Manner of the Division of the Eighth Orb into Zodiacal Signs and an Account of a Few Situations Regarding the Fixed Stars") resonate with the relevant chapters in the *Tadhkira*. However, there are also chapters in which the presentation of the subject follows the structure of the *Mulakhkhaṣ*. An obvious example is Chapter 6 on the various motions of the planets. In the *Tadhkira*, chapters are designed with respect to the planets; each chapter treats the configuration of the orbs and longitudinal motions of the relevant planet(s) together. On the contrary, the *Mulakhkhaṣ* introduces the configurations of the orbs for all the planets in one chapter and their various motions in another.

If we turn our attention to Part 2 ("On an Explanation of the Configuration of the Earth and Its Divisions into Climes; An Explanation of [the Consequences] Accruing to it

Due to the Positions of the Celestial Bodies") and Part 3 ("On Finding the Measurements of the Distances and the Bodies"), the *Tadhkira* has a decisive influence on the outline of the *Fatḥiyya*. Besides this, one can observe several passages from the *Tadhkira* included in the *Fatḥiyya verbatim*. However, Qūshjī rearranges some chapters and adds new ones. For instance, the topics covered in the *Tadhkira* such as "On the Lengths of the Nychthemerons (III.8)," "On Dawn and Dusk (III.9)," and "On Understanding the Units of the Day, Namely Hours, and What is Composed of Days, Namely Months and Years (III.10)" are treated altogether in one chapter in the *Fatḥiyya* under the title of "On the Nychthemerons, Their Daytime and Nighttime Parts, Equal and Unequal Hours, and Dawn and Dusk (II.6)." That being said, the most discernible difference between the two texts is observed in *Fatḥiyya*'s chapter entitled "On the Months, Years, and Epochs (II.7)." The subject of the epoch is not covered in the *Tadhkira*, but one can see an extensive account of it in Shīrāzī's *Tuḥfa* (III.11) and *Nihāya* (III.10). Moreover, when comparing the section in the *Fatḥiyya* to Shīrāzī's works, it is fairly clear that Qūshjī consulted Shīrāzī's scholarship on the subject. This is a significant example of how Qūshjī engaged with the post-Ṭūsī *hayʾa* literature when composing his works.

Another noteworthy difference between the *Fatḥiyya* and *Tadhkira* can be seen in the Introductory Chapter of Part 3. Entitled "Concerning That Which is Needed by Way of Introduction before Undertaking [Our] Objectives (III.Intro)," Qūshjī introduces a list of geometrical and mathematical propositions needed to calculate the sizes and distances of the planets. Ṭūsī in the *Tadhkira* also expresses the necessity of basic geometrical propositions before treating the same subject; yet he only presents propositions that pertain to the circumference and area of a circle and sphere, as drawn from Archimedes' propositions.[392] What is notable is that the *Tuḥfa* also introduces propositions including most of those found in the *Fatḥiyya*.[393]

Moving on from the structure to the content of the *Fatḥiyya*, I have argued that Qūshjī primarily benefits from the *Risālah*, *Mulakhkhaṣ*, *Tadhkira, Tuḥfa* and *Nihāya.* As I have shown in my commentary chapter, some discussions in the *Fatḥiyya* can be traced to Qāḍīzāda's *Sharḥ al-Mulakhkhaṣ* and *Sharḥ Ashkāl al-taʾsīs*, as well as Jurjānī's *Sharḥ al-Tadhkira*, among others. For instance, as Ghulam Sinān remarks, Qūshjī's parallax theory given in the *Fatḥiyya* is mainly inspired by Jurjānī's views on the subject in his *Sharḥ al-Tadhkira*.[394] However, another noteworthy source of the *Fatḥiyya*—and also of the *Risālah*—is *Zīj-i Ulugh Beg*, which he refers to several times as "the New Astronomical Handbook (*al-zīj al-jadīd*)". Qūshjī provides various parameters pertaining to the positions and motions of the planets, and occasionally expresses that they are based on "our observation (*raṣadunā*)" or *Zīj-i Ulugh Beg*.[395] That Qūshjī emphasizes his role in the Samarqand observations and in the preparation of the *Zīj-i Ulugh Beg* should stimulate further study on the nature of his contributions to Ulugh Beg's project. One should also note that Qūshjī also wrote a commentary on *Zīj-i Ulugh Beg*.

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[392] F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 1:310–11. See also my commentary chapter (III.Intro.[1]).
[393] Shīrāzī, *Al-Tuḥfa al-shāhiyya,* Köprülü Manuscript Library, Fazıl Ahmed Paşa Collection, MS 927, ff. 98b-100b. In fact, Qūshjī's engagement with Shīrāzī's scholarship deserves further investigation, especially with respect to how a scholar associated with the Maragha Observatory and its networks of scholars was received by a scholar affiliated with the Samarqand observatory and madrasa. In addition to the fact that Qūshjī benefits from Shīrāzī's *Tuḥfa* in his *Fatḥiyya* project, Qūshjī had a partial commentary on the same work of Shīrāzī. As I have pointed out in the commentary chapter (I.4.[1]), Ghulām Sinān reports that Qūshjī touched upon Shīrāzī and his *Tuḥfa* in a lecture. Jamil Ragep also notes Qūshjī's critical engagement with Shīrāzī's astronomy in several subjects, remarking that he makes quotations from Sḥīrāzī's *Tuḥfa* in *Sharḥ al-Tajrīd*. F. J. Ragep, "ʿAlī Qushjī and Regiomontanus," 359–71; F. J. Ragep, "Ṭūsī and Copernicus," 150, 154–60.
[394] For the details, see I.6.3.[1] in the commentary chapter.
[395] As examples see I.6.2.[8] and III.5.[1] in the Critical Edition and Translation.

Qūshjī's references to *Zīj-i Ulugh Beg* are not confined to the parameters, but also to the calculating methods used in the *Zīj* to derive parameters. One striking example is that in the section that introduces the mean and true positions, as well as the equations, Qūshjī tells us that there are two methods to calculate them, one of which was the "preferred" approach in the *Zīj* for its ease of use. One wonders why Qūshjī wanted his reader to know such subtle details related to the *Zīj-i Ulugh Beg*. Similar observations on the *Risālah* are also made by Heiderzadeh. According to him, the aforementioned method given in the *Zīj-i Ulugh Beg* is explained in the *Risālah* so well that "one can even prepare ephemerides by oneself" by consulting the method presented here and a *zīj*.[396] Considering this, it might be noted that investigating Qūshjī's approach to the relationship between the *hayʾa basīṭa*, the subfield to which the *Risālah* and the *Fatḥiyya* belong, and the *zīj* literature has the potential to uncover aspects of the history of *hayʾa* after the establishment of the Samarqand school.

To sum up, Qūshjī draws extensively on the *Mulakhkhaṣ* and *Tadhkira* in terms of the structure of the *Fatḥiyya* and the division of its chapters. Further, one can also see remarkable traces of Shīrāzī's scholarship in it. In addition to these sources, one can see the influence of other works that were studied or produced in the Samarqand context. Additionally, it is remarkable that Qūshjī used parameters derived from *Zīj-i Ulugh Beg,* which was considered the most up-to-date astronomical handbook of his time. I shall reiterate that when Qūshjī was preparing his own elementary level textbook, he was not only engaging with the most authoritative texts of the field in a critical way, but was also offering his conception of *hayʾa*, as typically seen in the Introductory Part of the text. In this

[396] Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 34.

sense, Qūshjī's *Fatḥiyya* can be regarded as part of "a period of innovations in theoretical as well as observational astronomy," which was initiated in Samarqand under the commission of Ulugh Beg.[397] The text therefore reflects innovative approaches in both theoretical and observational astronomy that flourished in the Samarqand School. In this sense, Qūshjī's *Fatḥiyya* project might be defined as a new synthesis of post-classical theoretical astronomy for a new intellectual setting, namely Ottoman Istanbul.

3.2.4. __General Characteristics of the Fatḥiyya__

3.2.4.1. __A Hay'a Project without Natural Philosophy__

In a 2001 article, F. Jamil Ragep shows that Qūshjī in his *Sharḥ al-Tajrīd* defends the idea that principles drawn from Aristotelian natural philosophy (*al-falāsifa*) and metaphysics are not needed in the science of *hay'a*. According to Qūshjī, one can establish this science without having to follow the "common practice" of presenting physical principles before delving into astronomical issues.[398] In this respect, he emphasizes an approach to the astronomical sciences that is "independent of philosophy," in the place of which he assigns the central roles of observation and mathematics in establishing the principles of the discipline.[399] As an extension of this position, Qūshjī although agreeing with Ṭūsī that the subject of the Earth's rotation cannot be established on observation, does not accept Ṭūsī's recourse to natural philosophical principles in the *Tadhkira*.[400]

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[397] S. P. Ragep, "Fifteenth-Century Astronomy in the Islamic World," 153.
[398] F. J. Ragep, "Freeing Astronomy from Philosophy," 62.
[399] "(1) some things are geometrical premises, which are not open to doubt; (2) others are suppositions (*muqaddamāt ḥadsiyya*)…(3) others are premises determined by (*yaḥkumu bihā*) the mind (*al-ʿaql*) in accordance with the apprehension (*al-akhdh*) of what is most suitable and appropriate…(4) other premises that they state are indefinite (*ʿalā sabīl al-taraddud*), there being no final determination (*al-jazm*)." Ibid, 68–71.
[400] Ibid, 62.

Qūshjī's position is also different from that of Shīrāzī, despite both sharing a high opinion of the role of mathematics in astronomy. Although Shīrāzī diverges from Ṭūsī by privileging mathematics over philosophy in providing proofs for astronomical principles, an approach that was inspired by Ptolemy's *Almagest*, he still makes references to the natural philosophical principles (*mabādiʾ*) in the Introductions to his *Nihāya* and *Tuḥfa*.[401] Qūshjī's notion of an "independent astronomy" proposed in *Sharḥ al-Tajrīd* does not merely remain at the theoretical level; rather he applies it in his *Fatḥiyya* by omitting a section on natural philosophy in the Introduction and by presenting only an explanation of geometrical terms. As Qūshjī writes in Sharḥ *al-Tajrīd*, "geometrical premises […] are not open to doubt."[402]

One should also note that with respect to the relationship between *hayʾa* and natural philosophy, the *Fatḥiyya* also differs from Jaghmīnī's *Mulakkhaṣ*. Although the latter does not cover issues in natural philosophy as extensively as in the *Tadhkira*, it is still committed to the dependency theory: "Every simple body, when left unimpeded in its natural state, is —as has been shown in another science— spherical in form."[403] In his commentary on the *Mulakkhaṣ*, Qāḍīzāda makes clear that the intended science here is Aristotle's "*De Caelo* in natural philosophy (*Kitāb al-samāʾ wa-al-ʿālam min al-ṭabīʿī*)."[404]

There is no doubt that Qūshjī offers a unique approach in the history of *hayʾa*. Ragep's article contextualizes it with respect to the ongoing discussion among astronomers, philosophers, and *mutakallimūn* in the post-classical period. However, the

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[401] Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 3b-4a; F. J. Ragep, "Ṭūsī and Copernicus," 156.
[402] F. J. Ragep, "Freeing Astronomy from Philosophy," 68–69.
[403] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 86–87.
[404] Qāḍīzāda al-Rūmī, *Sharḥ al-Mulakhkhaṣ*, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2660, f. 8a.

nature of Qūshjī's philosophy of astronomy and its relation to his *hayʾa* works needs further clarification.

According to David Pingree, Qūshjī had already excluded Aristotelian principles in his earlier *hayʾa* work, the *Risālah*. According to him, "the *Risālah dar hayʾah* is not a philosophically oriented text, so that there are in it no direct statements about the laws of Aristotelian physics as there are in the *Tadhkira*."[405] In line with Pingree's approach, Ragep also writes that in the *Risālah*, Qūshjī "took the highly unusual step of dispensing with the section on natural philosophy with which almost all other similar treatises began."[406] As these quotations suggest, both Pingree and Ragep present the *Risālah* as a realization of Qūshjī's project to break the link between Aristotelian natural philosophy and *hayʾa*. I argue, however, that although the *Risālah* was a significant step in Qūshjī's project of composing *hayʾa* works without natural philosophy, it still attaches itself structurally to the understanding of *hayʾa* that included natural philosophy, albeit not in the same way as one finds in *Tadhkira* or *Tuḥfa*. In this respect, I claim that it is the *Fatḥiyya* where Qūshjī's project of "freeing astronomy from philosophy" was fully realized, as far as its structure and content are concerned.

In order to understand the significance of the *Fatḥiyya*, one should first examine the place of natural philosophy in the *Risālah*. Qūshjī divides the *Risālah*'s Introduction into two main sections: The first is devoted to geometry (*handasiyyāt*) and the second to natural philosophy (*ṭabīʿiyyāt*). Therefore, it should be noted that in terms of the common practice accepted by the *hayʾa* writers, Qūshjī follows the same structure for his Introduction as in the *Tadhkira* and *Tuḥfa*. After a relatively lengthy account of the geometry section, Qūshjī

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405 Pingree, "Indian Reception of Muslim Versions of Ptolemaic Astronomy," 475.
406 F. J. Ragep, "Freeing Astronomy from Philosophy," 62.

treats the *ṭabīʿiyyāt* (natural philosophy) section. The first notable aspect of this section is that compared to the geometry one, it is significantly shorter, less than half of the former section.[407]

In the *ṭabīʿiyyāt* section, Qūshjī briefly presents the following information: A body is compound (*murakkab*) if it is composed of bodies whose natures are different (*ajsām mukhtalifa al-ṭabāʾiʿ*); if not, it is a simple body (*basīṭ*). A simple body is either celestial or elemental. The orbs are given as an example of the celestial bodies. They are also called the aetherial bodies and heavenly world (*ajrām-i athīrī wa ʿālam-i ʿulwī*). Then, Qūshjī introduces the four elements, namely fire, air, water, and earth, which are also called the sublunary world (*ʿālam-i suflī*) and the world of generation and corruption (*ʿālam-i kawn wa fasād*). A compound body is either complete or incomplete (*tāmm wa ghayr-i tāmm*). A complete compound is the one that sustains its form (*ṣūrat*) by itself for a long period of time. Minerals, plants, and animals are in this category. As examples of the incomplete compound body, clouds and muds are given. Qūshjī then classifies the motions of the orbs. It should be noted that Qūshjī does not mention rectilinear motion. He introduces two types of classifications. According to the first, a celestial motion is either simple (*basīṭ*), which is also called uniform (*mutashābih*), or variable (*mukhtalif*). The simple motion is explained as follows: Let us assume a circular motion around a point that is the center of the circle. It is a uniform motion, if the angles that occur at the center of the circle as a result of the motion within the same period are the same. To put it differently, if the same distance is traversed along the circumference of the circle in the same period, it is a uniform motion. Otherwise, it is a variable motion.

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[407] ʿAlī al-Qūshjī, *Risālah dar ʿilm-i hayʾah,* Ayasofya, MS 2639, ff. 6a-7a.

As for the second type of classification for the celestial motions, it is either singular (*mufrad*) or composed (*murakkab*). Singular motion is one that emerges from a single orb. Composed motion, in turn, is one that emerges from a combination of the motions of more than one orb. Qūshjī completes this section by adding that every singular motion is a simple one, and every variable motion is a composed one. However, not all simple motions are singular; furthermore, not all the composed motions are variable.

As Pingree and Ragep point out, in his section on natural philosophy, Qūshjī does not make any references to the natural philosophical principles (*mabādiʾ*) as one would find in the *Tadhkira* or the *Tuḥfa*. However, it is important to note that he still devotes a section to what he calls *ṭabīʿiyyāt*. Thus, he does not completely sever himself from the standard practice of the authoritative texts, at least structurally. In other words, while Qūshjī minimizes the discussions of natural philosophical subjects in the *Risālah*, he does not free himself fully from his predecessors in terms of the structure of his work. Therefore, I consider the *Risālah* as the first step towards the exclusion of natural philosophy in Qūshjī's astronomical scholarship.

We must note that Qūshjī's *ṭabīʿiyyāt* section is linked to his predecessors as far as its content is concerned. Heiderzadeh compares this section to the relevant chapter in Ṭūsī's *Risāla-yi Muʿīniyya*, implying that the latter was a source of Qūshjī's *Risālah*.[408] At first glance, one might accept this assumption because of the several similar phrases one finds in both the texts. Nevertheless, I argue that the main source Qūshjī uses when writing this section was more likely Shīrāzī's *Tuḥfa*. As seen above, Qūshjī gives us two types of classifications of the celestial motion: simple vs. variable, and singular vs. composed. The

[408] Heiderzadeh also points out the differences between the texts. Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 31–33.

first categorization is based on whether a motion is uniform or not, whereas the second is with respect to the number of orbs that bring about the motion. In order to highlight the relationship between these two categories, Qūshjī writes that although every singular motion is a simple one and every variable motion is a composed one, not all simple motions are singular and not all the composed motions are variable. These two categorizations are also presented in the *Tuḥfa*, whereas the *Muʿīniyya* only gives the definition of the first (i.e. simple vs. variable). Moreover, Qūshjī's aforementioned statement is included in the *Tuḥfa*, but not in the *Muʿīniyya*. That being said, Qūshjī does not use the relevant section in the *Tuḥfa* entirely. For instance, Qūshjī discusses neither rectilinear motion nor natural philosophical principles, both of which are presented in the *Tuḥfa*.[409]

Unlike the *Risālah*, however, the *Fatḥiyya* excludes completely any discussion pertaining to natural philosophy, including basic definitions of the body and celestial motion. To put it differently, Qūshjī applies his understanding of *hayʾa* to the *Fatḥiyya* in its final form. This is another indication that shows how the *Risālah* can be deemed as part of the development of the *Fatḥiyya*.

*3.2.4.2. **An Ottoman Hayʾa Work in the Post-Samarqand Experience***

To the best of my knowledge, Qūshjī's *hayʾa* works are the first original compositions (*matn*) written after the establishment of the Samarqand observatory and madrasa, and they rely on *Zīj-i Ulugh Beg* for most of their parameters. Importantly, as mentioned above, Qūshjī makes several explicit references to the *Zīj* and his role in the Samarqand observations. Revealing Qūshjī's active engagement with the preparation of the

[409] Shīrāzī, *Tuḥfa,* Fazıl Ahmed Paşa, MS 927, ff. 3b-4a.

Zīj-i Ulugh Beg, his references show the interaction between *al-hayʾa al-basīṭa* and *zīj* literatures in Islamic history, particularly after the Samarqand experience.

With respect to the *Fatḥiyya*'s important presence and influence in Ottoman science, which has been attested to by the literature, I have attempted to substantiate this view with further evidence. My critical edition demonstrates that the *Fatḥiyya* was constantly revised by Qūshjī until his death. More importantly, Ghulām Sinān's commentary shows that Qūshjī taught the *Fatḥiyya* in Istanbul. What is intriguing is that all the derivative texts of the *Fatḥiyya* were produced in the Ottoman context. Likewise, almost all the extant *Fatḥiyya* copies were copied in Ottoman lands. However, as far as the number of available copies is concerned, the *Fatḥiyya* did not seem to have reached a wide audience as compared to the *Risālah*. This latter text, along with its commentaries, particularly by Lārī, attracted considerable attention among Ottoman scholars. This intriguing observation deserves particular study; but for the time being this can be in part explained by the fact that as far as the *hayʾa* literature in Arabic is concerned, the rivals of the *Fatḥiyya* as an elementary level text, such as Ṭūsī's *Tadhkira* and its derivatives, as well as Jahmīnī's *Mulakhkhaṣ* and its derivatives, especially Qāḍīzāda's commentary, dominated theoretical astronomy education in the Ottoman Empire, as is the case with most of the Islamic East during the early modern period. Moreover, the question of why some Ottoman scholars preferred the *Risālah* over the *Fatḥiyya*, as is the case with Saydī ʿAlī Raʾīs who prepared an expanded Turkish version of the *Risalah*, should stimulate further interest in the general place of the Persian scientific literature in the Ottoman context.

3.2.4.3. ***A New Synthesis in the Hayʾa Literature***

Earlier, I asked the question why Qūshjī wrote new *hayʾa* works, given the fact that many significant works including the *Tadhkira*, *Mulakhkhaṣ*, *Tuḥfa*, *Nihāya*, and their derivative texts were already studied across the Islamic East, including in Ottoman and Anatolian lands. One of my central arguments in this chapter is that Qūshji's approach in the *Fatḥiyya* of making selective use of the *hayʾa* literature, especially those studied in the Samarqand context, as well as by using up-to-date parameters taken from *Zīj-i Ulugh Beg*, allowed him to offer a new synthesis in a new intellectual setting, namely in Ottoman Istanbul. This intellectual environment was supported by the Ottoman elites, primarily by Sultan Meḥmed II, who embarked on making large investments to promote science and learning in post-conquest Istanbul. In this respect, it is notable that Qūshjī wrote his *Fatḥiyya* only three years after the establishment of the Ṣaḥn-i Thamān Madrasas, the largest educational project commissioned by the Sultan.

Studies on intellectual history during this period of Meḥmed II's reign are not mature enough to fully appreciate the intellectual and scientific debates that occurred when Qūshjī was in Istanbul; therefore, the question of how contemporaneous Ottoman scholars received Qūshjī's *Fatḥiyya* needs further study. Nevertheless, available sources indicate that the *Fatḥiyya* was the subject of ongoing discussion, given the increased interest in *hayʾa* works after Qūshjī's arrival. Of course, I do not want to attribute this interest completely to Qūshjī. However, we know that following this period there is a noticeable increase in the number of copies of earlier *hayʾa* texts, as can be observed for instance in Bāyazīd II's library. The library's catalog leaves no doubt that by the early sixteenth-century, works pertaining to almost all kinds of perspectives in the *hayʾa* literature were available in Istanbul.[410] Even a preliminary survey reveals that more than ten *hayʾa* related works were written by Ottoman scholars within a quarter century after Qūshjī's death.[411] The text that attracted the most attention was Qādīzāda's *Sharḥ al-Mulakhkhaṣ* upon which several derivative works were composed. One might say that in the late fifteenth- and early sixteenth-centuries, the Ottomans discussed issues pertaining to *hayʾa* and evaluated works written from various perspectives comparatively. Further research is needed to examine how they evaluated these *hayʾa* works.

3.3) <u>Concluding Remarks</u>

This chapter examined the *Fatḥiyya* from the perspective of the historical, local, and scientific contexts within which it was written. Since Qūshjī's available *hayʾa* works are somehow related to each other, I began by introducing the *Fatḥiyya* and the *Risālah*, as well as the commentaries and translation of the former text. In order to show that the *Fatḥiyya* is better understood when we consider the earlier *hayʾa* literature, the second part of the chapter offered a history of the development of *hayʾa* as a discipline. Then we discussed the content and sources of the *Fatḥiyya*. With reference to the *Risālah* and its expanded Turkish rendition made by Saydī ʿAlī Raʾīs, I pointed out that Qūshjī's astronomy underwent some significant changes over the course of his life, which manifested themselves in its reception by Ottoman scholars. Finally, I outlined the general characteristics of the *Fatḥiyya* in an attempt to situate it within both the history of *hayʾa* in general and Ottoman science in the late fifteenth- and sixteenth-centuries.

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[410] Ragep et al., "Astronomical and Other Mathematical Sciences in ʿAṭūfī's Inventory of Bāyezīd II's Library," 836.
[411] Ekmeleddin İhsanoğlu et al., eds., *Osmanlı Astronomi Literatürü Tarihi*, 1: 40-68.

PART 2

AL-RISĀLA AL-FATḤIYYA: AN EDITION, TRANSLATION, AND COMMENTARY

CHAPTER 4

DESCRIPTION OF THE MANUSCRIPTS AND EDITORIAL PROCEDURES

4.1) Description of the Manuscripts

This section includes descriptions of the *Fatḥiyya* manuscripts about which I could obtain information, either by acquiring their digital copies or by consulting the two most comprehensive bibliographical sources for Ottoman astronomical works.[412] These sources are quite helpful in providing listings of *Fatḥiyya* copies, but one needs to be cautious about some witness details they provide, because one can find some copies of *Risālah dar hay'ah,* which Qūshjī wrote in Persian earlier in 1458, listed under the *Fatḥiyya* in those bibliographical sources*.* In order to provide a more reliable list of the *Fatḥiyya* copies, I have listed below all the extant *Fatḥiyya* copies that I am aware of, with their descriptions, in accordance with their copy dates. I examined all of them from their digital copies, except for the one in Cairo (see below, no. 17), for whose details I relied on the bibliographical sources. The copies' colophons in Arabic are given as they are written in the manuscripts.

[412] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi*; Rozenfeld and İhsanoğlu, *Mathematicians, Astronomers and Other Scholars*.

Sigla	Description of Manuscript

1. ص [= S]

Istanbul, Süleymaniye Manuscript Library, Ayasofya, MS 2733; ff. 1b-70a; 11 lines/page; 12.5 x 17.4 cm (6 x 9.5 cm). It is an autograph copy, completed and copied by ʿAlī Qūshjī himself around the middle of Rabīʿ al-Awwal in 878 (August 1473), on the day of Meḥmed II's victory over the Aq Qoyunlu Sultan Uzūn Ḥasan in the Battle of Otlukbeli (August 11, 1473) in a place called Tarjān, today in the city of Erzincan in Turkey. The Sultan is praised in the incipit, showing that the text was dedicated to him. Additionally, there are three seals on the cover page, two of which are of the Ottoman Sultans Bāyazīd II (r. 1481-1512) and Maḥmūd I (r. 1730- 1754). There are almost no marginal notes on the copy, except for a few additions and corrections by the author/copyist.

The colophon reads (f. 70a):

فرع العبد المولف من تحريره فى اواسط ربع الاول سنه ثمان وسبعين وثمانمائه كتب هذه

الاسطر المشوشه الفقير الحقير على بن مُحَمَّد القوشجى وهو مولف هذه النسخه وكاتبها يوم ظفر

السلطان الاعظم ابو الفتح سلطان مُحَمَّد خان خلد الله ملكه على ازون حسن فى نواحى ترجان

فى مقام اوت بِيلِگَى قرب قُبَاسِوْرى

The writing of this [copy] was completed by the servant, the author, in the middle of Rabīʿ al-Awwal in 878. These muddled lines were written by the needy and miserable ʿAlī b. Muḥammad al-Qūshjī, who is the author and copyist of this copy, on the day of the Great Sultan Abū al-Fatḥ Sulṭān Muḥammad Khān's victory, May God perpetuate his sovereignty forever, over Uzūn Ḥasan around Tarjān, in the location [called] Ūt Bīlikay [Otlukbeli], which is close to Qubāsivrī.

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2. ك [=K]

Kütahya, Vahit Paşa Manuscript Library, Vahit Paşa Collection, MS 2010; ff. 0b-46b; 15 lines/page. The colophon does not have a copy date, but it includes the name of the copyist: Walī al-Dīn b. Shaykh Muḥammad al-Samarqandī. This copy is important in the sense that on the cover page is a note stating that the copy includes notes from the author, namely Qūshjī. More importantly, on f. 24b, there is a note emphasising that "this marginal note [referring to a marginal note on top of it] is in the handwriting of the author; May God the Exalted bless him." This marginal note is very close to Qūshjī's handwriting that can be seen in the *Fatḥiyya*'s autography copy (Ayasofya, 2733) and the *Kitāb al-Makhrūṭāṭ* witness that was also copied by Qūshjī (Ayasofya, 2724). Given the fact that it was copied when Qūshjī was alive, its copy date must be before 879/1474, Qūshjī's death year. I could not uncover any information about the copyist; however, since he calls himself al-Samarqandī, he might be one of Qūshjī's students or even among his relatives who came to the Ottoman lands with Qūshjī. The copy's pagination does not start from the cover page, but one page after. Therefore, I consider the first page 0a when consulting this copy in my critical edition.

The colophon reads (f. 46b):

حرره الفقير المحتاج الى رحمه الله البارى ولى الدين بن شيخ مُحَّد السمرقندى[413] اصلح الله شانه

م

[The copy] was completed by the mendicant who is in need of the blessing of God the Creator, Walī al-Dīn b. Shaykh Muḥammad al-Samarqandī.

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3. غ [= G]

Sarajevo, Ghazi Husrev-Bey Library, MS R 5201; ff. 1b-47b; 15 lines/page; 10.5 x 18 cm (4.5 x 11 cm). It was copied from a copy that was read in front of Qūshjī. Its copy date is given as [8]88 (1483) in the catalog.[414] However, it should be 884 [1479-80]. A puzzling feature of this copy is that although it was copied nearly 5 years after the death of Qūshjī, he was praised with the prayer "May God protect him

[413] After this word, there is another word that is crossed out by the copyist, and so it is unreadable.
[414] Mustafa Jahić, *Catalogue of the Arabic, Turkish, Persian & Bosnian Manuscripts in the Ghazi Husrev-Bey Library*, vol. 12 (London & Sarajevo: al-Furqān Islamic Heritage Foundation Publication, 1424/2003), 180-81.

(*sallamahu Allahu*)," which gives the impression that Qūshjī was still alive at the time of copying. Unfortunately, the name of the copyist is not given in the colophon. It includes a number of marginal notes, some of which are corrections (صحّ), and the others are comments on parts of the text. One folio of the copy (f. 11) has a different handwriting, which seems to have been copied and attached to the copy later (16-17 lines/page). The importance of this version is that it seems to have been the latest version of *the Fatḥiyya* confirmed by Qūshjī, given the fact that the commentary of Ghulām Sinān, Qūshjī's student in Istanbul, on the book is largely based upon this version. Moreover, most of the available copies rely mainly on this version. However, most probably due to a scribal error, the copy lacks a part amounting approximately to one folio, observed when passing from 17b to 18a in the copy. For that part, I will use the Mashhad witness for establishing this version; the importance of the Mashhad witness will be explained below.

The colophon reads (f. 47b):

تمت رسالة فتحيّة [ل]على بعون العلىّ الاولى فى عشر آخر رمضان المبارك سنه ٨٨٤ وكتبت

وصححت عن النسخة التى قرات على المص[نف] سلمه الله

The treatise of ʿAlī's [al-Qūshjī] *Fatḥiyya* was completed with the help of the Most Exalted One, in the last ten days of blessed Ramaḍān in the year 884. It was written and verified from a copy that was read to the author, May God protect him.

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4. م [=M]

Mashhad, Dānishkada-yi Ilāhiyyāt, MS 746; ff. 1b-70b; 11 lines/page; 12.5 x 18 cm (5 x 9 cm).[415] This copy is incomplete; the last three chapters of the third and last part of the work have been somehow separated from the codex. Therefore, it does not have a colophon. Yet, it is quite important because while the main text is almost the same as the Ayasofya copy, the parts Qūshjī revised later are crossed out, and his latest additions are written in the margin. Interestingly, with those revisions, this copy turns out to be almost the same as the Ghazi Husrev copy. Somewhat surprisingly, when the marginal notes in this copy are compared to the marginal notes in Qūshjī's handwriting in Ayasofya 2733 and Ayasofya 2724, there is a strong possibility that the marginal notes in this Mashhad copy (Dānishkada-yi Ilāhiyyāt, MS 746) are in Qūshjī's hand. Therefore, one might date the copy as pre-1474.

[415] Maḥmūd Fāẓil, *Fihrist-i nuskhahhā-yi khaṭṭī-i Kitābkhānah-i Dānishkadah-i Ilāhiyyat va Maʿārif-i Islāmī-yi Mashhad*, vol. 1 (Mashhad: Dānishgāh-i Firdawsī, 1376/1956-57), 209-10.

5.

Istanbul, Boğaziçi University Observatory and Earthquake Research Institute, Kandilli Collection, MS 122; ff. 1b-63b; 15 lines/page; 18.2 x 11 cm (10.5 x 5 cm). This copy does not have a colophon. However, the second work after the *Fatḥiyya* copy in the same codex, entitled Sharḥ *al-Maʿūna fi ʿilm al- ḥisāb* is an autograph copy written and copied by Aḥmad b. Muḥammad b. al-Humām. The handwriting in the *Fatḥiyya* copy suggests that it was also copied by Aḥmad b. Muḥammad b. al-Humām. In addition, the second work has a colophon saying that the work was completed on Friday, 22 Rabīʿ al-ākhir 992 (3 May 1584). Therefore, we can surmise that the *Fatḥiyya* copy was also completed in the same year.[416]

6.

Istanbul, Süleymaniye Library, Halet Efendi Collection, MS 538; ff. 1b-69b; 13 lines/page; 13.2 x 23.1 cm (5 x 14.5 cm). According to the colophon, it was copied by al-Sharīf ʿAbd Allah ibn Ḥusayn al-Anqarī in Istanbul in 1056/1646. The copy includes a table of contents for the *Fatḥiyya*. There are a number of marginal notes in it from the following works: commentaries on the *Fatḥiyya*, written by Ghulām

[416] Günay Kut et al., *Kandilli Rasathanesi el Yazmaları: Boğaziçi Üniversitesi, Kandilli Rasathanesi ve Deprem Araştırma Enstitüsü, Astronomi, Astroloji, Matematik Yazmaları Kataloğu,* vol. 2: Arapça-Farsça Yazmalar (İstanbul: Boğaziçi Üniversitesi Yayınevi, 2007), 111-13, 399.

Sinān and Mīrīm Chalabī, Muṣliḥ al-Dīn al-Lārī's commentary on Qūshjī's *Risālah dar hayʾah,* Qāḍīzāde's commentary on al-*Mulakhkhaṣ fī ʿilm al-hayʾa*, Quṭb al-Dīn al-Shīrāzī's *Nihāyat al-idrāk fī dirāyat al-aflāk*, and Sayyid al-Sharīf al-Jurjānī's commentary on Naṣīr al-Dīn al-Ṭūsī's *al-Tadhkira fī ʿilm al-hayʾa*.

The colophon reads (f. 69b):

قد وقع الفراغ من تحريره على يد اضعف عباد الله الشريف عبد الله بن حسين الانقرى فى مدينة قسطنطنية حميت عن البلية فى اواخر شهر جمادى الاخرة من شهور سنة ست وخمسين والف

[This copy] was completed by the hand of the weakest servant of God, al-Sharīf ʿAbd Allah ibn Ḥusayn al-Anqarī, in the city of Constantinople, may it be protected from calamity, in the latter part of Jumādā al-Ākhira, which is among the months of the year 1056.

7.

Istanbul, Süleymaniye Library, Yeni Camii Collection, MS 1176; ff. 247b-264b; 29 lines/page; 14 x 24.1 cm (7.1 x 18.3 cm). The copy's colophon provides us only with the copy date, which is around the middle of Dhū al-Hijja 1061 (November/December 1651).

The colophon reads (f. 264b):

تم فى اواسط دى الحجه الشريفه لسنة احدى وستين والف

[The copy] was completed around the middle of Dhū al-Ḥijja, the honorable [month], in the year 1061.

8.

Istanbul, Süleymaniye Library, Pertevpaşa Collection, MS 623; ff. 287b-310a; 27 lines/page. It was copied in the month of Dhū al-Ḥijja in 1089/January (February 1679). The date is given in abjad numerals (غفط).

The colophon reads (f. 310a):

تم الكتاب بعون الوهاب واحد من دى الحجه لسنه غفط الهجرى

The book was completed with the help of the Giver of All, on a day in Dhū al-Ḥijja in the year 1089 AH.

9.

Istanbul, Süleymaniye Library, Lala İsmail Collection, MS 292; ff. 1b-55b; 17 lines/page; 9.7 x 19.3 cm (4 x 14 cm). This copy does not have a colophon. However, the last work in same the codex, *Ḥall al-taqwīm* written by Abū al-Khayr Taqī al-Dīn Muḥammad ibn Muḥammad al-

Fārisī al-Shīrāzī, has the same handwriting as that of the *Fatḥiyya* text. Its colophon gives the copyist's name as Walī, which leads me to think that he might be the copyist of the *Fatḥiyya* text as well. The *OALT* suggests that it was copied in the seventeenth century.[417]

10.

Konya, Yusuf Ağa Manuscript Library, Yusuf Ağa Collection, MS 5002; 33 ff.; 21 lines/page; 11.5 x 19.4 cm (5.5 x 11.5 cm). It does not include a colophon. The *OALT* suggests that it was copied in the 11th/17th century.[418] A note written in modern Turkish is attached, to the inner side of the codex's cover probably by a librarian, noting that an astronomical work with 72 pages, whose title is not mentioned, was removed from the codex. The note, however, does not indicate any clue as to what happened to the removed work.

11.

Paris, Bibliothèque Nationale de France (BNF), Manuscrits-Orient Arabe, MS 2504; ff. 145b-173b; 23 lines/page; 15 x 20.5 cm. The colophon provides us with its copy date, which is 1174/1760-61; however, the name of the copyist is not mentioned. Although it is a late copy, it is quite interesting that, among the available copies, it includes the fewest changes compared to the autograph copy

[417] İhsanoğlu et al., *Osmanlı Astronomi Literatürü Tarihi,* 34.
[418] Ibid.

(Ayasofya, 2733). The copy, however, does not provide any evidence that those changes could be somehow linked to Qūshjī.

The colophon reads (f. 173b):

تم بعون الله تعالى وصلى الله على سيدنا مُحَمَّد وعلى اله وصحبه وسلم تسليما الى يوم الدين والحمد

لله رب العالمين سنة ١١٧٤

[The copy] was completed with the help of God the Exalted; may God bless our master Muḥammad, his family and companions, and grant them salvation until the Day of Judgement; Praise be to the Lord of the Worlds; in the year 1174.

12.

Konya, Koyunoğlu Museum and Library, Koyunoğlu Collection, MS 11359; ff. 21b-54b. 19 lines/page; 18 x 11.5 cm (12.5 x 5.8 cm). The copy lacks an introduction and nearly all the first five sections in the first chapter. It is an important copy in the sense that the *Fatḥiyya* was copied by Ḥusayn Rifqī, who calls himself, in the colophon, the chief-instructor at the Ottoman Imperial School of Land Engineering in the nineteenth century. Moreover, he adds numerous notes from Mīrīm Chalabī's commentary on the *Fatḥiyya*. Its colophon gives the copy year as 1122/1710-1711; however, Ḥusayn Rifqī died in 1817.[419] Therefore, it could be that the copyist made a mistake, and the copy date might be 1222/1807-8.[420]

The colophon reads (f. 54b):

قد وقع الفراغ عن تمنيق هذه الرسالة على يد اضعف العباد حسين رفقى بن مُحَمَّد معلم اوّل

مهندسخانهٔ همايون لسنة اثنى وعشرين بعد المائة والالف من هجرة من له العزّ والشرف

The elegant composition of this treatise was completed by the hand of the weakest of servants, Ḥusayn Rifqī b. Muḥammad, the chief-instructor in the Royal Engineering School, in the year 1122 of the Hijra of the one to whom all glory and honor.

13.

Istanbul, Istanbul Technical University Library, Rare Manuscripts Collection, 7094; ff. 1a-42b; 17 lines/page; 10.5 x 16 cm (7.5 x 14 cm). This copy was copied by Ḥusayn Maṣdariyajī-zāda, who was the chief assistant (*khalīfa-i awwal*), in the Ottoman Imperial School of Land Engineering in Istanbul. The copy date given in the colophon is

[419] For more information about his biography and scholarship, especially his translation of Euclid's *Elements*, see Ali Rıza Tosun, *Hüseyin Rıfkı Tâmânî ve Elementler Çevirisi* (Ankara: Atatürk Kültür Merkezi Yayınları, 2010).

[420] The Ottoman Imperial School of Land Engineering, in which Ḥusayn Rifqī worked, was established in 1795; therefore the copy date of the witness should not be 1122/1710-1711. For a history of the Ottoman engineering schools and their major figures including Ḥusayn Rifqī, see Kemal Beydilli, *Türk Bilim ve Matbaacılık Tarihinde Mühendishâne, Mühendishâne Matbaası ve Kütüphânesi, 1776-1826* (İstanbul: Eren Yayıncılık, 1995).

1124/1712-13, but it must be a scribal error, because Ḥusayn Maṣdariyajī-zāda worked in the engineering school in the first half of the nineteenth century.[421] Thus, the copy date might be 1224/1809-10.[422]

The colophon reads (f. 42b):

قد وقع الفراع عن تميق هذه [ال]رسالة على ىد اضعف العباد حسين بمصدريه جى زاده حليفهٔ

اول مهندسخانهٔ همايون لسنة اربعه وعشرين بعد المائة والف من هجرة من له العر والشرف بمـ م

The elegant composition of this treatise was completed by the hand of the weakest of servants, Ḥusayn Bimasdariyajī-zāda [Maṣdariyajī-zāda], the chief assistant in the Royal Engineering School, in the year 1124 of the Hijra of the one to whom all glory and honor.

14.

Istanbul, Süleymaniye Manuscript Library, Darülmesnevi Collection, MS 340; ff. 1b-61b; 15 lines/page; 20 x 14 cm (14 x 4 cm). The copy's colophon (تمت النسخة) does not include either the name of the copyist, or its copy date. However, the endowment seal gives the year of

[421] İhsan Fazlıoğlu, "Seyyid Ali Paşa," *TDV İslam Ansiklopedisi* 37 (İstanbul: Diyanet Vakfı Yayınları, 2009), 48.
[422] It is interesting that the two copies produced in the engineering school context seem to have the same type of scribal error in their copy dates. I have not examined the two copies in detail in terms of their relations, but it is important to consider that the style of the colophons of both copies is quite similar. Given the fact that the copyist of the earlier copy, Ḥusayn Rifqī, and the copyist of this copy, Ḥusayn Bimasdariyajī-zāda, were colleagues in the same period in the engineering school, my impression is that the latter might have been copied from the former in the engineering school context.

1248/1832-33. The endower, al-Shaykh Ḥāfiẓ Muḥammad Murād, taught various topics at Dār al-Mathnawī in Istanbul. This copy is from its collection.[423] Therefore, it might have been copied in the nineteenth century. The copy includes marginal notes gleaned from Ghulām Sinān's commentary on *al-Fatḥiyya*, entitled *Fatḥ al-Fatḥiyya*.

15.

Amasya, Amasya Manuscript Library, Amasya Collection, MS 1791; ff. 133b-185b; 13 lines/page; 13.5 x 18 cm (6 x 11.5 cm). The copy does not have a colophon, and I could not find any clue for the copy date.

16.

Madinah, Islamic University of Madinah Collection, 10202660073 (Arabic Union Catalog Number); 18b-42b; 23 lines/page. The colophon of the copy does not provide us with the name of the copyist or its copy date. In the same codex, one also finds a copy of Mīram Chalabī's commentary on the *Fatḥiyya* (ff. 43b-136b).

The colophon reads (f. 42b):

تمت الاوراق بعناية الرؤف الرزاق

[423] Hatice Özdil, "19. Yüzyıl İstanbulu'nun İlim Merkezlerinden Murad Molla Tekkesi ve Kütüphanesi," *Osmanlı İstanbul'u II: II. Uluslararası Osmanlı İstanbulu Sempozyumu Bildirileri, 27-29 Mayıs 2014, İstanbul 29 Mayıs Üniversitesi*, eds. Feridun M. Emecen, Ali Akyıldız, Emrah Safa Gürkan (İstanbul: İstanbul 29 Mayıs Üniversitesi Yayınları & İstanbul Büyükşehir Belediyesi Kültür A.Ş., 2014), 609-36.

[These] leaves are completed thanks to the Providence of the Merciful and the Maintainer.

17.

Cairo, Dār al-Kutub, Ṭalʿat Majāmīʿ, MS 366/8; ff. 92b-102b; 11 x 17 cm. It is an incomplete copy, including only the introduction and the first chapter.[424]

4.2) Editorial Procedures

Establishing the Text

Before I started to examine the *Fatḥiyya* copies in detail, my assumption was that since there is an autograph copy (Ayasofya MS 2733), the other copies were most likely derived from it. The main reason behind this assumption was that Qūshjī died in Istanbul nearly sixteen months after he compiled the *Fatḥiyya*, which I wrongly assumed was too short a period to revise his text. However, the practice of revising texts during this time was common among Islamic scholars, and *hay'a* writers were no exceptions. For instance,

[424] I have not obtained images of this copy, so I relied upon the bibliographical sources about it. See, *Osmanlı Astronomi Literatürü Tarihi*, 34. Apart from those listed so far, the *OALT* lists another copy of the *Fatḥiyya* in the Āyat Allāh Marʿashī collection (MS 890), but it is rather Qūshjī's work in Persian, entitled *Risālah dar hay'ah,* though it is catalogued in the Āyat Allāh Marʿashī catalogue under the title of the *Fatḥiyya*. See, Sayyid Maḥmūd Marʿashī et al., *Fihrist-i nuskhahhā-yi khaṭṭī-i Kitābkhānah-i 'Umūmī-i Ḥaẓrat Āyat Allāh al-'Uẓmā Najafī Mar'ashī*, vol. 3 (Qum: Chāpkhānah-i Mihr-i Ustuvār, 1354 [1975/1976]), 86. One of the challenges in searching for the *Fatḥiyya* text in the Iranian catalogues is that the *Fatḥiyya* was sometimes given as an alias of Qūshjī's *Risālah,* or the two works are confused with one another.

Naṣīr al-Dīn al-Ṭūsī and his student Quṭb al-Dīn al-Shirāzī revised their astronomical works over a period of years.[425]

As my examination of the copies proceeded, I reached the conclusion that, like his predecessors, Qūshjī also made revisions to the *Fatḥiyya* until his death, whose scientific and pedagogical significance will be elaborated in my commentary chapter. Due to reasons that will be explained shortly, I argue that Qūshjī made at least two substantial revisions to the original text at different times. To put it differently, my argument is that the *Fatḥiyya* has three major versions made by Qūshjī himself over the period in which he taught the text in Istanbul. My critical edition, however, will be based on four copies : Istanbul, Ayasofya MS 2733 (ص); Sarajevo, Ghazi-Husrev Bey MS R 5201 (غ); Kütahya, Vahitpaşa MS 2010 (ك); and Mashhad, Dānishkada-yi Ilāhiyyāt MS 746 (م). The process and reasons for my selection of those copies are as follows:

1) Unlike the other witnesses, these copies have indications of Qūshjī's interventions. As I have already mentioned, while the Ayasofya copy is an autograph, the Vahitpaşa and Mashhad copies include marginal notes, most probably in Qūshjī's handwriting. As for the Ghazi-Husrev copy, the colophon suggests that it was copied from a copy verified (*ṣuḥḥiḥat*) by Qūshjī himself. Equally important, it includes marginal notes with reference to "my teacher

[425] Naṣīr al-Dīn al-Ṭūsī, in his *al-Tadhkira fī ilm al-hay'a*, and Quṭb al-Dīn al-Shirāzī, in his *Nihāyat al-idrāk fī dirāyat al-aflāk* and *al-Tuḥfa al-shāhiyya*, all of which are among the most important works in the history of theoretical astronomy in Islamic societies, made revisions to their texts. For the evaluation of those revisions, see: F. Jamil Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy*, 65-75; Morrison, "Quṭb al-Dīn al-Shīrāzī's Hypotheses for Celestial Motions," 21-140; Ragep, "Shīrāzī's Nihāyat al-idrāk: Introduction and Conclusion," 41-57; Fateme Savadi, "The Historical and Cosmographical Context of *Hay'at al-arḍ.*" Another important *hay'a* writer who revised his work, entitled *Kitāb al-hay'a,* is Mu'ayyad al-Dīn al-ʿUrḍī. See, Saliba, *Tārīkh ʿilm al-falak al- ʿArabī: Kitāb al-hay'ah*.

(*ustādhī*)," which deserves further attention, as they might be notes from Qūshjī's lectures. Furthermore, these four copies are the oldest ones among the available copies.

2) After differentiating the four copies from the others in terms of their close connection with the author, my task was to figure out which copy is the best option to use as the base text for the critical edition. After comparing the manuscript copies of a number of sections of the text, I concluded that the Ayasofya copy is, as expected, the earliest one. While the Vahitpaşa copy has a great deal of Qūshjī's revisions, it is the Ghazi-Husrev Bey copy, which, I argue, represents the final version of the *Fatḥiyya* with almost all of Qūshjī's revisions. First, as mentioned above, the Ghazi-Husrev Bey copy was copied from a copy verified by Qūshjī, and its copy date ([8]84/1479-80) is close to his death in 879/1474. Secondly, and more importantly, Ghulām Sinān's commentary on the *Fatḥiyya*, which was completed in 890/1485 and dedicated to the Ottoman sultan Bāyazīd II (d. 918/1512),[426] is based upon the version found in the Ghazi-Husrev Bey copy.[427] Interestingly enough, many of the marginal notes included in this copy are quotations from the Ghulām Sinān's commentary, and therefore the Ghazi-Husrev Bey copy might have been produced by a student of Ghulām Sinān or at least within his intellectual and educational milieu. Another important piece of evidence for my argument is the Mashhad copy. The main text of this copy includes the *Fatḥiyya*'s first version, namely the Ayasofya version;

[426] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih MS 5396, ff. 78b, 188a.
[427] It is interesting that the other commentator of the *Fatḥiyya*, Mīrīm Chalabī (d. 1525), who was a descendant of Qūshjī, uses, in his commentary, the *Fatḥiyya* text that seemingly excludes a few of the latest revisions Qūshjī made. I will deal with this in the commentary chapter.

the places where there were later revisions have been crossed out in the main text, and the revisions are written in the margin. As mentioned above, Qūshjī is most probably the one who wrote those marginal notes. With those revisions, the Mashhad copy is almost identical with the Ghazi-Husrev Bey one. I prefer the latter to the former as the base text, because the Mashhad copy is incomplete. Having said this, for the part somehow omitted in the Ghazi-Husrev Bey, I will use the Mashhad copy as the base text (ff. 29b-31a; it includes a portion from the First Section of Chapter 6 in Part 1).

3) One of my main questions during my research on the *Fatḥiyya* copies was whether any of the copies I would use for the critical edition represented the *Fatḥiyya* version(s) used by its commentators, namely Ghulām Sinān and Mīram Chalabī. This question is significant for two reasons: First, both Ghulām Sinān, as a student of Qūshjī, who studied the *Fatḥiyya* with him, and Mīram Chalabī, as a leading astronomer of his period and a grandchild of Qūshjī, should have had knowledge of at least one of the *Fatḥiyya* versions verified by Qūshjī himself that contain his revisions. As mentioned above, Ghulām Sinān's commentary is based upon the final version of the text, and therefore the *Fatḥiyya* version he uses in his commentary is almost the same as the one represented by the Ghazi-Husrev and Mashhad copies. But how about Mīram Chalabī's commentary? Quite surprisingly, none of the three versions I have identified above fully agrees with the *Fatḥiyya* text used by Mīrim Chalabī in his commentary. After collating a number of sections from the *Fatḥiyya* text given in Mīram Chalabī's commentray with the ones in the extant *Fatḥiyya* copies, I came to the conclusion that Mīrim

Chalabī appears to have used another *Fatḥiyya* 'version' that seems to be between the second and third/final versions of the text. My first inclination was to add another copy to establish my critical edition that would represent Mīrim Chalabī's *Fatḥiyya* text; this procedure would then help reveal the different editorial revisions of the *Fatḥiyya*. This expanded critical edition could also provide a means for further studies on Mīrim Chalabī's commentary. However, none of the extant *Fatḥiyya* copies, except for the Madina one[428], fully agrees with Mīrim Chalabī's *Fatḥiyya* "version." However, after closely examining the Madina copy, I decided not to use it for the critical edition, primarily for two reasons: 1) Lacking its copy date, the Madina copy does not suggest any evidence that this "version" could be linked to Qūshjī's interventions, as is the case for the other copies I selected for the critical edition; 2) Equally important, the reason why the *Fatḥiyya* text in the Madina copy is identical with the one in Mīrim Chalabī's commentary is that a number of Mīrim Chalabī's explanatory remarks are incorporated into the Madina copy of the *Fatḥiyya*. There is a simple explanation for this: As mentioned earlier, in addition to the *Fatḥiyya* copy, there is a copy of Mīrim Chalabī's commentary in the Madina codex. The parts from Mīrim Chalabī's commentary that are incorporated in the Madina copy of the *Fatḥiyya*, are mistakenly marked in the copy of Mīrim Chalabī's commentary in as parts of the main *Fatḥiyya* text. That is to say, the Madina copy of the *Fatḥiyya* seems to have been produced simply by bringing together the parts marked as the *Fatḥiyya* text in the copy of Mīram Chalabī's commentary from the same

[428] For the details of this copy, please see no. 16 in the List of Manuscripts above.

codex. Having said this, the question remains of why there is no extant *Fatḥiyya* copy identical with the one used in the Mīrim Chalabī's commentary. This deserves close attention for further studies regarding the reception and evolution of the *Fatḥiyya* text.

4) Another challenge in selecting appropriate copies for the critical edition was the Paris copy.[429] For reasons that remain unclear to me, it is the copy that has the fewest changes among the extant *Fatḥiyya* copies, as compared to the first version one finds in the Ayasofya copy. Due to the fact that the Paris copy was copied almost three centuries after the compilation of the *Fatḥiyya*, and there is no evidence what changes there were due to Qushji, I decided against using it for my critical edition.

5) One of my primary goals in preparing a critical edition of the *Fatḥiyya* is to trace Qūshjī's interventions into the text. Not surprisingly, the Ayasofya copy is the first version of the text. The Vahitpaşa includes more revisions and thus I consider it as the second stage in the author's interventions. As I have argued above, the Ghazi-Husrev Bey and Mashhad copies, in turn, contain almost all the final revisions made by Qūshjī, and therefore they represent the third and final stages in the evolution of the *Fatḥiyya* text. Therefore, as mentioned above, I will use the Ghazi-Husrev Bey copy as the base text in establishing the critical edition, showing the various stages of the revision in footnotes. I assign the following letters for those revisions/versions: First version: α; second version:

[429] For the details of this copy, please see no. 11 in the List of Manuscripts above.

β; third/final version: γ. I will also provide a full critical apparatus in endnotes, in which I refer to the *sigla*s assigned for the copies used in the critical edition.

6) Although the Ghazi-Husrev and Mashhad copies, include Qūshjī's final interventions into the *Fatḥiyya,* and are almost identical, they do differ in some cases. In such situations, I consult the *Fatḥiyya* commentaries, especially the one by Ghulām Sinān, to help establish the "final" version. I have also depended on the marginal notes in Qūshjī's handwriting in the Mashhad copy. Yet, in a few cases, the available evidencedoes not allow for a conclusive decision as to whether the Ghazi-Husrev or Mashhad copies give the final intervention(s). In such situations, I have made decisions, based upon Qushji's preferences for similar examples. Differences between the Ghazi-Husrev and Mashhad copies will be indicated in the critical apparatus.

4.3) Explanation of Signs and Conventions

used in the Arabic Critical Edition and Apparatus

The following conventions will be used for the Arabic edition:

1- The orthography and rules for *hamza* are based upon modern conventions.

2- The dotting of ي follows the rules used by printers in Syria and Lebanon.

3- *Tanwīn* is generally added (but not on feminine *tāʾ* endings).

4- *Shadda*s have been supplied (except for sun letters and *nisba*s).

5- Short vowels are used only to avoid ambiguity and/or to help the reader.

Critical Apparatus

[Separates reading in edition from any variant.

: Separates variant and manuscript *sigla*

\+ Added in

\- Missing from

= Indicates another variant

(…) Editor's comments

[…] Editor's additions to the critical edition

ص (S) Istanbul, Süleymaniye Manuscript Library, Ayasofya MS 2733, ff. 1b-70a

غ (G) Sarajevo, Ghazi Husrev-Bey Manuscript Library MS R 5201, ff. 1b-47b

ك (K) Kütahya, Vahit Paşa Manuscript Library, Vahit Paşa MS 2010; ff. 0b-46b

م (M) Mashhad, Dānishkada-yi Ilāhiyyāt MS 746; ff. 1b-70b

با بياض (blank)

تا تحت السطر في (under the line in)

شا مشطوب في (crossed out in)

طا مطموس، غير مقروء، إلخ (smudged, unreadable, etc.)

فا فوق السطر في (above the line in)

ها في الهامش في (in the margin in)

CHAPTER 5

AN ARABIC EDITION OF *AL-RISĀLA AL-FATḤIYYA*

[الرسالة الفتحية لعلي القوشجي]

/[1] بسم الله الرحمن الرحيم[2]

[١] الحمد لله الذي خلق السموات ليتفكّر في عجائبها أولو الألباب، وقدّر[3] فيها منازل[4] ليعلموا عدد السنين والحساب، والصلوة على رسوله قطب فلك الهداية وعلى آله نجوم سماء الخلافة والولاية. وبعد فإنّ من أجلّ[5] نعم أنعمها الله تعالى[6] عليّ وأفضل أيادي أسبغها إليّ أن أسعدني بدولة الانخراط في سلك خدم[7] حضرة السلطان[8] الأعظم، مالك رقاب الأمم، ظلّ الله في الأرضين، قهرمان الماء والطين، سلطان الغُزاة والمجاهدين[9]، قامع العداة[10] والمتمرّدين، أعدل الملوك في العالمين، ناصر[11] عباد الله، حافظ بلاد الله، مُحيي[12] مراسم العدل والإنصاف[13]، هادم أساس الجور والاعتساف. البحر رَشْحة من رَشَحات إحسانه[14]، والشمس لمعة من لمعات إكرامه؛ عطاياه سمت فوق المدى، وتباعدت عن رتبة الإدراك. الدرّ والدرّيّ خافا جوده فتحصّنا في البحر والأفلاك[15]. المؤيَّد[16] من السماء، المظفّر على الأعداء[17]، مُحرِز ممالك الدنيا[18]، مُظهِر كلمة الله العليا[19]، سلطان البرّين، خاقان البحرين: أبو الفتح سلطان مُحَمَّد خان، أسعده الله في الدارين، ومهّد[20] مِهادَ دولته فوق فرق الفرقدين. هو الذي رفع رايات العلم بعد انتكاسها، وعمّر رباع الفضل بعد اندراسها[21]. فعادت[22] رياض العلوم إلى روائها مُخضّرة[23] الأطراف، وآضت[24] حدائقها إلى بهائها[25] مزهرة الجوانب والأكناف. فإنّي منذ كنت في خدمته[26]، رأيت الحكمة أفضل مرغوب فيه عنده، وأجلّ[27] متحف به لديه، فاخترت منها[28] علم الهيئة الذي أثنى التنزيل على عالميه بقوله عزّ قائلاً ﴿الَّذِينَ يَذْكُرُونَ اللَّهَ قِيَامًا وَقُعُودًا وَعَلَىٰ جُنُوبِهِمْ وَيَتَفَكَّرُونَ فِي خَلْقِ السَّمَاوَاتِ وَالْأَرض رَبَّنَا مَا خَلَقْتَ هَٰذَا بَاطِلًا﴾ [سورة آلِ عمران،١٩١]. وصنّفت[i] [29] فيه مختصراً برسمه، معنوناً بإسمه، قليل اللفظ، كثير المعنى، صغير الحجم،

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[i] وصنّفت] γ = وصنعت: β، α.

كبير[30] الفحوى. ولمّا اتّفق اختتامه مقارناً بفتح[ii] [31] معظم ممالك الربع المسكون، سمّيته بالرسالة الفتحيّة. قرنه[iii] الله تعالى[32] بفتح[33] سائر البلاد، وخلّد دولة الفاتح إلى يوم التناد، إنّه[34] ميسّر كلّ مرام ومراد.

[٢] ورتّبته على مقدّمة وثلاثة مقالات.[iv] [35]

[ii] بفتح] γ = لفتح: β، α.

[iii] قرنه] γ، β = قرنها: α

[iv] ورتّبته على مقدّمة وثلاثة مقالات] γ = –β، –α.

المقدّمة

فيما يُحتاج إلى تقديمه قبل[36] الشروع في المقاصد

[١] النقطة ذو وضع لا يتجزّأ؛ والخطّ ما له طول فقط، وينتهي بالنقطة إن تناهى[37] وضعاً؛ والسطح ما له طول وعرض لا غير[38]، وينتهي[39] بالخطّ والنقطة[40] أيضاً إن تناهى[41] وضعاً؛ والجسم ما له طول وعرض[42] وعمق، وينتهي بالسطح وقد ينتهي بالخطّ والنقطة أيضاً. والمستقيم من الخطوط هو أقصر الخطوط الواصلة بين النقطتين؛ والمستدير منها ما يوجد في تقعيره نقطة، يتساوى[43] الخطوط الخارجة منها إليه، وتلك النقطة مركزه[v] وتلك[44] الخطوط أَنصافُ أقطاره[vi][45]. وما[46] سواهما يقال له منحنٍ. والمستوي من السطوح هو الذي إذا وُصل بين كلّ نقطتين منه بخطّ مستقيم، لم يخرج هذا الخطّ من هذا[47] السطح؛ والمستدير منها هو الذي إذا قطع بسطح[48] مستوٍ، حدث فيه[49] دائرة. وقد يُخصّ المستدير بما يوجد في تقعيره نقطة، يتساوى الخطوط الخارجة منها إليه، وهذه النقطة مركزه[vii][50]. وما[51] سوى المستوي والمستدير من السطوح يقال له منحنٍ.

[٢] الزاوية المسطّحة، وتسمّى[52] البسيطة أيضاً، هي هيئة تحدث عند[53] نقطة من السطح من حيث هو[54] ذو حدّين[55] متّصلين بتلك النقطة؛ والزاوية المجسّمة هي مُجتَمَع سطح[56] أو سطوح[57] محيطة بالجسم عند نقطة واحدة منه؛ والنقطة التي يتّصل أو يتقاطع عليها خطّان فصل مشترك لهما، وكذا الخطّ للسطوح والسطح للأجسام. والزاوية قائمة إن أحاط ضلعاها[58]، بعد الإخراج، بأربع زوايا

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[v] مركزه] γ، β = مركزها: α.
[vi] أقطاره] γ، β = أقطارها: α.
[vii] مركزه] γ، β = مركزها: α.

متساوية، وإلّا فالأصغر حادّة والأكبر منفرجة.[59] [viii] والخطّ عمود على الخطّ إن قطعه على قوائم، وعلى السطح إن أحاط مع كلّ خطّ مستقيم يفرض[60] فيه ملاقياً له بزوايا متساوية[ix] [61]؛ ومائل إن لم يكن كذلك. والسطحان[62] متقاطعان على قوائم إن أحاط العمود على فصلهما المشترك في أحدهما مع خطّ آخر في السطح الآخر بقائمة، أو نقول إن لم يخرج العمود الخارج من نقطة في فصلهما المشترك على أحد السطحين من السطح الآخر.[x] [63]

[٣] والمتوازية من الخطوط هي[64] المستقيمة الكائنة في سطح واحد التي لا تتلاقى وإن اخرجت في الجهتين إلى غير النهاية؛ ومن[65] السطوح هي[66] المستوية التي لا تتلاقى وإن اخرجت في الجهات[xi] [67] كذلك. وقد يقال في غير المستقيمة والمستوية منها متوازية إذا لم يختلف الأبعاد[68] بينها أصلاً[69]، كالسطوح الكريّة المرسومة[70] على مركز بعينه، والدوائر المرسومة عليه أو على قطبين بأعيانها.

[٤] الشكل ما أحاط به حدّ أو أكثر، والمسطّح منه هو المحاط بخطّ أو أكثر، والمجسّم هو المحاط بسطح أو أكثر. الدائرة شكل مسطّح[71] يحيط به خطّ مستدير، هو محيطها، ومركزه مركزها، وأنصاف أقطاره[72] أنصاف أقطارها؛ والمستقيم[73] الخارج منه[xii] [74] إلى المحيط في الجهتين قطر لها، منصّف إياها. وكلّ خطّ يقطع الدائرة فهو وتر لها، وما يفرزه من المحيط قوس[75]. وقطعة الدائرة شكل

[viii] فالأصغر حادّة والأكبر منفرجة] γ = –β، –α.

[ix] بزوايا متساوية] γ = بزاوية قائمة: β، α.

[x] العمود على فصلهما المشترك في أحدهما مع خطّ آخر في السطح الآخر بقائمة، أو نقول إن لم يخرج العمود الخارج من نقطة في فصلهما المشترك على أحد السطحين من السطح الآخر] γ، β = كلّ عمودين مستقيمين يخرجان فيهما من أيّة نقطة تفرض على فصلهما المشترك بقائمة: α.

[xi] الجهات] γ، β = الجهتين: α.

[xii] منه] γ = منها: β، α.

مسطّح يحيط به الوتر مع طائفة من المحيط نصفاً[76] كانت[xiii] [77] أو أكبر أو أصغر من النصف، ويسمّى الوتر قاعدة القطعة. الجيب المستوي عمود يخرج من أحد طرفي القوس على قطر يمرّ بالطرف الآخر منها، وما بين موقع العمود وطرف القوس الآخر من القطر[xiv] [78] جيب معكوس لها[79]، يسمّى سهماً أيضاً، والجيب المستوي لا يجاوز نصف القطر، ويقال له الجيب الأعظم؛ والجيب الكلّي بخلاف الجيب المعكوس، فإنه قد[80] يجاوزه.

[٥] الأشكال المستقيمة الأضلاع هي التي يحيط بها[xv] خطوط مستقيمة، ويسمّى مثلّثاً إن كانت ثلاثة خطوط بها[xvi] [81]، وذا أربعة أضلاع إن كانت[82] أربعة، وذا[83] خمسة أضلاع إن كانت خمسة، وعلى هذا القياس. والمثلّث[84] إمّا متساوي الأضلاع[85] أو متساوي الساقين أو مختلف الأضلاع؛ وأيضاً إمّا قائم الزاوية أو منفرج الزاوية، أو حاد الزوايا. عمود المثلّث خطّ[86] مستقيم[87] يخرج من إحدى زواياه، ويقوم على الضلع الموتّر لها، ويسمّى ذلك الضلع بالقاعدة[88].

[٦] الكرة شكل مجسّم يحيط به سطح مستدير، هو محيطها. في داخله نقطة يكون[89] الخطوط الخارجة[90] منها إليه متساوية، وتلك النقطة مركزها، والخطوط أنصاف أقطارها. كلّ واحد من الخطوط الخارجة[xvii] [91] منها إلى المحيط من الجانبين قطر لها، فإن كان هو الذي تتحرّك[92] عليه الكرة فذلك[93] مِحور[94] لها، وطرفاه قطبا الكرة. قطعة الكرة التامّة قطعة[95] من الكرة تحيط[96] بها قطعة من[97]

[xiii] كانت] γ، β = كان: α.

[xiv] الآخر من القطر] γ = —β، —α.

[xv] بها] γ، β = به: α.

[xvi] بها] γ = —β، —α.

[xvii] كلّ واحد من الخطوط الخارجة] γ = والخارجة: β، α.

سطحها ودائرة فقط، هي الحادثة من توهّم قطع سطح مستوٍ للكرة إلى[98] قطعتين إحداهما هي القطعة المذكورة، وهذه الدائرة فصل مشترك بين القطعتين.

[٧] المخروط المستدير[xviii] جسم يحيط به دائرة، هي قاعدته، وسطح صنوبري يُرتفع منها على التضايق[99] إلى نقطة هي رأسه، بحيث إذا[100] أدير مستقيم[xix] [101] واصل بين رأسه ومحيط قاعدته، ماسّ[xx] [102] السطح. والخطّ الواصل بين[103] رأسه ومركز قاعدته هو مِحور المخروط وسهمه، فإن كان عموداً على قاعدته فالمخروط قائم، وإلّا فمائل. والمخروط الناقص هو ما بقي من المخروط[104] بَعد[105] أن قُطع بسطح مستوٍ مواز لقاعدته وألقي[xxi] [106] ما فوق القاطع.[xxii] [107]

[xviii] المستدير] γ، β = –α.

[xix] مستقيم] γ، α = خطّ مستقيم: β.

[xx] ماسّ] γ، α = + ذلك الخط هذا: β.

[xxi] وألقي] γ، α = وألقي منه: β.

[xxii] القاطع] γ = + أو نقول هو ما بقي من المخروط بعد أن ألقى منه مخروط شبيه به: β، α.

المقالة الأولى

في بيان أحوال الأجرام العلويّة وهي مشتملة على ستّ[ة] أبواب[xxiii] [108]

الباب[109] الأوّل[110] [من المقالة الأولى]

في بيان عدد الأفلاك الكليّة وكيفيّة نضدها

[١] العالم كرة واحدة، مركزه[111] مركز الأرض. والأفلاك تسعة[112] يحيط بعضها ببعض بحيث يماسّ مقعّر[113] المحيط محدّب المحاط، بل يتّحدان وضعاً. والفلك المحيط بسائر الأفلاك يسمّى الفلك الأعظم، والفلك الأطلس، وفلك الأفلاك. وفي جوفه فلك الثوابت، وجميع الكواكب الثابتة مركوز فيه بحيث يساوي[114] قطر ما لا أعظم منه من الثوابت ثخن هذا الفلك. وفي جوفه[115] فلك زحل، ثمّ فلك المشتري، ثمّ فلك المرّيخ[116]، ثمّ فلك الشمس[117]، ثمّ فلك الزهرة، ثمّ فلك عطارد، ثمّ فلك القمر، وبه ينتهي عالم الفلكيّات. وفي جوفه عالم العناصر[118]، أوّلها[119] كرة النار، ثمّ كرة الهواء، ثمّ كرة الماء، ثمّ كرة الأرض.

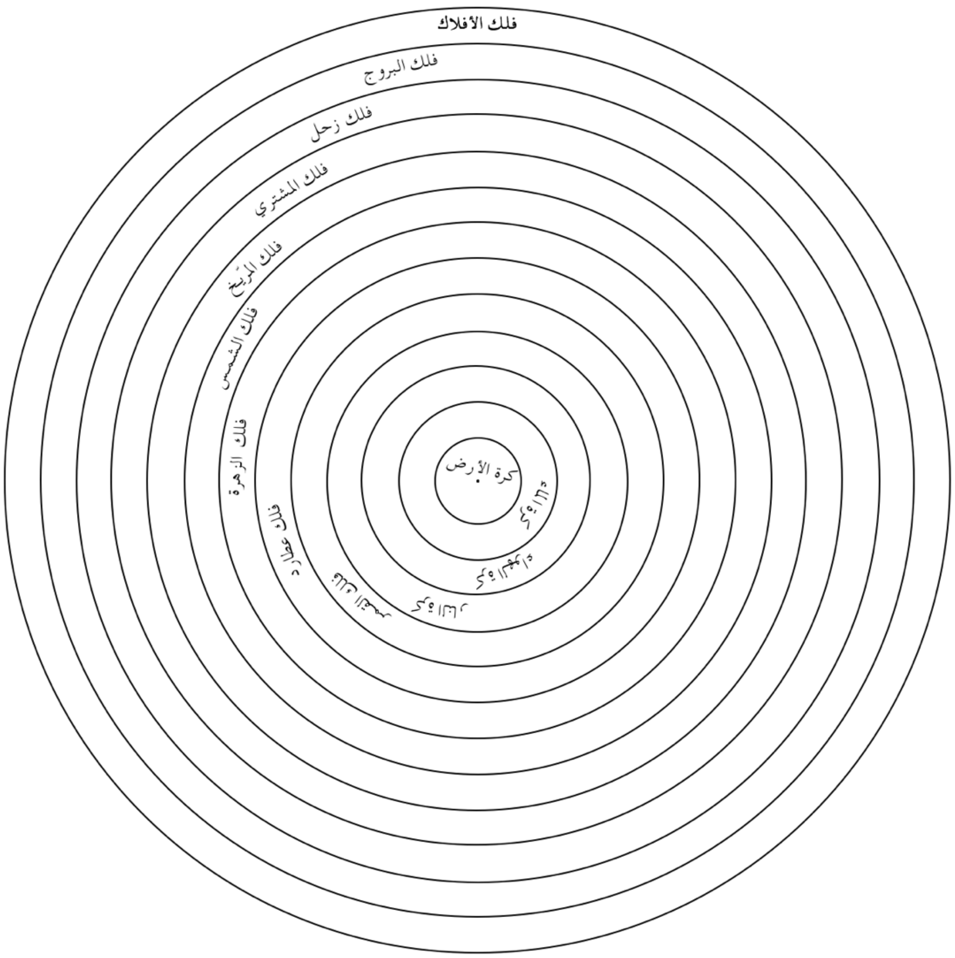
[٢] وهذه الكرّات يحيط بعضها ببعض إحاطة الأفلاك؛ أعني يتّحد محدّب سطحي المحاط ومقعّر[120] سطحي[121] المحيط وضعاً. إلّا أنّ العناية الإلهيّة اقتضت أن ينكشف من الماء بعض من[122] سطح الأرض ليكون مسكناً للحيوانات المتنفّسة[123]، وهو[124] قريب من رُبعه. والتضاريس التي على وجه الأرض من الجبال والتِلال والوِهاد لا تخرجها عن الكرويّة الحسّية، إذ ليس لها قدر محسوس بالنسبة إليها.[xxiv] [125]

[xxiii] المقالة الأولى في بيان أحوال الأجرام العلويّة وهي مشتملة على ستّ أبواب] γ، β = α–.

[xxiv] إليها] γ = إليه: β، α.

[٣] وهذه صورة الأفلاك والعناصر؛ كلّ دائرة سطح، وما بين دائرتين[126] فلك أو عنصر على ما هو قاعدة تصوير الأجسام في السطوح[127]:

صورة الأفلاك



[شكل ١]

الباب الثاني[xxv] [128] [من المقالة الأولى]

في الدوائر المشهورة من العظام والصغار والقسي المشهورة

[١] قسّموا[129] محيط[130] كلّ دائرة بثلاث مائة وستّين قسماً[131]، وقطر كلّ دائرة بمائة وعشرين قسماً، وسمّوا كلّ قسم درجة. ثمّ قسّموا كلّ درجة بستّين قسماً، وسمّوا كلّ قسم[xxvi] [132] دقيقة. ثمّ قسّموا كلّ دقيقة بستّين ثانية، وكلّ ثانية بستّين ثالثة، وهكذا إلى ما أرادوا. فربع الدور تسعون، وتمام كلّ قوس أقلّ منه ما يبقى إلى تسعين. وإذا عرفت ذلك، فنقول:

[٢] من العظام المشهورة: منطقة الفلك الأعظم[xxvii] [133] وتسمّى[134] معدّل النهار، وقطباها قطبي العالم: أحدهما شمالي وهو الذي يلي بَنات النعش[135]، والآخر جنوبي؛ ومنطقة فلك الثوابت[xxviii] [136] وتسمّى[137] منطقة البروج وفلك البروج أيضاً[xxix] [138]، وقطباها قطبي البروج. وهي[139] تقاطع معدّل النهار[xxx] [140] على[141] نقطتين متقابلتين، تسمّيان نقطتي الاعتدالين[xxxi] [142]؛ والدائرة المارّة بالأقطاب

[xxv] الباب الثاني] γ، β = الباب الثالث: α.

[xxvi] درجة ثمّ قسّموا كلّ درجة بستّين قسماً وسمّوا كلّ قسم] γ، β = —α.

[xxvii] الفلك الأعظم] γ = الحركة الأولى الفلك الأعظم: β = الحركة الأولى: α.

[xxviii] فلك الثوابت] γ = الحركة الثانية فلك الثوابت: β = الحركة الثانية: α.

[xxix] وفلك البروج أيضاً] γ، β = —α.

[xxx] النهار] γ، β = + في جميع الأفلاك التي تتحرك بالحركتين: α.

[xxxi] على نقطتين متقابلتين تسمّيان نقطتي الاعتدالين] γ، β = + فالتي إذا جاوزتها الشمس صارت شمالية عن المعدّل هو الاعتدال الربيعي ورأس الحمل والأخرى الخريفي ورأس الميزان وغاية البعد بين المنطقتين كالبعد بين قطبيهما الذين في جهته ويسمّى الميل الكلي: α.

الأربعة[143]، وهي عظيمة، تمرّ بأقطاب المنطقتين[144] [xxxii]؛ ودائرة العرض، وهي عظيمة، تمرّ بقطبي فلك البروج وبجزء منه أو بمركز كوكب. والقوس الواقعة من هذه الدائرة بين ذلك الجزء ومعدّل النهار من الجانب الأقرب[145] تسمّى[146] ميلاً ثانياً لذلك الجزء؛ والواقعة منها بين مركز الكوكب ومنطقة البروج[147] من[148] الجانب الأقرب تسمّى[149] عرض ذلك الكوكب[150] [151].

[٣] ودائرة الميل[152]، وهي عظيمة، تمرّ بقطبي العالم وبجزء من فلك البروج أو بمركز كوكب. والقوس الواقعة من هذه الدائرة بين ذلك الجزء ومعدّل النهار من الجانب الأقرب تسمّى[153] الميل الأوّل لذلك الجزء. والواقعة منها بين مركز الكوكب ومعدّل النهار من الجانب الأقرب تسمّى[154] بُعد ذلك الكوكب[155]؛ ودائرة الأفق وهي عظيمة، أحد قطبيها سمت الرأس والآخر سمت القدم. ونعني بسمت الرأس نقطة على الفلك ينتهي إليها الخطّ الخارج من مركز العالم ماراً على استقامة قامة[156] الشخص، ويقابلها سمت[157] القدم. وبها[158] [159] يُعرف طلوع الكواكب وغروبها، وتنصّف معدّل النهار على[160] نقطتين: تُدعى[161] إحداهما نقطة المشرق ومشرق الاعتدال[162]، والأخرى نقطة المغرب ومغرب الاعتدال. والخطّ الواصل بين تينك النقطتين يسمّى خطّ المشرق والمغرب. والقوس الواقعة من تلك الدائرة بين نقطة المشرق وجزء من فلك البروج أو مركز كوكب من الجانب الأقرب تسمّى[163] سعة المشرق[164] لذلك[165] الكوكب أو الجزء[166]. وتنصّف منطقة البروج[167] على نقطتين تسمّى[168] إحداهما طالعاً والأخرى غارباً وسابعاً أيضاً.

[٤] ودائرة نصف النهار[169] وهي عظيمة، تمرّ بقطبي العالم وبسمت الرأس والقدم. وتنصّف الأفق على نقطتين[170]: يُدعى أقربهما من القطب الشمالي شمالاً، ومن القطب الجنوبي جنوباً. والخطّ

[xxxii] المنطقتين] γ، α = + وأقصر قوس واقعة من هذه الدائرة بين منطقتين أو بين قطبيهما تسمّى بالميل الكلّي: β.

الواصل بينهما يسمّى خطّ نصف النهار. وتنصّف[171] منطقة[172] البروج على نقطتين: إحداهما فوق الأرض وتسمّى[173] عاشراً ووَتِدَ[174] السماء، والأخرى تحت الأرض وتسمّى[175] رابعاً ووتد الأرض. والقوس الواقعة من تلك الدائرة بين قطب الأفق ومعدّل النهار أو بين قطب المعدّل[176] والأفق[177] تسمّى[178] عرض البلد؛ ودائرة[179] المشرق والمغرب وتسمّى[180] دائرة أوّل السموت[181] أيضاً، وهي عظيمة تمرّ بسمتي الرأس والقدم وبنقطتي المشرق والمغرب[182].

[٥] ودائرة وسط سماء[183] الرؤية[184]، وهي عظيمة، تمرّ بقطبي فلك البروج وبسمتي[185] الرأس والقدم[186]. وتنصّف النصف الظاهر والخفيّ من فلك البروج، وقطباها نقطتا الطالع والغارب. والقوس الواقعة من تلك الدائرة بين قطب الأفق ومنطقة البروج أو بين الأفق وقطب[187] البروج من الجانب الأقرب تسمّى[188] [189] عرض إقليم الرؤية؛ ودائرة الارتفاع وهي عظيمة تمرّ بسمتي الرأس والقدم وبنقطة مفروضة من فلك[190] البروج[xxxiii] [191]. وتقطع[192] الأفق على نقطتين[xxxiv] [193] تسمّيان نقطتي السمت، ولهذا تسمّى[194] تلك الدائرة سمتيّة أيضاً. والخطّ الواصل بين تينك النقطتين يسمّى خطّ السمت[xxxv][195]. والقوس[196] الواقعة من تلك الدائرة بين هذه النقطة وبين الأفق تسمّى[197] ارتفاع تلك[198] النقطة إن كانت النقطة فوق الأرض[xxxvi]، وانخفاضها إن كانت تحته. والقوس الواقعة من الأفق بين تلك الدائرة ودائرة أوّل السموت[xxxvii] تسمّى[199] قوس سمت تلك[200] النقطة.

[xxxiii] فلك البروج] γ = الفلك : β، α.
[xxxiv] نقطتين] γ، α = + متقابلتين لكونهما عظيمتين: β.
[xxxv] خطّ السمت] γ، α = خطّ استواء السمت: β.
[xxxvi] الأرض] γ، α = الأفق: β.
[xxxvii] السموت] γ، β = السمت: α.

[٦] ومن الدوائر الصغار[201] المشهورة: مدارات الميول وتسمّى[202] المدارات[203] اليومية أيضاً. وهي[204] صغار[205] موازية لمعدّل النهار، ترتسم[206] من النقط المفروضة بالحركة الأولى. ويسمّى كلّ منها مدار النقطة التي يرتسم بحركتها، ويسمّى[207] ما يقع[208] فوق الأفق من مدار الكوكب قوس نهار ذلك الكوكب، وما يقع تحته قوس ليلية. والتفاضل بين نصف كلّ من قوس نهار الكوكب وقوس ليلية وبين ربع الدور تعديل[209] نهار ذلك الكوكب[210]. وما يقع من قوس نهار الكوكب بين مركزه والأفق يسمّى الدائر الماضي من النهار إن كان أفق الشرق، والدائر الباقي منه[xxxviii] [211] إن كان أفق الغرب. وما يقع من قوس ليلية بين مركزه والأفق يسمّى الدائر الماضي من الليل إن كان أفق الغرب، والدائر الباقي منه إن كان أفق الشرق.

[٧] ومدارات[212] العروض، وهي[213] صغار موازية لمنطقة البروج، ترتسم بحركة النقط المفروضة[xxxix] [214] بحركة الفلك الثامن؛ والمقنطرات، وهي صغار[215]، موازية للأفق، يسمّى ما وقع منها فوق الأفق[216] مقنطرات الارتفاع، وما[217] يقع منها تحته مقنطرات الإنحطاط. ومن المقنطرات، ما يماسّ سطح الأرض على[218] نقطة، ويسمّى الأفق الحسّي، والأفق المذكور آنفاً يسمّى الأفق الحقيقي.

[٨] ومن القسي المشهورة: طول البلد، وهو قوس من معدّل النهار[219] بين تقاطعيه الفوقانيين[xl] [220] مع[221] نصفي نهار[222] مبدأ العِمارة في المغرب والبلد. مبدأها تقاطع مبدأ العمارة[xli] [223] على توالي العمارة[xlii] [224]؛ ومنها، مطالع قوس من فلك البروج وهي ما يطلع[225] من معدّل النهار مع تلك

[xxxviii] منه] γ ، β = –α.

[xxxix] المفروضة] γ ، α = + المتحرّكة: β.

[xl] الفوقانيين] γ، β = –α.

[xli] مبدأها تقاطع مبدأ العمارة] γ = –β، –α.

[xlii] العمارة] γ ، α = + مبدأها تقاطع مبدأ العمارة: β.

القوس؛ ومنها، مطالع جزء من فلك البروج أو مركز كوكب[xliii] [226]. وهي[227] قوس من معدّل النهار بين أوّل الحمل وجزء من المعدّل يكون مع هذا الجزء من فلك البروج أو مركز[228] هذا الكوكب[xliv] [229] على أفق المشرق على التوالي.

[xliii] أو مركز كوكب] γ، β = —α.
[xliv] أو مركز هذا الكوكب] γ، β = —α.

الباب[230] الثالث[xlv] [231] [من المقالة الأولى]

في[232] بيان هيئة الفلك التاسع والثامن وحركتيهما[233] وكيفيّة قسمة الفلك الثامن إلى البروج

وذكر شمّة من أحوال الثوابت

[١] كلّ واحد من هذين الفلكين يحيط به[xlvi] [234] سطحان متوازيان، مركزهما مركز[235] العالم. والفلك التاسع يتمّ[236] دورته في قريب من[237] اليوم بليلته. والفلك الثامن يقطع في كلّ سبعين سنة شمسيّة درجة واحدة، ويتمّ دورته[238] في خمس وعشرين ألف سنة ومائتي سنة، وحركته من المغرب إلى المشرق. ومنطقة الفلك التاسع – كما سبق ذكره[xlvii] [239] – تقطع منطقة الفلك الثامن[xlviii] [240] على نقطتين[xlix] [241]: إحداهما وهي التي إذا جاوزتها[l] الشمس، وقعت[242] في جانب الشمال من المعدّل تسمّى الاعتدال الربيعي[243]، والأخرى تسمّى[244] الاعتدال الخريفي. وغاية البُعد بين تينك الدائرتين[245] [246] تسمّى الميل الكلّيّ. ووُجِدت بالأرصاد مختلفةً، وهي بحسب[247] رصدنا كج ل يز[248]. ونقطتان[249] من فلك البروج عندهما[250][251] غاية الميل تسمّيان نقطتي الانقلاب: إحداهما وهي التي في جانب الشمال تسمّى نقطة الانقلاب الصيفي، والأخرى نقطة الانقلاب الشتوي.

[xlv] الباب الثالث] γ، β = الباب الثاني: = α.
[xlvi] به] γ = بهما: β، α.
[xlvii] كما سبق ذكره] γ، β = ويسمّى معدّل النهار: α.
[xlviii] الثامن] γ، β = + ويسمّى منطقة البروج وفلك البروج أيضاً: α.
[xlix] على نقطتين] γ، β = + تسمّيان نقطتي الاعتدالين: α.
[l] جاوزتها] γ = جاوزته: β، α.

[٢] فتنقسم[252] منطقة البروج بهذه النقط[253] الأربع إلى أربعة أقسام متساوية، ومدّة[254] مكْث الشمس[255] في كلّ قسم من الأقسام الأربعة فصل من فصول السنة الأربعة المشهورة. وتوهّموا في كلّ من الربعين المتلاصقين من هذه الأرباع نقطتين، ينقسم هذا الربع بهما إلى ثلاثة أقسام متساوية. وتوهّموا خمس دوائر من دوائر العروض تمرّ[256] [257] إحداها بنقطتي الاعتدالين، والأربعة الباقية بتلك[258] النقط[259] الأربع. فلا محالة ينقسم فلك البروج بهذه الدوائر الخمس وبالدائرة المارّة بالأقطاب الأربعة إلى إثنى عشر قسماً، كخزّات البطّيخ، تسمّى البروج. طول كلّ برج ثلاثون درجة من منطقة البروج، وعرضه مائة وثمانون درجة من القطب إلى القطب. ثلاثة من هذه البروج ربيعية: وهي الحمل والثور[260] والجوزاء؛ وثلاثة صيفية: وهي السرطان والأسد والسنبلة؛ وثلاثة خريفية: وهي الميزان والعقرب والقوس؛ وثلاثة[261] شتوية: وهي الجدي والدلو والحوت. والكوكب إذا تحرّك من الحمل إلى الثور ثمّ الجوزاء، يقال إنّه تحرّك على[262] توالي[263] البروج. وإذا تحرّك[264] على[265] خلاف ذلك الترتيب، يقال إنّه تحرّك على خلاف توالي البروج. ولمّا كان ابتداء البروج من المغرب، فالحركات الغربيّة كلّها على توالي البروج، والحركات الشرقيّة على خلافها.

[٣] والكواكب الثابتة من الكثرة[266] بحيث لا يمكن عدّها. لكن علماء هذا الفنّ رصدوا ألفاً واثنين وعشرين كوكباً، وعيّنوا مواقعها من فلك البروج. وتوهّموا لتعيين مواضعها ثمانية وأربعين صورة. وقع بعض من تلك الكواكب على نفس الصور – أي على نفس الخطوط – التي[267] تتوهّم تلك الصور منها أو فيما بين تلك الخطوط[268]، ووقع بعضها خارجاً من تلك الخطوط. وإذا[269] أرادوا[270] أن[271] يشيروا إلى كوكب من الكواكب التي على نفس الصورة، قالوا الكوكب الذي على اليد اليمنى من[272] صورة[li] [273]

[li] صورة] γ = —β ، —α.

الأسد مثلاً، أو الرجل اليسرى منها[lii] [274]. وإذا أرادوا[275] أن يشيروا إلى كوكب من الكواكب الخارجة من الصورة، قالوا الكوكب الذي يقرب الرجل اليمنى من صورة الأسد، أو يقرب اليد[276] اليسرى[277] منها مثلاً وعلى هذا القياس. أحد وعشرون من تلك الصور الثماني والأربعين على شمال منطقة البروج، واثنى عشر منها على نفس المنطقة، وخمسة عشر منها على الجنوب.

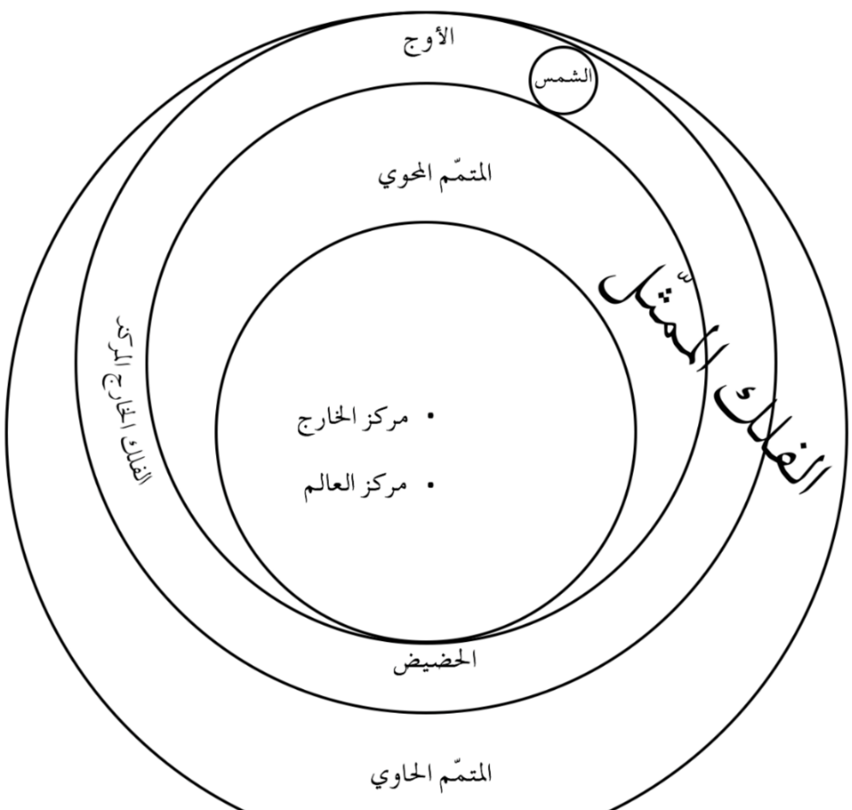
[lii] منها] γ = منه: β ، α.

الباب الرابع [من المقالة الأولى]

في هيئة أفلاك الكواكب السيّارة

[١] للشمس فلكان متوازيا السطحين: أحدهما مركزه مركز العالم مسمّى[278] بالممثّل. وينفصل عنه فلك آخر مركزه خارج عن مركز العالم، ولهذا يسمّى بخارج المركز. يماسّ محدّب سطحيه[279] محدّب سطحي الفلك الأوّل على نقطة مشتركة بينهما تسمّى الأوج. ويماسّ مقعّر سطحيه مقعّر سطحي الفلك الأوّل على نقطة أخرى مشتركة بينهما تسمّى الحضيض. والشمس جرم كريّ مُصمت مركوز في جرم فلكها الخارج المركز[280] بحيث يماسّ سطحها سطحيه على نقطتين مشتركتين.

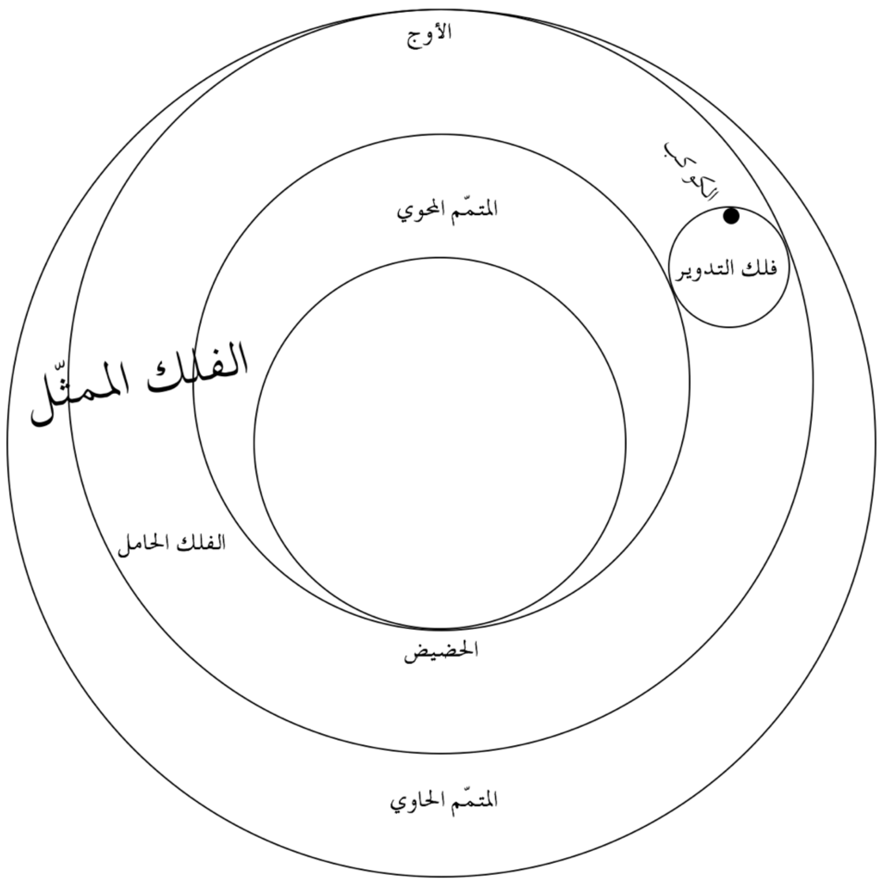
صورة فلك الشمس



[شكل ٢]

[٢] وهيئة[281] أفلاك كلّ من[282] الكواكب العلويّة والزهرة كهيئة فلك الشمس بعينها. لا فرق بينها إلّا بأنّ لكلّ من هذه الأربعة فلكاً آخر مسمّى بالتدوير، وهو جرم كريّ مصمت مركوز في جرم فلك[liii] الخارج المركز بحيث يتساوى[283] قطره ثخنه. والكوكب مركوز فيه بحيث يماسّ[284] سطحاها على نقطة مشتركة[liv] [285].

هيئة أفلاك العلويّة والزهرة

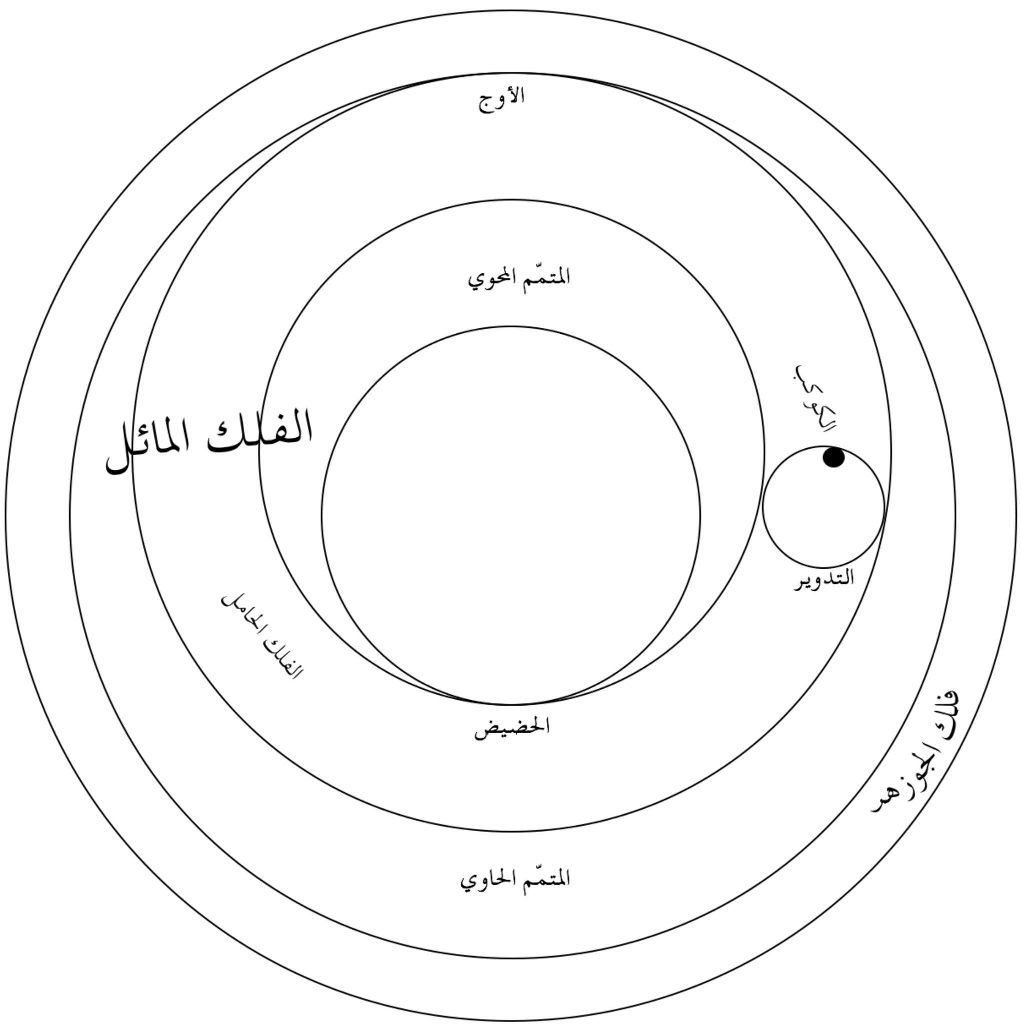


[شكل ٣]

[liii] فلك] γ، β = فلكها: α.
[liv] نقطة مشتركة] γ، β = نقطتين مشتركين: α.

[٣] وهيئة[286] أفلاك القمر كهيئة واحد من هذه الأربعة. لا فرق بينها إلّا بأنّ للقمر فلكاً آخر محيطاً[287] بسائر أفلاكه، مركزه مركز العالم مسمّى بالجوزهر. وفي القمر، يسمّى الفلك المحيط بالخارج المركز بالمائل.

صورة أفلاك القمر



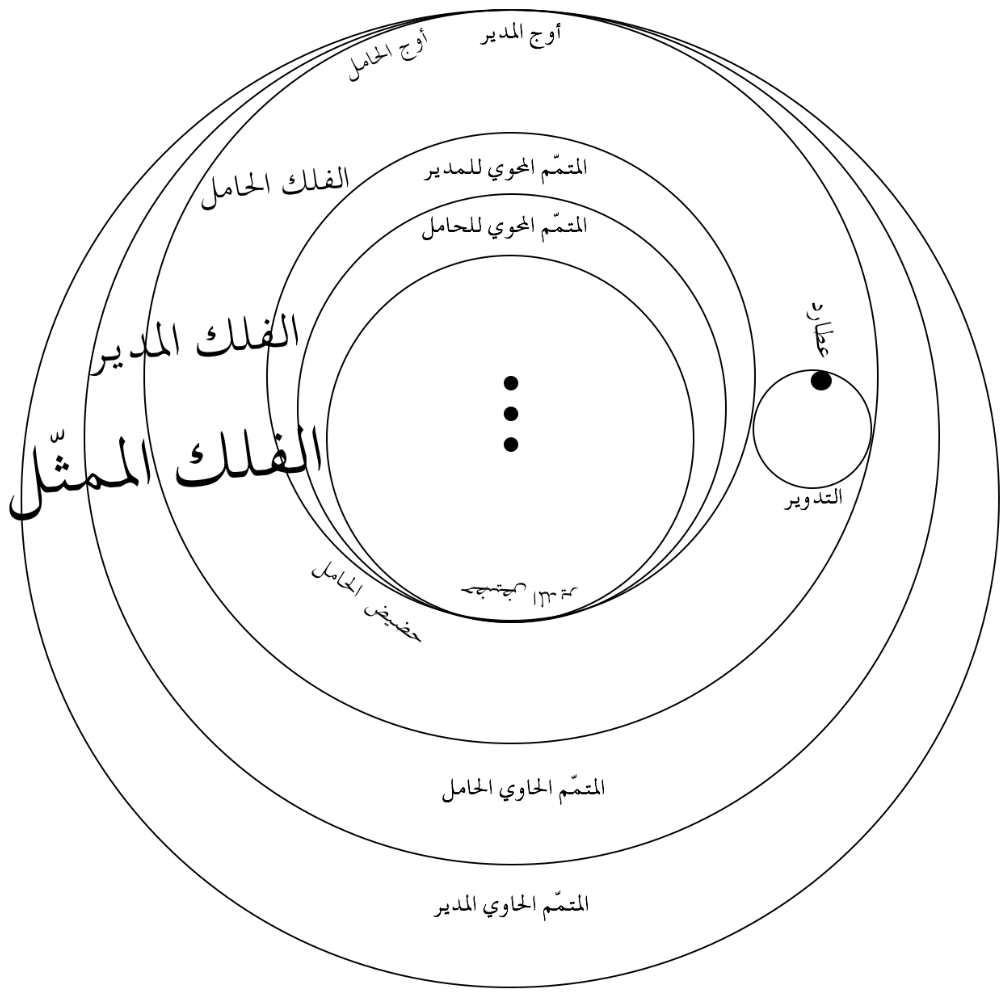
[شكل ٤]

[٤] وهيئة[288] أفلاك عطارد كهيئة أفلاك واحد من هذه الأربعة. لا فرق بينها إلّا بأنّ الفلك الذي ينفصل عنه الفلك الخارج المركز ليس مركزه مركز العالم. بل ينفصل هو أيضاً من فلك آخر[289][290]، مركزه[291] مركز العالم، مسمّى[292] بالممثّل[lv] [293]. وهذا الفلك[294] المنفصل[lvi] [295] يماسّ محدّب[296] سطحيه محدّب سطحي الفلك الممثّل على نقطة مشتركة تسمّي بالأوج. ويماسّ مقعّر سطحيه أيضاً مقعّر سطحي الفلك الممثّل على نقطة مشتركة تسمّى بالحضيض[297]، ويسمّى[lvii] بالمدير.

[٥] فلعطارد أوجان: أحدهما[298] نقطة مشتركة بين محدّبي الممثّل والمدير، والأخرى مشتركة بين[299] محدّبي الخارج المركز والمدير. وهكذا له حضيضان: إحداهما مشتركة بين مقعّري[300] الممثّل والمدير، والأخرى مشتركة بين مقعّري الخارج المركز والمدير. فالنقطة المشتركة بين الممثّل والمدير يقال لها[301] أوج المدير أو حضيضه[302]. والنقطة[303] المشتركة بين المدير والحامل يقال لها أوج الحامل أو[304] حضيضه. والأفلاك الخارجة المراكز التي في ثخنها أفلاك التداوير تسمّى[305] بالأفلاك الحاملة.

[lv] بالممثّل] γ، β = + ومركز: α.
[lvi] المنفصل] γ، β = + خارج عن مركز العالم و: α.
[lvii] ويسمّى] γ، β = وهذا الفلك أعني الفلك الذي ينفصل عن الممثل يسمّى: α.

[صورة أفلاك عطارد]



[شكل ٥]

الباب الخامس [من المقالة الأولى]

في حركات الأفلاك السيّارة

[١] حركات هذه الأفلاك على كثرتها قسمان: أحدهما من المغرب إلى المشرق، والثاني بالعكس. فمن القسم الأوّل: حركات الأفلاك الممثّلة وهي تساوي حركة الثوابت. ويتحرّك بهذه الحركة جميع الأوجات إلّا أوج[306] القمر وأوج حامل عطارد. وحركة خارج مركز الشمس وهي في اليوم بليلته تسع وخمسون دقيقة وثماني[307] ثوانٍ. وحركات الأفلاك الحاملة وهي كلّ يوم:

لزهرة مثل حركة خارج مركز الشمس

ولعطارد[308] ضعفها

ولزحل[309] دقيقتان

وللمشتري أربع دقائق تسع[310] وخمسون ثانية

وللمرّيخ إحدى وثلاثون دقيقة سبع وعشرون ثانية

وللقمر أربع وعشرون درجة واثنتان وعشرون دقيقة وثلاث وخمسون ثانية.

[٢] ومن القسم الثاني: حركة مدير عطارد وهي مثل حركة خارج مركز الشمس. وحركة جوزهر القمر وهي كلّ يوم ثلاث دقائق وإحدى عشر ثانية. وحركة مائل القمر وهي كلّ يوم إحدى عشرة درجة وتسع دقائق وسبع ثواني[311].

[٣] وأمّا[312] أفلاك التداوير، فلأنّها غير شاملة للأرض فحركة أعلاها[lviii][313]، إن كانت إلى التوالي - أعني من المغرب إلى المشرق - لا محالة تكون[314] حركة أسفلها إلى خلاف التوالي، كما[315] في تداوير المتحيّرة. وإن كانت[316] حركة[317] أعلاها إلى خلاف التوالي، تكون[318] حركة أسفلها إلى التوالي،

[lviii] أعلاها] γ = أعليها: β ، α.

كما في تدوير القمر. فحركاتها لا تندرج في هذين القسمين، فالأولى أن تعتبر[319] حركات أعلاها[320]، وتُعدّ[321] حركة تدوير القمر من الحركات الشرقيّة، وحركات باقي التداوير من الحركات الغربية. وحركة التدوير تسمّى الحركة الخاصّة وهي:

لتدوير القمر كلّ يوم ثلاث عشرة[322] درجة وثلاث دقائق وأربع وخمسون ثانية

ولكلّ من الكواكب العلويّة بقدر فضل[323] حركة خارج مركز الشمس على حركة حامله

وللزهرة ستّ وثلاثون دقيقة وثلاث وخمسون ثانية

ولعطارد ثلاث[324] درجات وستّ دقائق وأربع ثوانٍ.[325] [326]

الباب[327] السادس [من المقالة الأولى]

فيما يعرض للكواكب وهو أربعة فصول

الفصل الأوّل [من الباب السادس]

فيما يعرض للكواكب[328] في الطول[329] [330]

[١] طول الكوكب، ويقال له التقويم أيضاً، قوس من منطقة البروج بين أوّل الحمل وموضع الكوكب في الطول على التوالي[331]. وأعني بموضع الكوكب في الطول طرف خطّ يخرج من مركز العالم ويمرّ[332] بمركز الكوكب وينتهي إلى الفلك الأعلى، إن لم يكن للكوكب عرض. وإلّا نقطة تقاطع[333] دائرة عرض تمرّ بطرف ذلك الخطّ مع منطقة البروج، أعني أقرب التقاطعين من طرف الخطّ المذكور. وهذا الخطّ يسمّى بالخطّ التقويمي. والحركة[334] التي يقطع بها الكوكب هذه[lix] القوس تسمّى حركة الطول وحركة التقويم أيضاً.

[٢] ولمّا[335] كان لكلّ من السيّارة أفلاك متعدّدة، ليست حركتها جميعاً[336] متشابهة حول مركز العالم، تكون[337] حركاتها التقويمية[338] مختلفة. فاحتاجوا، لاستخراج تقويم كلّ منها في أيّ وقت أرادوا، إلى ضبط الأوساط والتعديلات[339]. مثلاً للشمس فلكان: أحدهما الممثّل وحركته متشابهة حول مركزه[340] الذي هو مركز العالم، والآخر خارج المركز وحركته متشابهة حول مركزه الذي هو غير مركز العالم. فتختلف[341] حركتها التقويمية حول مركز العالم.

[٣] وللقمر أربعة أفلاك: حركة اثنين منها، وهما الجوزهر والمائل، متشابهة[342] حول مركزهما الذي هو مركز العالم. وكذا حركة الفلك الحامل متشابهة حول[343] مركز العالم، وإن كان القياس يقتضي[344] أن تتشابه[345] حركته حول مركزه[346] الذي هو خارج عن مركز العالم. لكن علموا بالرصد

[lix] هذه] γ، β = هذا: α.

والحساب أنّ[347] حركته[lx] متشابهة حول مركز العالم[348]، وهذا من مشكلات هذا الفن. لكن حركة فلك تدويره، لكونها[lxi] متشابهة حول مركزه، غير متشابهة حول مركز العالم. فلذلك تختلف[349] حركته التقويمية.

[٤] ولكلّ من العلويّة والزهرة ثلاثة أفلاك: أحدها الممثّل وحركته متشابهة حول مركز العالم؛ وثانيها الحامل وحركته ليست متشابهة حول مركز العالم، ولا حول مركز نفسه، وإن كان القياس أن تتشابه حوله. لكن الرصد والحساب اقتضيا أن تكون[350] حركته متشابهة حول نقطة بُعدها عن مركز الحامل في جانب الأوج كبُعد[351] مركز الحامل عن مركز العالم في ذلك السمت، أعني على الخطّ المارّ بالمركزين، وهذا أيضاً من مشكلات هذا الفن[352] [lxii]؛ وثالثها[353] التدوير وحركته متشابهة حول مركز نفسه[354]. فتختلف حركتها التقويمية لهذين السببين.

[٥] ولعطارد أربعة أفلاك: أحدها الممثّل وحركته متشابهة حول مركز العالم؛ وثانيها المدير وحركته متشابهة حول مركزه الذي هو[355] خارج عن مركز العالم؛ وثالثها الحامل وحركته ليست متشابهة حول مركز نفسه، ولا حول مركز العالم، ولا حول مركز المدير، بل حول نقطة هي منتصف الخطّ المارّ بمركزي المدير والعالم. بُعدها عن كلّ منهما مثل بُعد مركز[356] الحامل عن مركز المدير. وهذه النقطة التي تتشابه[357] حركة الحامل حولها[358] في المتحيّرة تسمّى[359] مركز الفلك المعدّل للمسير، وهذا أيضاً من مشكلات هذا الفن[360] [lxiii]؛ ورابعها[361] التدوير وحركته متشابهة حول مركز نفسه، وهو غير مركز العالم. فتختلف[362] حركته التقويمية لهذه الأسباب.

[lx] حركته] γ، β = حركتها: α.

[lxi] لكونها] γ، β = لكونه: α.

[lxii] وهذا أيضاً من مشكلات هذا الفن] γ، β = —α.

[lxiii] وهذا أيضاً من مشكلات هذا الفن] γ، β = —α.

[٦] فثبت أنّ الحركات التقويمية للسيّارات مختلفة، فاضطرّ أهل هذا العلم، لاستخراج تقويم كلّ كوكب في كلّ وقت أرادوا، إلى ضبط الأوساط والتعاديل. والوسط في غير القمر قوس من الممثّل بين أوّل الحمل وطرف الخطّ الوسطي على التوالي. وفي القمر، قوس من المائل بين النقطة المحاذية لأوّل الحمل وطرف الخطّ الوسطي على التوالي. والمراد بالخطّ الوسطي[lxiv] [363] خطّ يخرج من مركز العالم ويمرّ بمركز التدوير، إن كانت حركته متشابهة حوله، كما في القمر. وإلّا خطّ يخرج من مركز العالم[364] موازياً لخطّ يخرج من نقطة تتشابه[365] حركة مركز التدوير أو الكوكب حولها ويمرّ به، كما في سائر السيّارة[366][lxv].

[٧] والحركة[367][368] التي يقطع بها الخطّ الوسطي قوس الوسط تسمّى حركة الوسط. وهي في الشمس والمتحيّرة، سوى عطارد، بمقدار مجموع حركتي الممثّل والخارج المركز. وفي القمر، بمقدار فضل[369] حركة الحامل على التوالي على مجموع حركتي الجوزهر والمائل على[370] خلاف التوالي. وفي عطارد، بمقدار فضل[371] مجموع حركتي الممثّل والحامل على التوالي على حركة المدير على خلاف التوالي.

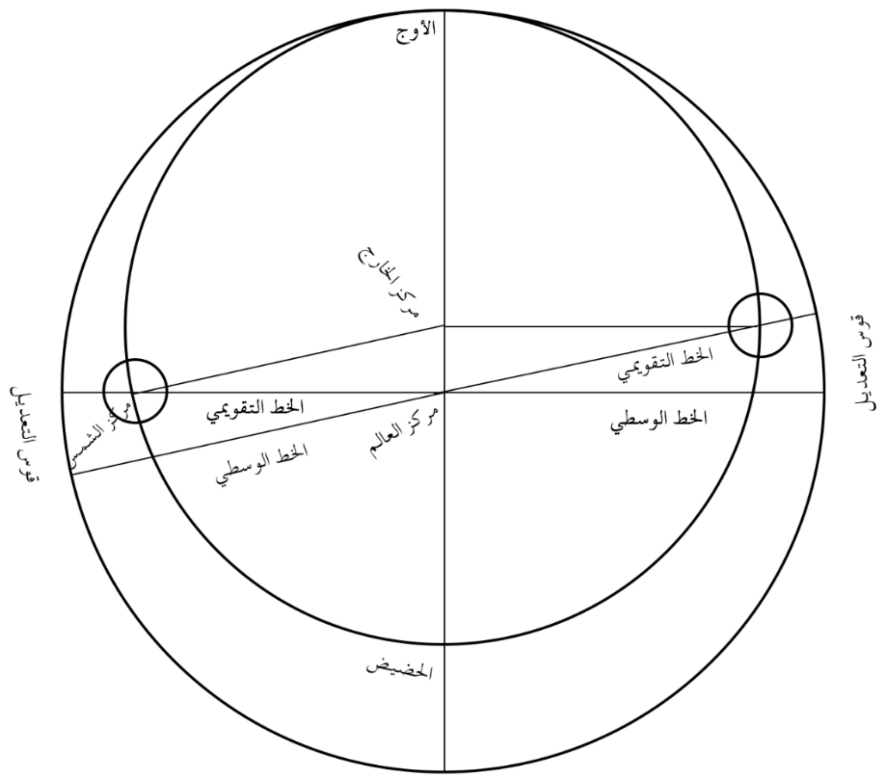
[٨] وأمّا التعديلات[372]، فللشمس تعديل واحد، وهي قوس من الممثّل بين طرفي الخطّ الوسطي[373] والخطّ التقويمي. وما دامت الشمس في النصف الهابط، أعني تحرّكت من الأوج إلى

[lxiv] الوسطي] γ ، β = + في القمر: α.

[lxv] إن كانت حركته متشابهة حوله كما في القمر وإلّا خطّ يخرج من مركز العالم موازياً لخطّ يخرج من نقطة تتشابه حركة مركز التدوير أو الكوكب حولها ويمرّ به كما في سائر السيّارة] γ = إن كانت حركته متشابهة حوله كما في القمر وإلّا خطّ يخرج من مركز العالم موازياً لخطّ يخرج من نقطة تتشابه حركة مركز الشمس أو مركز التدوير حولها ويمرّ به كما في سائر السيّارة: β = وينتهي إلى منطقة المائل وفي الشمس خطّ يخرج من مركز العالم موازياً لخطّ يخرج من مركز الفلك الخارج المركز إلى مركز الشمس وفي المتحيّرة خطّ يخرج من مركز العالم موازياً لخطّ يخرج من مركز المعدّل للمسير إلى مركز التدوير: α.

الحضيض، يُنقصّ التعديل من الوسط ليحصل التقويم. وما دامت في النصف الصاعد، يزاد التعديل على الوسط ليحصل التقويم. ومن هذا الشكل يسهل تصوّر ما قلنا:

[صورة تعديل الشمس]



[شكل ٦]

[٩] وفي[374] المتحيّرة أيضاً، يُحتاج إلى مثل هذا التعديل، لأنّ حركات حواملها ليست متشابهة حول مركز العالم. فالقوس المحصورة من الممثّل بين الخطّ الوسطي وخطّ المركز المعدّل، وهو[375] خطّ يخرج من مركز العالم يمرّ بمركز التدوير، وتسمّى[376] تعديلاً ثالثاً، وأهل العمل يسمّونها[lxvi] [377] تعديلاً أوّل، تنقصّ من الوسط، ما دام مركز التدوير في النصف الهابط– أعني متحرّكاً من الأوج إلى الحضيض– ليحصل المركز المعدّل. وما دام مركز التدوير في النصف الصاعد – أيْ متحرّكاً من

[lxvi] يسمّونها] γ = يسمّونه: β ، α.

الحضيض إلى الأوج – تزاد على الوسط ليحصل المركز المعدّل. وأنا أريد[lxvii] [378] بالمركز المعدّل قوساً[379] من الممثّل بين أوّل الحمل وطرف[380] خطّ[381] المركز المعدّل على التوالي[lxviii] [382].

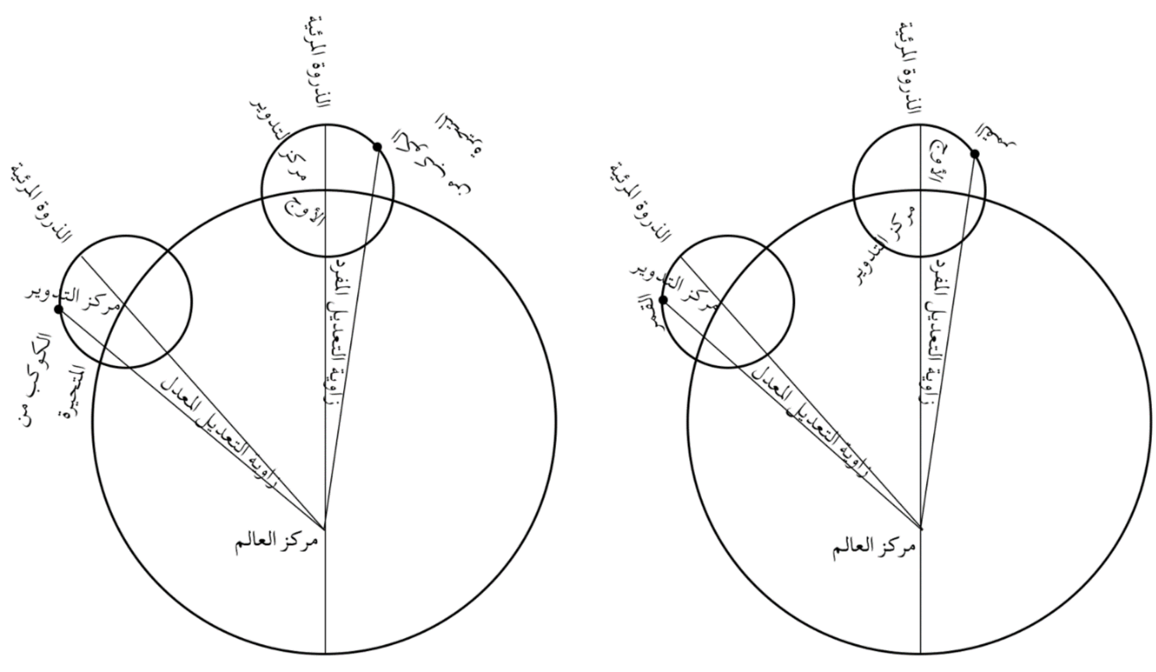
[١٠] والمعتبر في عطارد أوج المدير وحضيضه، ولا حاجة في القمر إلى هذا التعديل، لأنّ حركة حامله متشابهة حول مركز العالم. لكن في القمر والمتحيّرة، يُحتاج إلى تعديل آخر منشاؤه التدوير. بيان ذلك أنّ موقع خطّ المركز المعدّل من الممثّل يُعلم في القمر بمجرّد معرفة وسطه. وفي المتحيّرة، يُعلم توسّط التعديل الثالث، كما ذُكر آنفاً. فإن[383] كان هذا الخطّ ماراً بمركز الكوكب، لم نكن نحتاج في استخراج تقاويم الكواكب إلى عمل، لأنّ هذا الخطّ هو الخطّ التقويمي على هذا التقدير. لكن هذا الخطّ لا يمرّ بمركز الكوكب[384] إلّا عند كون الكوكب في الذروة أو الحضيض المرئيين. والمراد[385] بالذروة والحضيض[386] المرئيين هما نقطتا تقاطع الخطّ المذكور[387] مع محيط التدوير. أبعدهما هو الذروة المرئية، وأقربهما هو الحضيض المرئي.

[١١] وإذا تحرّك الكوكب من الذروة والحضيض المرئيين، يفترق الخطّ التقويمي من خطّ المركز المعدّل ويحيطان بزاوية عند مركز العالم. ثمّ تختلف[388] تلك الزاوية صغراً وكبراً[389] بحسب اختلاف بُعد مركز التدوير من مركز العالم. ففرضوا مركز التدوير[390] في الأوج واستخرجوا مقادير هذه الزوايا بحسب كون مركز الكوكب في جزء جزء من محيط التدوير، وسمّوها تعديلاً أوّل وتعديلاً مفرداً أيضاً. ثمّ استخرجوا ازديادها[391] بحسب كون[392] مركز التدوير في جزء جزء من الحامل، وسمّوا[393] هذه الزيادة[394] تعديلاً ثانياً. وسمّوا مجموع التعديلين تعديلاً معدّلاً.

[lxvii] وأنا أريد] γ، β = والمراد: α.

[lxviii] على التوالي] γ، β = –α.

[١٢] ففي القمر، إذا كان في النصف الهابط من التدوير– أي ذاهباً من[395] الذروة إلى الحضيض– ينقص التعديل المعدّل من الوسط. وفي النصف الآخر، يزاد على الوسط ليحصل التقويم لأنّ القطعة العليا من تدويره تتحرّك إلى خلاف التوالي، والقطعة السفلى من تدويره[396] تتحرّك إلى التوالي. وفي المتحيّرة، إذا كانت في النصف الهابط، يزاد التعديل المعدّل على المركز المعدّل[lxix] [397] ليحصل التقويم. وفي النصف الآخر، ينقص منه[lxx] [398] ليحصل التقويم لأنّ القطعة العليا من تداويرها تتحرّك[399] إلى التوالي، والقطعة السفلى منها[400] تتحرّك إلى خلاف التوالي. ومن هذين الشكلين[401] يسهل تصوّر ما قلنا[lxxi] **[402]**:



[شكل ٧]

[lxix] المركز المعدّل] γ = الوسط: β، α.
[lxx] منه] γ = من الوسط: β، α.
[lxxi] قلنا] γ = ذكرنا: β، α.

[١٣] وبعضهم[403] يفرضون مركز تدوير المتحيّرة في البُعد الأوسط بحسب المسافة من الحامل، وستعرف معنى البُعد الأوسط. ويستخرجون مقدار زاوية يحيط[404] بها خطّ[405] المركز المعدّل وخطّ[406] التقويم بحسب جزء جزء من محيط التدوير في[407] تلك الحالة، أعني عند كون مركز التدوير في البُعد الأوسط. ويسمّون هذه الزاوية تعديلاً أوّل وتعديلاً مفرداً أيضاً. ثم يستخرجون مقدار نقصان هذه الزاوية بحسب كون مركز التدوير في جانب الأوج من البُعد الأوسط، ومقدار زيادتها أيضاً بحسب كونه في جانب الحضيض. ويسمّون كلا من هذه الزيادة والنقصان تعديلاً ثانياً، وكلا من الحاصل بعد الزيادة والباقي بعد النقصان تعديلاً معدّلاً. ثمّ يستخرجون بوسيلة التعديل المعدّل، كما ذكرنا آنفاً، تقاويم المتحيّرة، وهذه الطريقة أشهر. لكنّا آثرنا الطريق الأوّل في الزيج[408] الجديد لسهولة العمل.

[١٤] وليعلم أنّ مركز كرة إذا[409] تحرّك على محيط دائرة حركةً بسيطةً، وجب أن تشابه حركته حول مركز[410] [lxxii] هذه الدائرة[411]، ويتساوى[412] أيضاً[413] بُعده عنه، ويحاذي أيضاً قطر من[414] أقطارها هذا المركز، أعني مركز هذه الدائرة. فهذه الأمور الثلاثة يجب أن تكون[415] محفوظة بالنسبة إلى نقطة بعينها. لكن الأرصاد شهدت على أنّ الأمور الثلاثة قد افترقت في القمر حيث تحرّك مركز تدويره على محيط حامله حركةً بسيطةً إلى نقط ثلاث[416]: فتساوى الأبعاد بالنسبة إلى مركز الحامل؛ والتشابه بالنسبة إلى[417] مركز العالم؛ ومحاذاة القطر بالنسبة إلى نقطة المحاذاة، وهي نقطة على الخطّ المارّ بمركزي[418] العالم والحامل[419]، بُعدها عن مركز العالم كبُعد مركز[420] العالم عن مركز الحامل.

[١٥] وفي المتحيّرة، قد افترقت[421] إلى نقطتين: تساوى الأبعاد بالنسبة إلى مركز الحامل وتشابه الحركة ومحاذاة القطر بالنسبة إلى مركز الفلك المعدّل للمسير[422]، وهذا أيضاً من مشكلات هذا الفن. وطرفا هذا القطر الذي يحاذي في المتحيّرة مركز الفلك المعدّل للمسير، وفي القمر نقطة المحاذاة

[lxxii] مركز] $\gamma = -\beta$ ، $-\alpha$.

يسمّى الأبعد منهما عن مركز العالم الذروة الوسطى؛ والأقرب منهما من مركز العالم الحضيض الأوسط. ويلزم ممّا ذكرنا[423] أن تتّحد[424] الذروتان وكذا الحضيضان عند كون مركز التدوير[425] في الأوج أو الحضيض، وتفترقا[426] إذا زايلهما.

[١٦] ولهذا السبب، يُحتاج في[427] معرفة الخاصة المرئية – أعني قوساً من منطقة التدوير[428] تنحصر بين الذروة المرئية ومركز الكوكب على توالي حركة التدوير وهي التي يستعلم[429] بقوّتها التعديل الأوّل والثاني– إلى تعديل آخر ويسمّى التعديل الثالث. بيان ذلك أنّ الخاصّة الوسطى، وهي قوس من منطقة التدوير بين الذروة الوسطى ومركز الكوكب[430] على توالي حركة التدوير، معلومة في أيّ وقت أردنا، لأنّ حركات التداوير معلومة على ما سبق ذكره. فإذا زدنا ما بين الذروتين على الخاصة الوسطى إذا كان مركز التدوير هابطاً، ونقّصناه منها إذا كان صاعداً، كان الحاصل بعد الزيادة أو الباقي بعد النقصان[431] مقدار الخاصة المرئية. فما بين الذروتين يسمّى تعديلاً ثالثاً. ولأنّ ما بين الذروتين[432] [433] في المتحيّرة بمقدار ما بين الخطّ الوسطى وخطّ المركز المعدّل، لم يزد[434] التعديلات في المتحيّرة على الثلاثة، كما في القمر.

[١٧] وممّا يعرض للكواكب الخمسة المتحيّرة في الطول: الرجعة، والاستقامة، والإقامة. بيان ذلك أنّ الكوكب إذا كان في[435] أعلى التدوير، تُرى حركته على التوالي سريعةً، لإنّه يرى متحرّكاً على التوالي[436] بمجموع الحركتين إذ حركة حوامل المتحيّرة –كما عرفته – على التوالي. وعرفت أيضاً أنّ[437] أعلى تداوير المتحيّرة يتحرّك على التوالي[438]، فيرى الكوكب مستقيماً. وإذا انتقل إلى أسفل التدوير –وقد سبق أنّ أسفل تداوير[439] المتحيّرة يتحرّك على خلاف التوالي – فتبطؤ[440] حركته على التوالي، لأنّه يرى حينئذٍ[441] بقدر فضل[442][443] حركة الحامل على التوالي على حركة التدوير على خلاف[444] التوالي.

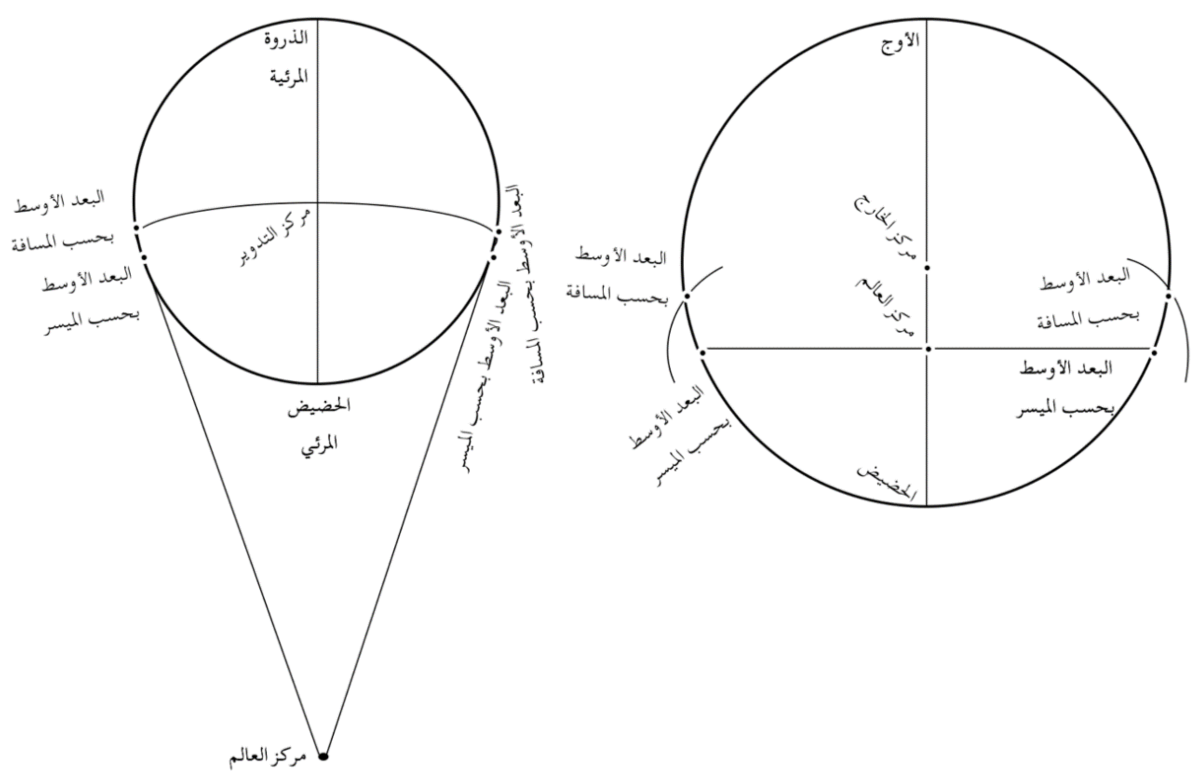
[١٨] وكلّما قرب من الحضيض، تسرع[445] حركة التدوير على خلاف التوالي، فيقلّ[446] الفضل المذكور ويشتدّ بطؤه. لكن ما دام حركة الحامل على التوالي[lxxiii] [447] أزيد[448] من حركة التدوير على خلاف التوالي، تُرى[449] الحركة المركّبة بقدر الفضل المذكور على التوالي. ويكون الكوكب باقياً على الاستقامة إلى أن[450] تقاوم حركة التدوير على خلاف التوالي مع حركة الحامل على التوالي، فيُرى الكوكب مقيماً إلى أن تفضل[451] حركة التدوير على خلاف التوالي على حركة الحامل على التوالي، فيُرى الكوكب راجعاً[452]. وكلّما قرب من الحضيض، يسرع في الرجعة إلى أن يصل الكوكب إلى الحضيض، وهناك غاية سرعته في[453] الرجعة.

[١٩] وإذا جاوز الحضيض، يبطؤ في الرجعة. وكلّما بعُد عن الحضيض، يزيد بطؤه في الرجعة إلى أن يصير مقيماً ثانياً. ثمّ يستقيم ويسرع في الاستقامة. كلّما قرب من الذروة إلى أن يصل إلى الذروة، وهناك غاية سرعته في الاستقامة، وتعود[454] الحالة الأولى. ويظهر ممّا ذكرنا أنّ الكوكب في ذروته على التدوير يصير مقيماً مرّتين: مرة بعد الاستقامة وقبل الرجعة وهو المقام الأوّل، وأخرى بعد الرجعة وقبل الاستقامة وهو المقام الثاني.

[٢٠] وممّا يعرض للكواكب السبعة السيّارة، اختلاف[455] أحوالها[456] بالصعود والهبوط والاستعلاء والانخفاض. بيان ذلك أنّ علماء هذا الفن[457] قسّموا كلّ واحد من فلكي[458] الخارج والتدوير أربعة أقسام تسمّى نطاقات: اثنان منها علويّان متساويان، واثنان منها سفليّان متساويان. ومبدأ القسم الأوّل هو الأوج في الخارج، والذروة[459] في التدوير بالاتّفاق. وكذا مبدأ القسم الثالث هو الحضيض فيهما بالاتّفاق.

[lxxiii] على التوالي] γ = –β ، –α.

[٢١] لكن مبدأ القسمين الآخرين مختلَف فيه. فمنهم من اعتبر الأبعاد، فجعل مبدأ القسمين حيث يكون البُعد متوسّطاً في البُعد والقرب. وذلك في الحامل مقطعا منطقته مع دائرة مرسومة على مركز العالم ببُعد[460] نصف[461] قطر الحامل؛ وفي التدوير مقطعا منطقته مع منطقة الحامل. ومنهم من اعتبر المسير، فجعل مبدأ القسمين المذكورين حيث يكون السير متوسّطاً في البطؤ السرعة[462]. وذلك في الحامل طرفا خطّ[463] يخرج من مركز العالم عموداً على الخطّ المارّ بالمركزين منتهياً إلى محيط الحامل من الجانبين. وفي التدوير، نقطتا تماسّ منطقته مع خطّ يخرج من مركز العالم. والكوكب في النطاقين الأوّل والثاني هابط، وفي النطاقين الآخرين صاعد. وفي النطاق الأوّل والرابع مستعلٍ[464]، وفي النطاقين الآخرين منخفض[465]. ومن هذين الشكلين يسهل تصوّر ما ذكرنا[466]:



[شكل ٨]

[٢٢] ونحن[467] نختم هذا الباب بذكر مقادير أقطار التداوير وما بين المراكز: فنقول بُعد مركز خارج مركز الشمس عن مركز العالم درجتان ودقيقة واحدة[lxxiv] [468] وعشرون ثانية بما به نصف قطر الخارج ستّون[lxxv] [469]. وبُعد مركز حامل القمر عن مركز العالم، بما به نصف قطر المائل ستّون، عشر درجات وثلاث وعشرون دقيقة. وبتلك الأجزاء[470] نصف قطر[lxxvi] [471] تدوير القمر خمس درجات واثنتا عشر[472] دقيقة. وبُعد مركز الحامل عن مركز العالم:

لزحل ثلاث درجات وتسع وعشرون دقيقة

وللمشتري درجتان وسبع وأربعون دقيقة

وللمرّيخ ستّ درجات وأربع عشرة[473] [474] دقيقة

وللزهرة اثنتان وخمسون دقيقة.

[٢٣] أمّا بُعد مركز حامل عطارد عن مركز العالم، فهو متفاوت، يزيد[475] وينقص من تسع درجات إلى ثلاث درجات. بيان ذلك أنّ بُعد مركز حامله عن مركز المدير ثلاث درجات. وكذلك بُعد مركز المدير عن مركز معدّل المسير وبُعد مركز معدّل المسير عن مركز العالم كلّ منهما[476] ثلاث درجات. لكن المدير يدير[477] مركز الحامل حول مركز نفسه على مدار يسمّى مدار مركز الحامل. فيلزم أن ينطبق مركز الحامل على مركز معدّل[478] المسير في دورة مرة[lxxvii]، وحينئذٍ يكون بُعده عن مركز العالم ثلاث درجات. ويقاطره مرّة أخرى وحينئذٍ يكون بُعده عن مركز العالم تسع درجات. وفي باقي

[lxxiv] واحدة] γ = –β ، –α.
[lxxv] بما به نصف قطر الخارج ستّون] γ = –β ، –α.
[lxxvi] قطر] γ = –β ، –α.
[lxxvii] مرة] γ، β = مرّتين: α.

الأحوال، يكون بين ثلاث درجات وتسع درجات. كلّ ذلك بما به نصف قطر حامل ذلك الكوكب[479] ستّون، وبهذه الأجزاء نصف قطر التدوير:

لزحل ستّ درجات وإحدى[480] وخمسون دقيقة

وللمشتري إحدى عشرة درجة وسبع وأربعون دقيقة

وللزهرة ثلاث وأربعون[481] درجة[482] وعشر دقائق[lxxviii] [483]

وللمرّيخ تسع وثلاثون درجة[484] وثلاث[485] وأربعون دقيقة

ولعطارد اثنتان[486] وعشرون درجة وثلاثون دقيقة.

وجميع تلك المقادير بحسب رصدنا، بعضها موافق للأرصاد السابقة وبعضها[487] مخالف لها.

[lxxviii] وعشر دقائق] γ = واثنتا عشرة دقيقة: β، α.

الفصل الثاني [من الباب السادس]

فيما يعرض للكواكب في العرض

[١] لا عرض للشمس، لانّ منطقتي ممثّلها وخارجها كلتاهما في سطح منطقة البروج.

[٢] وباقي الكواكب تارةً في شمال منطقة[488] البروج، وأخرى في جنوبها، أو على نفسها، لأنّ مناطق حواملها تقاطع منطقة البروج على نقطتين تسمّيان الجوزهرين. فالتي هي مجاز الكوكب إلى الشمال تسمّى رأساً، والأخرى ذنباً؛ هذا في القمر والعلويّة. وأمّا السفليّان، فرأس الزهرة[lxxix][489] مجازها إلى الأوج، ورأس عطارد مجازه إلى الحضيض، ويقابلها الذنب.

[٣] والدوائر التي تحدث في سطح الفلك الأعلى من توهّم قطع منطقة الحامل للأفلاك تسمّى الأفلاك المائلة، وغاية هذا الميل:

للقمر خمس درجات

ولزحل درجتان ونصف[490]

وللمشتري درجة وثُلث درجة

للمرّيخ درجة واحدة

وللزهرة سُدس درجة

ولعطارد[491] ثلاثة أرباع درجة.

[٤] وهذا الميل ثابت في القمر والعلويّة. وأمّا في السفليّين، فغير ثابت، بل ينطبق سطح الفلك المائل على سطح منطقة[492] البروج عند وصول مركزي تدويرهما إلى الجوزهرين. وبعد مجاوزتهما[493] عنها، يميل نصف الفلك المائل الذي فيه مركز التدوير أمّا[494] للزهرة فإلى الشمال، وأمّا

[lxxix] الزهرة] γ، β = + هي: α.

لعطارد فإلى الجنوب. وهذا الميل يتزايد إلى أن يبلغ مركز التدوير[495] إلى منتصف ما بين العقدتين، وهناك غاية الميل. ثمّ يتناقص إلى أن يبلغ مركز التدوير إلى العقدة الأخرى، وتنطبق[496] منطقة المائل على منطقة البروج ثانياً. ثمّ يميل النصف الذي وصل إليه[497] مركز التدوير[498] [499] أمّا للزهرة فإلى الشمال، وأمّا لعطارد فإلى الجنوب. ويتزايد إلى أن يبلغ غايته في منتصف ما بين العقدتين. ثمّ يتناقص إلى أن تتطابق[500] المنطقتان عند وصول مركز التدوير إلى العقدة الأولى، وتعود[501] الحالة الأولى. ويلزم ممّا ذكرنا أن يكون مركز تدوير الزهرة أبداً شمالياً عن منطقة البروج، ومركز تدوير عطارد أبداً جنوبياً عنها.

[٥] وليس للقمر غير هذا العرض، لأنّ مناطق المائل والحامل والتدوير في سطح واحد. وللمتحيّرة، عرض آخر يسمّى ميل الذروة والحضيض، وهو أنّ القطر[502] المارّ بالذروة[503] والحضيض لا يكون في سطح المائل؛ أمّا في العلويّة، إلّا عند كون مركز[504] التدوير في إحدى نقطتي[505] الرأس والذنب[506] [lxxx]. فإذا جاوز مركز التدوير عن الرأس، أخذت الذروة في الميل عن سطح المائل إلى الجنوب والحضيض إلى الشمال. ويتزايد الميل[507] [lxxxi] إلى أن يبلغ المركز التدوير ما بين العقدتين، وهناك غاية الميل. ثمّ يتناقص الميل إلى أن ينعدم عند وصول مركز[508] التدوير إلى الذنب. وهناك يدخل القطر المار بالذروة والحضيض في سطح المائل. ثمّ إذا جاوز مركز التدوير الذنب، أخذت الذروة في الميل إلى الشمال عن السطح المائل، والحضيض إلى الجنوب عنه. ويتزايد إلى أن يبلغ غايته عند وصول مركز التدوير إلى منتصف ما بين العقدتين. ثمّ يتناقص إلى[509] أن ينعدم عند الوصول إلى الرأس[510]، وتعود[511]

[lxxx] والذنب] γ = أو الذنب: β، α.

[lxxxi] الميل] γ، β = –α.

الحالة الأولى[512]. ويلزم ممّا ذكرنا أن تكون[513] الذروة[514] أبداً من المائل في جانب منطقة البروج، والحضيض بخلاف ذلك.

[٦] وأمّا في السفليين، إلّا عند كون مركز التدوير في منتصف ما بين العقدتين، وهناك الأوج والحضيض لهما، فعند الأوج، تبتدئ[515] ذروة التدوير في الميل للزهرة إلى الشمال، ولعطارد إلى الجنوب. وعند الحضيض، بالخلاف[516] فيهما، ويبلغ[517] الميل غايته عند العقدتين، وازدياده[518] وانتقاصه والانطباق على الرسم[519]، وغاية هذا الميل:

لزحل ستّ درجات

وللمشتري درجتان وستّ وأربعون دقيقة

وللمرّيخ درجتان وسبع دقائق

وللزهرة درجتان ونصف

ولعطارد[520] ستّ درجات وربع.

[٧] وليس للعلويّة عرض غير[521] ما ذكر. ولكن للسفليّين خاصّةً عرض آخر يسمّى[522] عرض الوِراب والاِنْحِراف والاِلْتِواء والاِلتِفاف[523]. وهو أنّ القطر المارّ بالبُعدين الأوسطين، أعني القطر المقاطع[524] للقطر المارّ بالذروة والحضيض على قوائم، لا يكون في سطح منطقة البروج ولا في سطح الفلك المائل، إلّا عند بلوغ مركز التدوير إحدى نقطتي الرأس والذنب، وانطباق المائل على منطقة البروج. فإن كانت النقطة الرأس، ابتداء الطرف المسائي من ذلك القطر يميل إلى الشمال، والطرف الصباحي إلى الجنوب. ويتزايد الميل إلى أن يبلغ غايته في منتصف ما بين النقطتين، وهناك[525] أوج الزهرة وحضيض عطارد. ثمّ يتناقص إلى أن ينعدم عند بلوغ[526] مركز التدوير[527] الذنب، وينطبق القطر المارّ بالبعدين الأوسطين على سطح[528] المائل. ثمّ إذا جاوز مركز التدوير الذنب، ابتداء الطرف المسائي من ذلك القطر يميل[529] إلى الجنوب، والصباحي إلى الشمال، إلى أن يبلغ غايته في منتصف ما بين

النقطتين. ثمّ يتناقص إلى أن ينعدم عند بلوغ مركز التدوير الرأس ثانياً، وتعود[530] الحالة الأولى. وغاية[531] هذا الميل للزهرة ثلاث درجات ونصف درجة، ولعطارد سبع درجات.

[٨] ولنختم هذا الفصل بذكر مواضع الأوجات والجوزهرات التي تتحرّك بحركة الثوابت. فنقول في غرّة محرّم سنة ثمانمائة وإحدى[532] [533] وأربعين من الهجرة النبويّة – عليه الصلاة والسلام[534] – وهي التاريخ الذي وضعنا عليه الزيج الجديد:

كان أوج الشمس في[535] درجتين وستّ وعشرين دقيقة من السرطان[536]

وأوج زحل في ستّ عشرة درجة وستّ وخمسين دقيقة من القوس

وأوج المشتري في تسع وعشرين درجة واثنتين[537] وثلاثين دقيقة من السنبلة

وأوج المرّيخ في إحدى[538] وعشرين درجة وسبع وخمسين دقيقة من الأسد

وأوج الزهرة في اثنتين[539] وعشرين درجة وخمس وعشرين دقيقة من الجوزاء

وأوج عطارد في[540] أربع درجات[541] وثمانية وعشرين دقيقة من العقرب.

[٩] وأمّا الجوزهرات، فرأس زحل[542] متأخّر عن أوجه بثلاث درجات[543]؛ ورأس المشتري متقدّم على[544] أوجه باثنتين[545] وثمانين درجة؛ ورأس المرّيخ متقدّم على أوجه بأربع وتسعين درجة؛ ورأس الزهرة متقدّم على أوجه بتسعين درجة؛ ورأس عطارد متأخّر عن[546] أوجه بتسعين درجة. كلّ ذلك بحسب رصدنا.

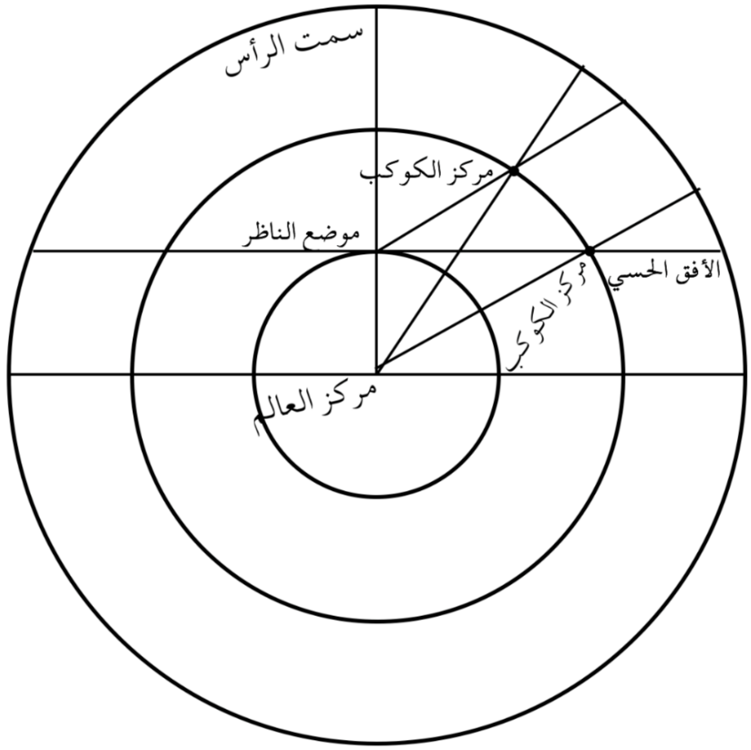
الفصل الثالث [من الباب السادس]

فيما يعرض للكواكب في الطول والعرض معاً

[١] قد يعرض للكواكب[547] القريبة من الأرض، وخصوصاً للقمر، أن تخالف مواضعها الحقيقية[548] مواضعها[549] المرئية[lxxxii][550]. والمراد بالموضع الحقيقي طرف خطّ يخرج من مركز العالم ويمرّ بمركز الكوكب وينتهي إلى سطح الفلك الأعلى. والمراد بالموضع المرئي طرف خطّ يخرج من مركز العالم موازياً للخطّ الخارج من منظر الأبصار[551] إلى مركز الكوكب[lxxxiii][552] منتهياً إلى الفلك الأعلى. فإن[553] كان الكوكب على سمت الرأس، انطبق الخطّان المذكوران. وإذا زايل عن سمت الرأس، افترق الخطّان المذكوران، وحدث بينهما[554] زاوية تسمّى[555] زاوية[556] اختلاف المنظر. والقوس التي تنحصر بينهما من دائرة الارتفاع[557] تسمّى قوس[558] اختلاف المنظر[559]. وهذه صورته:

[lxxxii] مواضعها الحقيقية مواضعها المرئية] γ = موضعه الحقيقي موضعه المرئيّ: β ،α.
[lxxxiii] إلى مركز الكوكب] γ، β = —α.

[صورة اختلاف المنظر]



[شكل ٩]

[٢] وكلّما[560] قرب[561] الكوكب من الأفق الحسّي، يعظم اختلاف المنظر، وغاية[562] عظمه عند الأفق الحسّي. والقوس التي تنحصر من دائرة الارتفاع بين الأفق الحقيقي وموضعه الحقيقي هو ارتفاعه الحقيقي. والتي تنحصر[563] بينه وبين موضعه المرئي هو ارتفاعه[564] المرئي، والارتفاع المرئي أقلّ دائماً من[565] الارتفاع الحقيقي. وإذا أجيز[566] دائرتا عرض بموضعي[567] الكوكب الحقيقي والمرئي، فإن انطبقت الدائرتان، وذلك إنّما يكون إذا كان الكوكب على دائرة وسط سماء الرؤية، لا يكون للكوكب اختلاف طول، واختلاف المنظر بعينه يكون اختلاف العرض[568]. وقد يكون الكوكب على نفس منطقة البروج

حين مرورها على سمت الرأس[569]. وحينئذٍ[570] يكون اختلاف منظره اختلاف الطول بعينه، ولا[571] يكون للكوكب عرض ولا اختلافه.

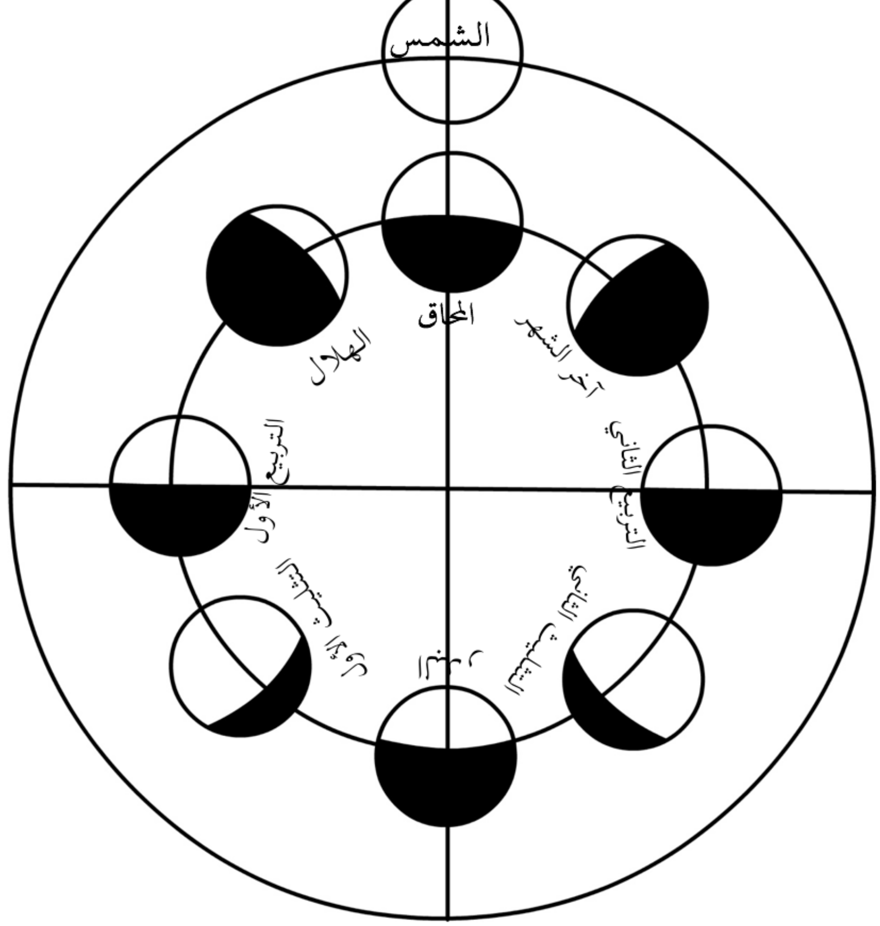
[٣] وفي غير هاتين الحالتين، تتقاطع[572] دائرتا عرض تمرّان بموضعيه[573] الحقيقي والمرئي على قطبي البروج. فتقاطعان[574] منطقة البروج على نقطتين أخرين، وما ينحصر[575] بينهما من منطقة البروج يكون اختلاف الطول. لكن قد يتساوى عرضاه الحقيقي[576] والمرئي، فلا يكون له في هذه الحالة اختلاف عرض.

الفصل الرابع [من الباب السادس]

فيما يعرض للكواكب في أوضاع ما بينها[lxxxiv] منها

[١] اختلاف نور[577] القمر كمالاً ونقصاناً، بيان ذلك أنّ القمر جرم صقيل يقبل الضوء من الشمس، ولأنّه كريّ أصغر من الشمس، يكون المضيء[lxxxv] [578] أكبر من نصفه بقليلٍ. فنصفه تقريباً[lxxxvi] [579] المواجه للشمس يكون دائماً مضيئاً، والنصف الآخر دائماً[580] مظلماً. ففي الاجتماع، يكون نصفه المواجه لنا مظلماً وذلك هو المحاق. ثمّ إذا بَعُد عنها قريباً من اثني عشرة درجة، مال نصفه[581] المضيء إلينا فنرى طرفاً منه وهو الهلال. وكلّما ازداد بُعده عنها، ازداد ميل النصف المضيء إلينا. فازداد ضياؤه حتّى إذا[582] قابلها[583]، صرنا بينهما[584]، وصار[585] ما يواجهها يواجهنا وهو البدر. فإذا انحرف عن المقابلة، مال إلينا شيء من نصفه[586] المظلم. ثمّ يأخذ الظلام في الزيادة، والضياء في النقصان، إلى أن يمحق ثانياً. وهكذا إلى غير النهاية. وإن اشتبه عليك شيء[lxxxvii] [587]، فاستعن بهذا الشكل:

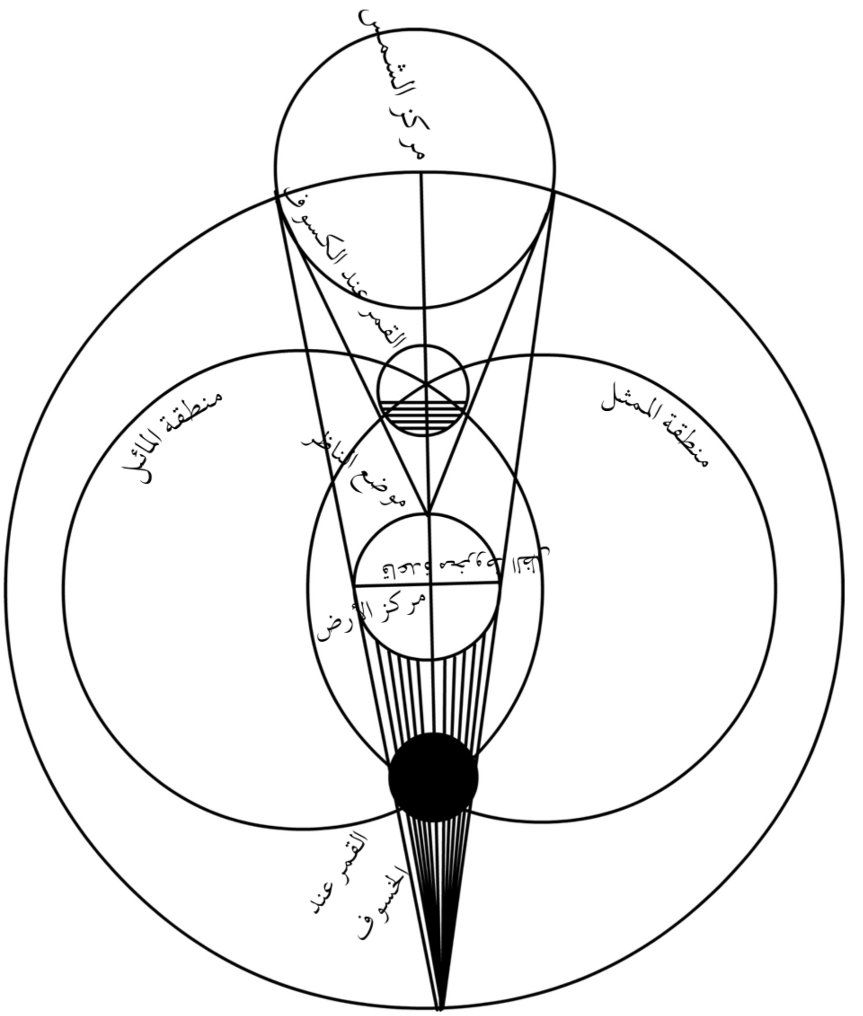
[lxxxiv] بينها] γ = بينهما: β، α.
[lxxxv] المضيء] γ، β = + نصفه بل: α.
[lxxxvi] تقريباً] γ، β = –α.
[lxxxvii] شيء] γ، β = –α.



[شكل ١٠]

[٢] ولذلك[588] إذا كان القمر عند الاجتماع أو حواليه على[589] طريقة الشمس – وذلك عند الرأس أو الذنب أو حواليهما[590] – حال القمر بينها وبيننا، ويستر ضوءها عنّا كلاً أو بعضاً، وهو كسوف الشمس. والسواد الذي يظهر فيها هو لون القمر، ولهذا يبتدئ سوادها وكذا انجلاءها من جهة المغرب. وإذا كان عند الاستقبال في طريقة الشمس، حال الأرض بينهما ولم يصل ضوء الشمس إليه. فيبقى على

ظلامه الأصلي، وهو خسوف القمر. ويبتدئ خسوفه[lxxxviii] [591] وانجلاؤه[592] من[593] جهة المشرق، لأنّه يلحق ظلّ الأرض من جهة المغرب. فيصل طرفه[594] الشرقيّ أوّلاً إلى الظلّ. وكذلك يكون مرور طرفه الشرقيّ بالظلّ أوّلاً، فيبتدئ منه الانجلاء[595].



[شكل ١١]

[lxxxviii] خسوفه] γ = خسوف القمر: β، α.

[٣] ومنها[596] ما يعرض للقمر بالقياس إلى الشمس، وهو توسّطها بين أوجه ومركز تدويره. بيان ذلك أنّ الشمس وأوج القمر ومركز تدويره إذا اجتمعت في جزء من فلك البروج – وليكن أوّل الحمل مثلاً – ثمّ يتحرّك[597] مركز التدوير[598] بحركة[599] الحامل كلّ يوم كدكب[600] دقيقة؛ والمائل مع الجوزهر يحرّكان الأوج على خلاف التوالي كلّ يوم يا يب[601] دقيقة، ويردّان[602] مركز التدوير بهذا المقدار[603][604]، فيبقى بُعد مركز التدوير عن الشمس يج ي[605] دقائق[606]. فإذا[607] تحرّكت الشمس ٠ نط[608] دقيقة، صار بُعدها[lxxxix] [609] عن كلّ من أوج القمر ومركز تدويره[610] يب يا[611] دقيقة[xc] [612]. ولذلك تسمّى حركة الحامل البعد المضاعف، أيّ ضِعف بُعد مركز التدوير عن الشمس[xci]. ويلزم ممّا ذكرنا أن يكون مركز[613] التدوير [614] أبداً، في الاجتماع والاستقبال، في الأوج؛ وفي التربيع، في الحضيض. وأن يبلغ مركز التدوير في كلّ شهر مرّتين إلى الأوج ومرّتين إلى الحضيض.

[٤] ومثل هذا التوسّط[615] يعرض لأوج مدير عطارد مع مركز تدويره وأوج حامله. وذلك[616] لأنّ مركز تدويره إذا اجتمع مع أوجه في جزء من فلك البروج – وليكن أوّل الحمل مثلاً – ثمّ تحرّك مركز التدوير على التوالي بحركة حامله[617] بقدر[618] ضعف حركة مركز الشمس، وحرّك[619] المدير أوج الحامل بقدر حركة مركز الشمس إلى خلاف التوالي، وردّ مركز التدوير أيضاً بهذا المقدار، صار بُعد أوج المدير عن كلّ من أوج حامله ومركز تدويره بقدر[620] مركز الشمس. ويلزم ممّا ذكرنا أن[621] يبلغ مركز تدوير عطارد، من حين مفارقة أوج المدير إلى معاودته إليه، إلى كلّ من أوج الحامل وحضيضه مرّتين.

[lxxxix] بُعدها] γ = بعد الشمس: β، α.
[xc] دقيقة] γ = –β، –α.
[xci] الشمس] γ ، β = الأوج: α.

[٥] ومنها ما يعرض للمتحيّرة بالقياس إلى الشمس: أمّا للعلويّة، فهو أنّ بُعد مراكز[622] العلويّة عن[623] ذرى[624] تداويرها[625] مثل[626] بُعد مراكز تداويرها[627] عن مركز[628] الشمس. فاحتراقات العلويّة أبداً في الذروة في وسط الاستقامة، ومقابلاتها في الحضيض في وسط الرجعة. ولهذا كان المرّيخ في الاحتراق أبعد من الشمس[629] منه في[630] المقابلة، لأنّه يُبيّن[631] [632] في مباحث الأبعاد والأجرام[633] [634] أنّ قطر تدوير المرّيخ أعظم بكثير من قطر ممثّل الشمس مع ثخانة متمّم المرّيخ[635].

[٦] وأمّا للسفليّين، فهو أنّ مركزي تدويرهما أبداً مسامتان لمركز[636] الشمس. لا يبعد[xcii] [637] مركز السفليّين عنه[638] إلّا بمقدار ما يقتضيه نصف قطر التدوير[639] [640]. هذا هو المشهور بين أهل الصناعة[641]، وهو كلام ظاهريّ. والتحقيق أنّ أوساطها متوافقة لا تزول[642] عن التوافق قط.

[xcii] يبعد] γ = يبعدان: β، α.

المقالة الثانية[643]

في بيان هيئة[644] الأرض وقسمتها[xciii] إلى الأقاليم وبيان ما يلزمها[xciv] بحسب أوضاع العلويّات

وهي عشرة[645] أبواب

الباب الأوّل[646] [من المقالة الثانية]

في بيان هيئة[647] الأرض[xcv] [648] وقسمتها[649] إلى الأقاليم[650]

[١] الأرض كريّة الشكل، وتبتني[651] على كرويتها مسألة غريبة: وهي أنّه لو تيسّر[652] السير على جميع الأرض، وفُرض[653] تفرّق ثلاث[654] أشخاص من موضع معيّن بأن سار أحدهم[655] نحو المغرب والآخر نحو المشرق، وأقام[656] الثالث حتّى عاد إليه السائر إلى[657] المغرب من المشرق والسائر إلى المشرق من المغرب في وقت واحد، كانت[658] الأيّام التي عدّها الغربيّ في مدّة الدور أنقص من أيّام المقيم بواحد، وأيّام[659] الشرقيّ أزيد منها أيضاً بواحد. وتتفرّع[660] عليها مسائل غريبة[661]، يُسأل عنها كما يقال: هل[xcvi] [662] يجوز أن يكون يوم بعينه جمعة عند شخص، وخميساً عند آخر، وسبتاً عند ثالث، وغير ذلك ممّا[663] هو من هذا القبيل؟ ويجاب بالجواز ويُستغرب.

[٢] ويُفرض[xcvii] [664] عليها ثلاث دوائر: إحداها في سطح معدّل النهار وهي خطّ الاستواء؛ والثانية في سطح أفق الاستواء[665]؛ والثالثة في سطح دائرة نصف النهار. وكلاهما في منتصف[666] المعمورة بخطّ الاستواء: فالأولى تقطع[667] الأرض بنصفين جنوبي وشمالي[668]؛ والثانية تنصّف[669] كلّ

[xciii] وقسمتها] γ، β = وقسمته: α.
[xciv] يلزمها] γ، β = يلزمه: α.
[xcv] الأرض] γ = + وعرضها وطولها: β، α.
[xcvi] هل] γ، β = –α.
[xcvii] ويُفرض] γ = ونفرض: β، α.

واحد من[670] [xcviii] النصفين المذكورين، فتصير[671] الأرض بهما أرباعاً، ربعان جنوبيان وربعان شماليان. والمعمور منها أحد الربعين الشماليين وهو المشهور بالربع المسكون. لكن ذلك الربع تمامه غير معمور[672]، بل عرض المعمور ستّ وستّون درجة[673] [xcix] ونصف، وطوله مائة وثمانون وابتداؤه من المغرب عند اليونانيّين. إلّا أنّ بعضهم يأخذه[674] من ساحل البحر الغربيّ، وبعضهم من جزائر مسماة بجزائر[675] الخالدات وجزائر السعداء، بُعدها من الساحل عشر درجات، كانت في القديم معمورة والآن مغمورة؛ والثالثة تقطع[676] المعمورة بنصفين غربيّ وشرقيّ ونقطة التقاطع بين[677] الدائرة الأولى والثالثة تسمّى[678] قبّة الأرض.

[٣] ثمّ[679] قسّموا معظم المعمورة[680] [c] من الربع المسكون، وهو ما يجاوز عشر درجات[681] في العرض إلى حدود خمسين. وبعضهم قسّموا تمام المعمور سبع قطاع دفيّة مستطيلة على موازاة خطّ الاستواء، تسمّى[682] أقاليم. كلّ إقليم يحيط به نصفا مدارين متوازيين وقوسان من أفق القبّة، يكون مقدارهما[683] قليلاً، وهو مقدار ما يوجب تفاضل نصف ساعة في مقدار النهار[684] الأطول. ومبادئ[685] الأقاليم وأوساطها وساعات النهار الأطول هي هذه: أمّا الأوّل فمبدؤه عند الجمهور حيث نهاره الأطول اثنتا عشرة ساعة ونصف ورُبع، وعرضه اثنتا عشرة درجة وثُلثا درجة، وعند بعض من خطّ الاستواء؛ ووسطه بالاتّفاق حيث النهار[686] ثلاث[687] عشر ساعة[688] [ci]، والعرض ستّ عشر درجة ونصف وثُمن. ومبدأ الثاني حيث النهار ثلاث عشر ساعة ورُبع، والعرض عشرون[689] درجة[690] [cii] ورُبع وخُمس[691].

[xcviii] كلّ واحد من] γ، β = كلاً :α.

[xcix] درجة] γ، β = —α.

[c] المعمورة] γ = المعمور: β، α.

[ci] ساعة] γ = درجة : β، α.

[cii] درجة] γ = —β، —α.

ومبدأ الثالث حيث النهار ثلاث عشر ساعة ونصف ورُبع، والعرض سبع وعشرون ونصف. ومبدأ الرابع حيث النهار أربع عشر ساعة ورُبع، والعرض ثلاث وثلاثون ونصف وثُمن. ومبدأ الخامس حيث النهار أربع عشر ساعة ونصف ورُبع، والعرض تسع وثلاثون إلّا عُشر. ومبدأ السادس[692] حيث النهار خمس عشر ساعة ورُبع، والعرض ثلاث وأربعون ورُبع وثُمن. ومبدأ السابع حيث النهار خمس عشر ساعة ونصف ورُبع، والعرض سبع وأربعون وخُمس، ووسطه بالاتّفاق[693] حيث النهار ستّ عشر ساعة، والعرض ثمان[694] [695] وأربعون ونصف[696] ورُبع وثُمن، وآخره عند الجمهور حيث النهار ستّ عشر ساعة ورُبع، والعرض خمسون وثُلث. وعند البعض منتهى العمارة وقد سبق تعيينه. وآخر كلّ إقليم سواه أوّل الذي يليه[697]. ولا يخفى بعد معرفة عروض أوائل الأقاليم وأواسطها[698] وأواخرها أنّه يسهل[699] من معرفة عرض البلد كونه في أي إقليم، وأنّه لو انضمّ إليها معرفة طوله، تعيين موقعه منه. وبعد هذا الضابط، لا حاجة إلى تعداد[700] ما في كلّ إقليم من البلاد على ما جرّت به العادة.

الباب الثاني[701] [من المقالة الثانية]

في خواصّ خطّ الاستواء

[١] كلّ بقعة على خطّ الاستواء[702] فمعدّل النهار يمرّ[703] بسمت رأسها، وقطباه[704] على أفقها. والآفاق الاستوائيّة[705] تقطع[706] جميع المدارات اليومية بنصفين ظاهر وخفيّ، ولذلك تتساوى[707] الأيّام[708] والليالي فيها. ولجميع الكواكب فيها طلوع وغروب، ومنطقة البروج تمرّ في يوم بليلته بسمت رؤوسها مرّتين: مرّة عند وصول أوّل الحمل بسمت الرأس، ومرة عند وصول أوّل الميزان به. وقطبا البروج في الحالتين على الأفق. وفي مدّة مرور النصف الشمالي من منطقة البروج على نصف النهار، يكون[709] الظاهر من[710] قطبي البروج جنوبيهما؛ وفي مدّة مرور النصف الجنوبي، يكون[711] الظاهر شماليهما، ولا يزيد[712] ارتفاعهما على قدر الميل الكلّي. وفصول السنة تكون[713] ثمانية: صيفان وابتداؤهما وقت[714] حلول الشمس الاعتدالين؛ وشتاآن وابتداؤهما وقت حلولها الانقلابين؛ وربيعان وابتداؤهما وقت حلولها أواسط الأسد والدلو؛ وخريفان وابتداؤهما وقت حلولها[715] أواسط الثور والعقرب[716]. ويكون[717] دور الفلك هناك دولابياً، ولذلك تسمّى[718] آفاقها[719] بآفاق[720] الفلك المستقيمة.

[٢] والشيخ الرئيس أبو علي بن سينا حكم بأنّها أعدل البقاع. والإمام العلّامة فخر الدين الرازي – رضي الله عنه[721] – حكم بأنّ أعدل البقاع[722] الإقليم الرابع. وقال الحكيم المحقّق[723] نصير الدين الطوسي[724] – قدّس سرّه – الحق في ذلك أنّه إن عُني بالاعتدال تشابه الأحوال فلا شكّ أنّه في خطّ الاستواء أبلغ. وإن عُني به تكافؤ الكيفيّتين – أعني[725] اعتدال[726] الحرّ والبرد – فلا شكّ أنّ خطّ الاستواء ليس كذلك، وتدلّ عليه شدّة سواد لون سكّانه وجعودة شعورهم وغير ذلك ممّا يقتضيه[727] حرارة الهواء. وكثرة التوالُد والتناسُل وتوفُّر العمارات في الإقليم الرابع وكون سكّانه أحسن الناس[728] خَلقاً[729] وخُلقاً[730] تدلّ[731] على أنّ هواءه أعدل.

الباب الثالث [من المقالة الثانية]

في[732] خواصّ الآفاق المائلة على الوجه الكلّيّ

[١] كلّ[733] موضع لا يكون تحت معدّل النهار ولا تحت قطبيه يكون[734] دور الفلك هناك حمائلياً، وأفقه يسمّى[735] الأفق المائل، وهو على خمسة أقسام: الأوّل ما عرضه أقلّ من الميل الكلّي؛ والثاني ما عرضه يساوي الميل[736] الكلّي؛ والثالث ما[737] عرضه أكثر من الميل الكلّي وأقلّ من[738] تمامه؛ والرابع ما عرضه يساوي[739] تمامه؛ والخامس ما عرضه أكثر من[740][741] تمام الميل وأقلّ من تسعين. وهذه الأفاق أحد قطبي معدّل النهار فوقها بقدر عرض البلد، والآخر تحتها بهذا القدر بعينه. وتنصّف معدّل النهار، فإذا حلت الشمس إحدى الاعتدالين[742]، تساوي[743] الليل والنهار في جميع تلك الآفاق. وتقطع[744] المدارات[745] اليومية بقسمين مختلفين: أعظمهما القسم الظاهر فيما يكون[746] في جهة القطب الظاهر؛ والخفيّ فيما يكون[747] في جهة القطب الخفيّ. إلّا ما لا يكون[748] بُعده أقلّ من تمام عرض البلد، فإنّها[ciii] لا تقطعها بل يكون[749] أبديّ الظهور ما هو في جهة القطب الظاهر، وأبديّ الخفاء ما هو في جهة القطب الخفيّ. ويماسّ الأفق ما بُعده مساوٍ لتمام[750] عرض البلد من فوق إن كان في جهة القطب الظاهر، ومن تحت إن كان في جهة القطب الخفي.

[٢] وكلّ[751] مدارين متساوي البعد من جانبي المعدّل، فالقسم الظاهر من أحدهما يساوي القسم الخفيّ من الآخر. وكلّ مدارين[752] في جانب واحد من المعدّل، فالظاهر من أقربهما أصغر أيّ أقلّ أجزاء[753] من ظاهر أبعدهما إن كانا في جانب القطب الظاهر، وبالعكس إن[754] كانا في جانب القطب الخفيّ. ولهذا السبب، يكون[755] في الأفق الذي يقطع[756][757] مداري المنقلبين أطول الأيّام يوم المنقلب الذي في جانب القطب الظاهر. وكلّ مدار بُعده في جانب القطب الخفيّ أو في جانب القطب الظاهر

[ciii] فإنّها] γ = فإنّه: β، α.

أكثر من عرض البلد لا يقطع[758] أوّل[759] السموت فوق الأفق[760]. وما بُعده في جانب القطب الظاهر يساوي عرض البلد يماسّ[761] أوّل السموت في سمت الرأس ولا يقطعه[762]. وما بُعده في الجانب أقلّ من عرض البلد يقطعه[763] على نقطتين شرقيّ وغربيّ يكون[764] الكوكب عندهما عديم السمت.

الباب الرابع [من المقالة الثانية]

في خواصّ قسم قسم من الأقسام الخمسة للآفاق المائلة

[١] أمّا القسم الأوّل، فكلّ مدار بُعده عن معدّل النهار في جهة القطب الظاهر يساوي[765] عرض البلد يقطع منطقة البروج[766] بقسمين مختلفين على نقطتين[767] متساويتي البُعد عن معدّل النهار. فإذا وصل الشمس إليهما، لم يكن[768] للأشخاص ظلّ[769] في نصف نهار ذلك اليوم، وكان قطبا البروج في تلك الحالة على الأفق. وما دامت الشمس[770] في قوس تكون[771] بين النقطتين من جانب القطب الظاهر، وهي أصغر القسمين، مرّت الشمس في جانب القطب الظاهر من سمت الرأس، ووقع ظلّ نصف النهار[772] في جانب القطب الخفيّ. وما دامت في القوس الأخرى، وهي أعظم القسمين، مرّت في جانب القطب[civ] [773] الخفيّ من سمت الرأس، ووقع الظلّ في جانب القطب الظاهر[774]. وكان[775] لقطبي البروج طلوع وغروب، فما دامت القوس الأولى تمرّ بنصف النهار، يكون قطب البروج الذي في جانب القطب الظاهر تحت الأرض، والقطب الآخر فوقها. وما دامت القوس[776] الأخرى تمرّ[777] به، يكون قطب البروج الذي في جانب القطب الظاهر[778] فوق الأرض، والقطب[779] الآخر تحتها. ويكون[780] لارتفاع الشمس في النقصان[781] غايتان: إحداهما في جانب القطب[782] الظاهر[783]، وهي أعظم، والأخرى في جانب[784] القطب الخفيّ، وهي أصغر.

[٢] وأمّا في[785] القسم الثاني، فمدار المنقلب الذي في جهة القطب الظاهر[786] يمرّ بسمت الرأس، ومدار المنقلب الآخر يمرّ بسمت الرجل. ولارتفاع الشمس غاية واحدة في النقصان، وهي بقدر ضعف[787] الميل الكلّي، وفي الزيادة يبلغ[788] تسعين[789]. والظلّ أبداً في جانب القطب الظاهر[790] إلّا وقت[791] حلول الشمس في المنقلب الظاهر[792] فإنّه لا يكون في نصف نهار هذا اليوم لشخص ظلّ.

[civ] القطب] γ = –β، –α.

ويكون[793] قطب البروج الذي في جانب القطب الظاهر[794] أبديّ الظهور، والقطب[795] الآخر[796] أبديّ[797] الخفاء، يماسّان الأفق، لا يغرب الظاهر[798] ولا يطلع الخفيّ.

[٣] وأمّا في القسم الثالث، فللشمس[cv] [799] ارتفاعان: أعلى وهو بقدر مجموع تمام عرض البلد والميل الكلّي، وأسفل وهو بقدر فضل تمام عرض البلد على الميل الكلّي. ولظاهر قطبي فلك البروج ارتفاعان: أعلى وهو عند وصول المنقلب الخفيّ إلى نصف النهار، وأسفل وهو عند وصول المنقلب الظاهر إلى نصف النهار.

[٤] وأمّا في القسم الرابع، فمدار المنقلب الظاهر[800] أعظم المدارات الأبديّة الظهور، ومدار المنقلب الخفيّ أعظم المدارات الأبديّة الخفاء. وفي دورة مرّة، يصل[801] المنقلبان[802] إلى الأفق، وقطب البروج الظاهر[803] إلى سمت الرأس، والخفيّ إلى سمت القدم، وينطبق[804] منطقة[805] البروج على الأفق. ثمّ إذا زال القطب[806] عن سمت الرأس، ارتفع النصف الشرقيّ من المنطقة دفعة عن[807] الأفق – أعني النصف الذي يتوسّطه[808] الاعتدال الربيعي إن كان القطب الظاهر[809] شمالياً، والخريفي إن كان جنوبياً– وانخفض النصف الآخر من المنطقة دفعة عن الأفق. ثمّ يغيب النصف المرتفع جزءً بعد جزء[cvi] [810] في جميع أجزاء النصف الغربيّ من الأفق، ويطلع النصف المنخفض[811] جزءً بعد جزء من جميع أجزاء النصف الشرقيّ من الأفق في مدّة اليوم بليلته، إلى أن يعود وضع الفلك إلى الحالة الأولى. ويكون[812] هناك كلّ من سعة المشرق وتعديل النهار ربعاً من الدور. وزيادة[813] النهار إلى أن يصير[814] مقدار يوم بليلته نهاراً كلّه. ثمّ[815] يحدث ليل ويزيد إلى أن يصير مقدار يوم بليلته ليلاً كلّه. هذا بحسب الجليل من النظر. وأمّا بدقيق النظر، فقد يبلغ النهار مقدار دورتين[816] من المعدّل[817]، وكذا يمكن[818] أن يبلغ[819]

[cv] فللشمس] γ = للشمس: β، α.

[cvi] جزءً بعد جزء] γ، β = –α .

الليل بذلك المقدار. وغاية ارتفاع الشمس بقدر ضعف الميل الكلّي من جانب القطب الخفيّ. وتنتهي[820] العمارة في جانب الشمال بهذه الآفاق.

[٥] وأمّا القسم الخامس، ففيه يقطع أعظم المدارات الأبديّة[cvii] [821] الظهور منطقة البروج على نقطتين ميلهما في جانب القطب الظاهر[822] يساوي[823] تمام عرض البلد. وكذا أعظم[824] المدارات الأبديّة الخفاء يقطع[825] منطقة البروج على نقطتين متساويتي الميل. وتنقسم[826] منطقة البروج بهذه النقط الأربع إلى أربع قسيّ: إحداها[827] أبدية[828] الظهور وهي التي في منتصفها المنقلب الظاهر ومدّة كون الشمس فيها النهار الأطول[829]؛ وأخرى أبديّة[830] الخفاء وهي التي في منتصفها المنقلب الخفيّ ومدّة كون[831] الشمس[832] فيها الليل الأطول. وطرفا القوس الأولى[833] يماسّان الأفق ولا يغربان[834]، وطرفا[835] القوس الأخرى يماسّان[836] الأفق ولا يطلعان[837]. وأمّا[cviii] القوسان الباقياتان، فالتي في منتصفها أوّل الحمل[838] تطلع[839] معكوسة وتغرب[840] مستوية إن كان القطب الشمالي ظاهراً، وتطلع[841] مستوية وتغرب[842] معكوسة إن كان القطب الجنوبي ظاهراً. والتي في منتصفها أوّل الميزان بالعكس في الطلوع والغروب. وللمنقلب الظاهر في تلك الآفاق ارتفاعان[843]: أعلى[844] وهو بقدر مجموع الميل الكلّي وتمام عرض البلد في جهة القطب الخفيّ من سمت الرأس؛ وأسفل وهو[845] بقدر فضل الميل الكلّي على تمام عرض البلد في جهة القطب الظاهر[846] من سمت الرأس. ويكون[847] قطب البروج والمنقلب الظاهران على[848] نصف النهار معاً، ولكن في الجهتين المتقابلتين من[849] سمت الرأس والارتفاعين المتبادلين.

[cvii] الأبديّة] γ، β = — α.

[cviii] وأمّا] γ، β = أمّا: α.

الباب الخامس [من المقالة الثانية]

في خواصّ المواضع التي يكون عرضها ربعاً من الدور

[١] وذلك لا يكون على الأرض إلّا عند نقطتين، عندهما يكون إحدى قطبي معدّل النهار على سمت الرأس، والأخرى على سمت[850] القدم. وتصير[851] دائرة معدّل النهار منطبقة على الأفق، ويدور الفلك هناك رَحَوياً[852]. فيكون النصف من الفلك الذي يكون من معدّل النهار في جمة القطب الظاهر[853] أبديّ الظهور والنصف الآخر أبديّ الخفاء.

[٢] والشمس ما دامت في النصف الظاهر من فلك البروج يكون نهاراً، وما دامت في النصف[854] الخفيّ منه يكون ليلاً. فتكون[855] السنة كلّها يوماً بليلته، ويفضل[856] مقدار[857] أحدهما على الآخر من جمة بطؤ[858] حركتها وسرعتها. ويكون[859] تحت القطب الشمالي في هذا التاريخ مدّة النهار أزيد من الليل بتسعة أيّام بلياليها[860] من أيّامنا. وذلك لكون أوج الشمس في أوائل السرطان وحضيضها في أوائل الجدي. وتكون[861] مدّة الصبح والشفق خمسين يوماً من أيّامنا[862]. وتكون[863] غاية ارتفاع الشمس وغاية انحطاطها بقدر[864] غاية الميل. ويكون طلوع الشمس والكواكب وكذا[865] غروبها بالحركة الثانية، لا من موضع وفي موضع بعينهما من[cix] الأفق.

[٣] وتختلف[866] مدّتا الظهور والخفاء للثوابت بحسب بُعد مدارها العرض عن فلك البروج وقربه[cx] إليه. والكوكب الذي عرضه مساوٍ للميل الكلّي يماسّ الأفق في دورة واحدة من الحركة الثانية[867] مرّة واحدة. ولا يكون له[868] ولا للذي يزيد[869] عرضه على الميل الكلّيّ طلوع ولا غروب، بل يكون أبديّ الظهور أو أبديّ[870] الخفاء.

[cix] بعينهما من] γ ، β = بعينه في: α.
[cx] وقربه] γ = وقربها: β، α.

الباب السادس [من المقالة الثانية]

في الأيّام بلياليها[871] وأجزائها من الليل والنهار والساعة المستويّة والمعوّجة والصبح والشفق

[١] إذا كانت الشمس فوق الأرض، استضاء وجهها المواجه لنا[cxi] [872] ووقع ظلّها في[873] مقابلة جهتنا[cxii] [874]، وذلك هو النهار. وإذا كانت تحت الأرض، أظلم هذا الوجه[875] لوقوع[cxiii] [876] ظلّها فوقها، وهو الليل. ومبدأ النهار، في عرف المتشرّعة، من طلوع الصبح الصادق[877]، وفي عرف المنجّمين والفرس والروم، من طلوع الشمس. ومبدأ الليل، في عرفهم[878] جميعاً، من غروب الشمس. إلّا أنّ أهل الشرع قالوا: هذا إن ظهر غروبها كما في الصحارى[879]؛ وإن لم[880] يظهر كما في خلال[881] الجبال والعمران[882]، فإن لا يبقى على رؤوس الجدران وقلل الجبال شيء من الشعاع ويقبل[883] الظلام من الشرق.

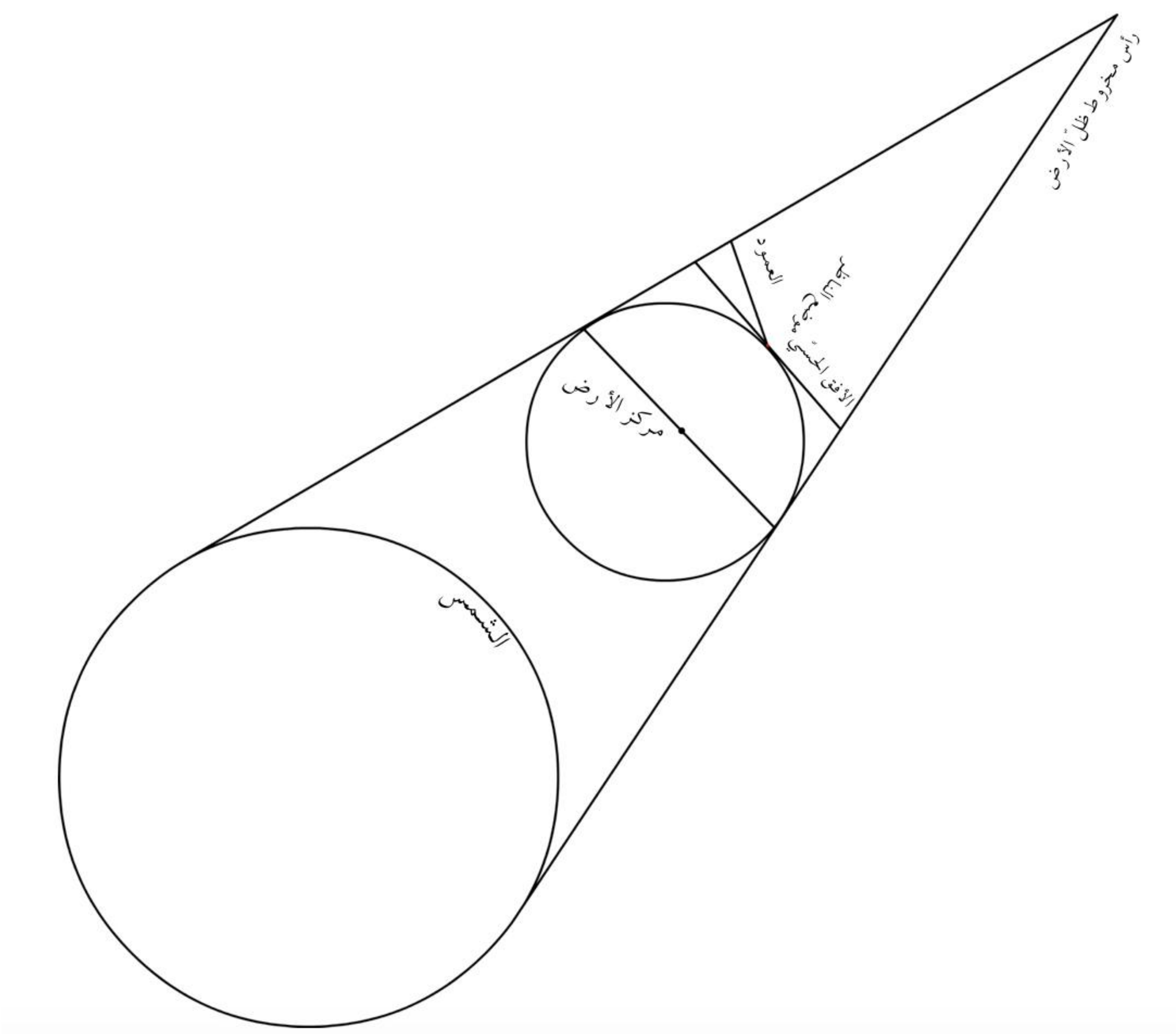
[٢] ولمّا كانت الشمس أكبر من الأرض، يستضيء[884] أكبر من نصفها، ويفصل بين المضيء والمظلم دائرة صغيرة على سطح الأرض. ويكون[885] ظلّها على هيئة[886] مخروط مستدير[887] قاعدته هذه الصغيرة الفاصلة، ويستدقّ[888] شيئاً فشيئاً إلى أن ينتهي عند أفلاك الزهرة. وإذا قربت[889] الشمس من الأفق الشرقيّ، مال مخروط الظلّ نحو المغرب. فيكون المرئي من الشعاع المحيط به أوّلاً ما[890] هو أقرب من البصر. والأقرب منه هو موقع العمود الخارج من البصر إليه، لا موضع اتّصاله بالأفق، لأنّه أطول من العمود لكونه وتر قائمة والعمود وتر[891] حادّة. لأنّا إذا توهّمنا سطحاً يمرّ بمركزي الشمس والأرض وبسهم المخروط، حدث مثلّث، تكون[892] زاويته التي بين الأفق وضلعه الذي يلي الشمس حادّة. فاذن أوّل ما يُرى نور الشمس مرئى فوق الأفق كخطّ مستقيم منطبق على الضلع المذكور، ويكون[893] ما يقرب

[cxi] لنا] γ، β = للشمس: α.

[cxii] جهتنا] γ، β = جهة الشمس: α.

[cxiii] لوقوع] γ، β = وقع: α.

من[894] الأفق[895] بعد مظلماً. فلذلك[896] يسمّى ذلك النور بالصبح الكاذب. إذ لو كان يصدُق[897] أنّه نور الشمس، لكان المستنير ما يلي[898] الشمس، أعني حوالي الأفق، دون ما فوقه. وهذه صورة المثلّث والأفق والعمود والشمس:



[شكل ١٢]

[٣] ثمّ[899] إذا قربت الشمس من الأفق جداً، انبسط النور، فصار الأفق منيراً وصار الصبح صادقاً. والشفق على عكس الصبح. وقد عُرف بالتجربة[900] أنّ انحطاط[901] الشمس[902] من الأفق عند أوّل طلوع الصبح وآخر غروب الشفق يكون[903] ثماني عشرة درجة.

[٤] واليوم بليلته، عند المنجّمين، عبارة عن مدّة مفارقة الشمس عن نصف متحدّد بقطبي العالم من نصف النهار إلى عودها إليه، وهي أزيد من دورة معدّل النهار بمطالع ما سارته في مدّة المفارقة إلى المعاودة. ولأنّ[904] سير الشمس مختلف، وعلى تقدير تساويه مطالعها مختلفة، تكون[905] مقادير الأيّام بلياليها مختلفة؛ لكنّ اختلافها غير محسوس في يوم أو يومين لقلّة التفاوت، ويحسّ[906] به في[907] أيّام كثيرة. وأهل الحساب، لمّا[908] اضطرّوا إلى[909] استعمال أيّام بلياليها متساوية الأقدار لمعرفة الأوساط وتركيب الجداول، اخذوا تلك الزيادة مقدار حركة وسط الشمس. وسمّوا تلك الأيّام المأخوذة بالتساوي الأيّام الوسطيّة. والأيّام المأخوذة على الوجه الأوّل الأيّام الحقيقية، وسمّوا الفضل بين الأيّام الحقيقية والوسطيّة تعديل[910] الأيّام.

[٥] وعند العرب وأكثر أصحاب الشرائع من حين غروب الشمس إلى غروبها ثانياً؛ لأنّ مبادئ[911] شهورهم من الهلال ورؤيته بعد الغروب. وعند بعضهم من طلوع الشمس إلى طلوعها ثانياً[912]. ثمّ إنّ المنجّمين قسّموا كلا من الأيّام الحقيقية والوسطيّة إلى أربعة وعشرين قسماً بالتساوي سمّوها ساعات[913] مستوية ومعتدلة. وقسّموا كلا من الليل والنهار إلى إثنى عشر قسماً[914] بالتساوي، سمّوها ساعات زمانيّة معوّجة.

الباب السابع [من المقالة الثانية]

في الشهور والسنين[915] والتواريخ

[١] لمّا كان أشهر الأجرام السماويّة النيّرين، اعتبر أكثر الأمم في وضع شهورهم وسنيهم دورهما. فجعلوا مدّة مفارقة الشمس من نطقة معيّنة -كأوّل الحمل مثلاً- إلى معاودتها إليها سنة؛ ومدّة مفارقة القمر من وضع معيّن يكون له مع الشمس-كالهلال مثلاً- إلى معاودته[916] إليه شهراً. ولمّا كان مدّة اثنى عشرة دورة للقمر قريباً من[917] مدّة دورة الشمس، جعل بعضهم اثنى عشر شهراً سنة، وسمّوا هذه سنة قمرية، وتلك سنة شمسيّة. وأيضاً لمّا كان مدّة دورة القمر قريباً من مدّة سير الشمس في برج[918] واحد[919]، جعل بعضهم مدّة سير الشمس في برج[920] واحد شهراً، وسمّوا هذه شهراً شمسيّاً[921]، وتلك شهراً قمريّاً. فصار كلّ من السنة والشهر شمسيّاً وقمريّاً. ثمّ كلّ واحد منهما، إمّا حقيقي اعتبر فيه السير[922] الحقيقي للنيّرين، أو اصطلاحيّ اعتبر فيه عدد الأيّام والشهور، فصارت الأقسام ثمانيّة؛ ذهب إلى كلٍّ طائفة.

[٢] وأمّا التأريخ، فهو عبارة عن[923] تعيين يوم ظهر فيه شائع كمِلّة أو دولة أو حدث فيه هائل من طوفان أو زلزلة أو غيرهما لمعرفة ما بينه وبين أوقات الحوادث وما يجب ضبط[924] وقته في مستأنف الزمان. ومن التواريخ المشهورة في زماننا:

[٣] تأريخ الروم، وسنوه شمسيّة اصطلاحية هي ثلاثمائة وخمسة وستّون[925] يوماً وربع يوم، وكذا شهورهم شمسيّة[926] اصطلاحية. وتفصيل أسامي شهورهم وعدد أيّامها هو هذه: تشرين[927] الأوّل، لا؛ تشرين الآخر، ل؛ كانون الأوّل، لا؛ كانون الآخر، لا؛ شباط، كح؛ آذار، لا؛ نيسان، ل؛ أيّار، لا؛ حزيران، ل؛ تمّوز، لا؛ آب، لا؛ أيلول، ل . ثمّ إنّهم يكسبون في كلّ[928] أربع سنين يوماً واحداً لاجتماع[929] الأرباع، ويلحقونه بأيّام شباط؛ فجعلون أيّامه تسعة وعشرين، ويسمّون هذه[930] سنة

الكبيسة. وأوّل هذا التاريخ يوم الاثنين بعد اثنتى عشرة سنة شمسيّة من وفاة الاسكندر بن فيلقوس الرومي الذي استولى[931] على الأقاليم السبعة.

[٤] وتأريخ الهجرة، وسنوه عند العرب ومن لا دُربة له بحساب حركات[932] النيّرين قمريّة حقيقية، وكذا[933] شهوره. إذ مبادئها من الرؤية، وزمان الشهر ما بين هلالين، وهو لا يزيد على ثلاثين يوماً، وأكثر المتوالية منه أربعة[934]؛ ولا ينقص من تسعة وعشرين، وأكثر المتوالية منه[935] ثلاثة. والمنجّمون يأخذون المحرّم ثلاثين والصَفَر تسعة وعشرين، وهكذا يأخذون شهراً ثلاثين وشهراً تسعة وعشرين[936] إلى آخر السنة. وفي كلّ ثلاثين سنة، يأخذون[937] ذي الحجّة أحد عشر مرّة ثلاثين: وذلك في السنة الثانية، والخامسة، والسابعة، والعاشرة، والثالثة عشرة، والخامسة عشرة، والثامنة[938] عشرة، والحادية والعشرين، والرابعة والعشرين، والسادسة والعشرين، والتاسعة والعشرين[939]، وتجمعها لفظة بَهَزْ يَجْهَحْ اَدُوْط. فسنوه وكذا شهوره على اعتبار المنجّمين قمريّة اصطلاحية[940]. واسماء شهوره الاثنى عشر، لغاية الشهرة مستغن عن الذكر. وأوّل هذا التأريخ يوم الخميس بحسب الأمر[941] الأوسط، ويوم[942] الجمعة بحسب الرؤية، غرّة المحرّم من سنة هاجر فيها نبيّنا – عليه الصلوة[943] والسلام[944] – من مكّة إلى المدينة.

[٥] وتأريخ الفرس، وسنوه شمسيّة اصطلاحية هي ثلاثمائة وخمسة وستّون يوماً، وكذا شهورهم الاثنا[945] عشر وهي: فروردين، ارديبهشت، خرداذ، تير، مرداد، شهريور، مهر، آبان، آذر، دي، بهمن، اسفندارمذ[cxiv] [946]. لأنّها ثلاثون[947] ثلاثون، والخمسة الزائدة تسمّى[948] الخمسة المُسترقة واللواحق. وبعضهم يوردونها في آخر آبان[949] ماه؛ والمنجّمون يوردونها في آخر اسفندارمذ ماه لئلّا يختلف[950] عدد الأيّام في أوراق التقاويم[951]. ولخلوّ سني هذا التاريخ وشهوره عن الكسر، صار استعمال

[cxiv] اسفندارمذ] γ = + وكذا شهورهم: β، α.

المنجّمين له أكثر من غيره. وكان جُلّ الأزياج، بل كلّها، ممّا وقع إلينا[952] مبنياً عليه، إلّا الزيج المعتبر. وأوّل هذا التأريخ يوم الثلاثاء وهو أوّل يوم من سنة ملك فيها يَزدَجِرد بن شهريار آخر ملوك الفرس.

الباب الثامن [من المقالة الثانية]

في مطالع القسي من فلك البروج

[١] وهي في أفق الاستواء تنحصر بين دائرتي ميل إحداهما أفقهم؛ وفي الآفاق المائلة بين دائرة الأفق وبين دائرة عظيمة[953] مارّة بأوّل تلك القوس ومماسّة لأعظم الأبديّة الظهور. وفي خطّ الاستواء، كلّ ربع من فلك البروج يتّحد بنقطتين من الأربع الاعتدالين والانقلابين، يطلع[954] مع ربع من المعدّل، فالمطالع والطوالع لا يتساويان في غير ما ذكر. وفي الآفاق المائلة، كلّ نصف من البروج متحدّد بالاعتدالين[955] يطلع مع نصف من المعدّل. لكن في العروض التي أقلّ من الميل الكلّي[956]، قد[957] يتّفق أن يتساوى[958] عرضا البلد وإقليم الرؤية[959]، متبادلي جهة العرض، فيتساوى[960] حينئذٍ[961] المطالع والطوالع مع كون كلّ منهما أقلّ من النصف.

الباب التاسع [من المقالة الثانية]

في درجات ممرّ[962] الكواكب بنصف النهار ودرجات طلوعها وغروبها

[١] إذا خرج خطّ من مركز العالم إلى مركز[963] الكوكب وانتهى إلى سطح[964] الفلك الأعلى، فإن اتّفق أن ينتهي[965] إلى نفس منطقة البروج، كانت نهايته درجة الكوكب ومكانه. وإلّا، فأقرب تقاطعي[966] العرضية[967] المارّة برأسه درجة الكوكب. والجزء من فلك البروج الذي يكون[968] مع رأس الخطّ المذكور في نصف متحدّد بقطبي[cxv] [969] العالم[970] من الميليّة المارّة به[971] درجة ممرّ الكوكب. وهي تكون[972] درجة الكوكب بعينها، إذا[973] لم يكن للكوكب[974] عرض أو كان وكان الكوكب على إحدى المنقلبين. ولم يكن بين قطبي البروج والعالم، إذ لو كان بينهما، تكون[975] درجة ممرّ الكوكب مقابلة درجته[976]. وفي غير ما ذكرنا، تكون[977] درجة ممرّ الكوكب نقطة أخرى[978] غير درجته؛ وما وقع بينهما من منطقة البروج يسمّى اختلاف الممرّ[979]. والقوس من المعدّل التي بين نصف الميليّة المذكور ونصف من العرضيّة متحدّد بقطبي البروج مارّ برأس الخط المذكور[cxvi] [980] تسمّى[981] تعديل درجة[982] الممرّ. والتي[983] من المعدّل بين أوّل الحمل وهذا النصف من الميليّة على التوالي تسمّى[984] مطالع ممرّ الكوكب[cxvii] [985].

[٢] فالكوكب إن كان درجته فيما بين المنقلب الشتوي إلى[986] المنقلب الصيفي، يمرّ بنصف النهار قبل درجته إن كان عرضه في جهة القطب الظاهر من قطبي[987] العالم[cxviii] [988]؛ ويمرّ[989] بعد درجته[990] إن كان في جهة القطب الآخر. وإن كان[991] درجته من النصف الآخر من فلك البروج – أيّ

[cxv] بقطبي] γ، β = بين قطبي: α.

[cxvi] والقوس من المعدّل التي بين نصف الميلية المذكور ونصف من العرضية متحدّد بقطبي البروج مارّ برأس الخط المذكور] γ، β = وما بين دائرتي ميل الكوكب وعرضه: α.

[cxvii] والتي من المعدّل بين أول الحمل وهذا النصف من الميليّة على التوالي تسمّى مطالع ممرّ الكوكب] γ، β = –α.

[cxviii] من قطبي العالم] γ، β = –α.

كانت فيما بين المنقلب الصيفي إلى المنقلب الشتوي– يمرّ[992] بنصف النهار بعد[993] درجته إن كان عرضه[994] [cxix] في جهة القطب الظاهر[995] من قطبي[996] العالم؛ وقبل درجته إن كان[997] عرضه في جهة القطب[998] الخفيّ.

[٣] وأمّا درجة طلوع الكوكب وغروبه، فهي ما يطلع ويغرب معه من أجزاء منطقة البروج. ففي خطّ الاستواء، يكون طلوع الكواكب وغروبها كمرورها على نصف النهار في سائر الآفاق؛ أعني[cxx] [999] إذا كان درجة الكوكب إحدى الانقلابين[1000] [cxxi] ولم يكن الكوكب بين القطبين[1001] [cxxii]، يطلع[1002] الكوكب ويغرب مع درجته[1003] [cxxiii]. وإذا[cxxiv] كان درجة الكوكب من المنقلب الشتوي إلى المنقلب الصيفي[1004] [cxxv]، يطلع[1005] الكوكب ويغرب[1006] قبل درجته[1007] [cxxvi] إذا كان عرضه في جهة القطب الظاهر[1008] من قطبي العالم؛ ويطلع[1009] ويغرب[1010] بعد درجته[1011] [cxxvii] إذا[cxxviii] كان في جهة القطب

[cxix] عرضه] γ = –β = درجته: α.

[cxx] يكون طلوع الكوكب وغروبها كمرورها على نصف النهار في سائر الآفاق أعني] γ = –β ، –α.

[cxxi] الانقلابين] γ، β = + ففي بلد ينقص عرضه من الميل الكلّي إذا كان درجة الكوكب إحدى النقطتين اللتين تمرّان بسمت رأس البلد وينقسم منطقة البروج بهما إلى قوسين عظمى وصغرى وفيما يساوي عرضه الميل الكلّي إذا كان درجة الكوكب المنقلب الصيفي: α.

[cxxii] ولم يكن الكوكب بين القطبين] γ = –β ، –α.

[cxxiii] درجته] γ ، β = + وفي خطّ الاستواء: α.

[cxxiv] وإذا] γ، β = إذا: α.

[cxxv] الصيفي] γ، β = + وفيما ينقص عرضه إذا كان الكوكب في القوس العظمى وفيما يساوي عرضه الميل الكلّي إذا لم يكن الكوكب في المنقلب الصيفي وفيما يزيد عرضه على الميل الكلّي مطلقاً: α.

[cxxvi] ويغرب قبل درجته] γ = قبل درجته ويغرب بعدها: β، α.

[cxxvii] ويغرب بعد درجته] γ = بعد درجته ويغرب قبلها: β، α.

[cxxviii] إذا] γ، β = إن: α.

الخفيّ[cxxix] [1012] [1013]. وإذا[cxxx] كان في النصف[1014] الآخر من منطقة البروج – أيْ كانت درجته من المنقلب الصيفي إلى المنقلب الشتوي[cxxxi] [1015] – يطلع الكوكب ويغرب[1016] بعد[1017] درجته[cxxxii] [1018] إذا كان عرض[cxxxiii] [1019] الكوكب في جانب[1020] القطب الظاهر[1021] من قطبي العالم؛ ويطلع ويغرب[1022] قبل درجته[cxxxiv] [1023] إذا كان في جانب القطب الخفيّ[1024]. وفيما زاد عرض البلد[cxxxv] [1025] على الميل الكلّي، يطلع[1026] الكوكب قبل[1027] درجته ويغرب[1028] بعدها[1029] إن كان في جانب القطب الظاهر[1030] من قطبي العالم؛ وبالعكس[1031] إن كان في جانب[1032] الآخر، أيْ يطلع بعد[1033] درجته ويغرب[1034] قبلها.

[٤] وفي بلد يساوي[1035] عرضه الميل الكلّي، إذا كان درجة الكوكب الاعتدال[1036] الخريفي، يطلع[1037] الكوكب مع درجته، أيّ جانب كان عرضه، ويغرب[1038] بعدها إن كان في جانب القطب الظاهر[1039]، وقبلها إن كان في الجانب[1040] الآخر. وإن كانت[1041] درجته الاعتدال الربيعي، يغرب[1042] الكوكب مع درجته، أيّ جانب كان عرضه، ويطلع[1043] قبلها إن كان في جانب القطب[1044] الظاهر[1045]، وبعدها إن كان[1046] في الجانب الآخر. وإذا كان درجة الكوكب جزء[1047] آخر[1048] غير ما ذكرنا من أجزاء منطقة البروج، فالحكم ما ذكرنا فيما زاد عرضه على الميل الكلّي.

[cxxix] الخفيّ] γ، β = + وفي خطّ الاستواء: α.
[cxxx] وإذا] γ = إذا : β، α.
[cxxxi] الشتوي] γ ،β = + وفيما ينقص عرضه من الميل الكلّي إذا كان الكوكب في القوس الصغرى: α.
[cxxxii] ويغرب بعد درجته] γ = بعد درجته ويغرب قبلها: β = قبل درجته ويغرب قبلها: α.
[cxxxiii] عرض] γ = –β، –α.
[cxxxiv] ويغرب قبل درجته] γ = قبل درجته ويغرب بعدها: β، α.
[cxxxv] وفيما زاد عرض البلد] γ = وفيما زاد عرضه: β = –α.

[٥] وفي بلد ينقص[1049] عرضه من الميل الكلّي، إذا كان درجة الكوكب أحد طرفي[cxxxvi] قوس تساوي[1050] أصغر قسمي منطقة البروج اللذين يحصلان[1051] من النقطتين اللتين تمرّان[1052] بسمت الرأس وعلى منتصفها الاعتدال[1053] الربيعي[cxxxvii] [1054]، فالكوكب يغرب[1055] مع درجته ويطلع[1056] قبلها. وإن كان درجة الكوكب[1057] إحدى نظيرتي[1058] هذين الطرفين[cxxxviii] [1059]، فالكوكب يطلع[1060] مع درجته ويغرب[1061] بعدها. وإن كان درجة[1062] الكوكب جزء[1063] من أجزاء هذه القوس، فالكوكب يطلع[1064] ويغيب[1065] قبل درجته. وإذا كان درجة الكوكب نظيرة جزء من أجزاء هذه القوس، فالكوكب يطلع[1066] ويغيب[1067] بعد درجته. وإن كان درجة الكوكب جزء[1068] آخر[1069] من أجزاء منطقة البروج غير ما ذكرناه، فالكوكب يطلع[1070] قبل درجته ويغيب[1071] بعدها. هذا كلّه إن كان عرض الكوكب في جانب القطب[1072] الظاهر[1073] من قطبي[1074] العالم. وإن كان عرضه في جانب القطب الخفيّ منهما[1075] وكان درجة الكوكب أحد طرفي[cxxxix] القوس المذكورة[1076]، فالكوكب يغرب[1077] مع درجته ويطلع[1078] بعدها. وإن كانت[1079] درجة الكوكب إحدى نظيرتي[1080] هذين الطرفين[cxl]، فالكوكب يطلع[1081] مع درجته ويغرب[1082] قبلها. وإن كان درجة الكوكب جزء[1083] من أجزاء هذه القوس، فالكوكب يطلع ويغيب[1084] بعد درجته. وإن كانت درجة الكوكب نظيرة جزء من أجزاء هذه[1085] القوس، فالكوكب يطلع ويغيب[1086] قبل درجته. وإن كانت درجة الكوكب[1087] جزء[1088] آخر[1089] من أجزاء منطقة البروج غير ما[1090] ذكرنا، فالكوكب يطلع[1091] بعد درجته ويغرب[1092] قبلها. وفي هذا البلد، قد يتّفق[1093] للكواكب القريبة[1094] من

[cxxxvi] أحد طرفي] γ = مبدأ: β = —α.
[cxxxvii] الربيعي] γ = + أعني طرفها المتقدّم في الطلوع: β = —α.
[cxxxviii] إحدى نظيرتي هذين الطرفين] γ = نظيرة منتهى هذه القوس: β = —α.
[cxxxix] أحد طرفي] γ = مبدأ: β = —α.
[cxl] إحدى نظيرتي هذين الطرفين] γ = نظيرة منتهى هذه القوس: β = —α.

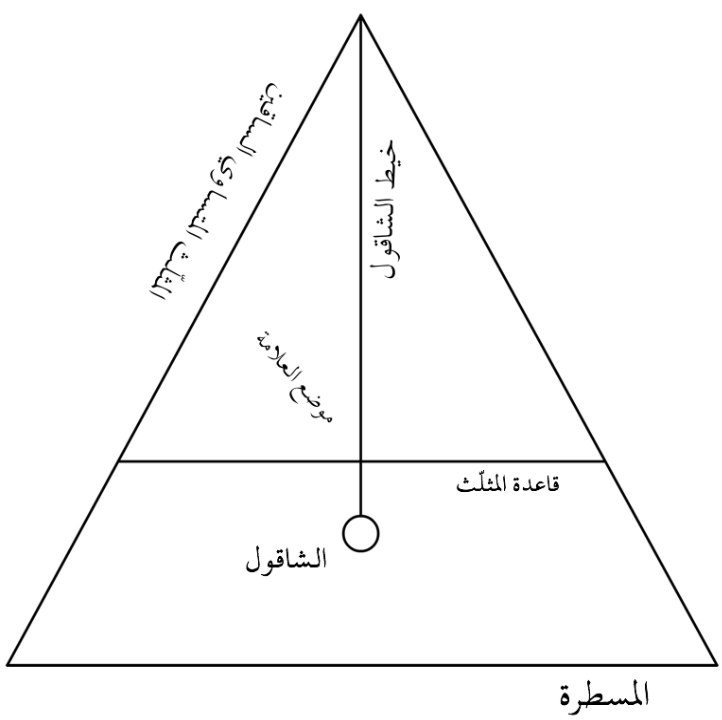
القطب – أعني التي يزيد[1095] عروضها[1096] على تمام الميل الثاني لدرجتها – أن تطلع[1097] مع نظيرة درجتها فيما قلنا أنّه يغرب[1098] مع درجته، وتغرب[1099] مع نظيرة درجتها فيما قلنا أنّه[1100] يطلع[1101] مع درجته على عكس ما قلنا. وهذا دقيق نفيس جداً.[cxli] [1102] [1103]

[cxli] على الميل الكلّي يطلع الكوكب قبل درجته ويغرب بعدها إن كان في جانب القطب الظاهر من قطبي العالم (...) وفي هذا البلد قد يتّفق للكواكب القريبة من القطب أعني التي يزيد عروضها على تمام الميل الثاني لدرجتها أن تطلع مع نظيرة درجتها فيما قلنا أنّه يغرب مع درجته وتغرب مع نظيرة درجتها فيما قلنا أنّه يطلع مع درجته على عكس ما قلنا. وهذا دقيق نفيس جداً] γ ،β = –α.

الباب[1104] العاشر [من المقالة الثانية]

في استخراج خطّ نصف النهار ومعرفة أوقات الصلوة[cxlii] وسمت القبلة

[١] نحتاج فيه إلى السطح الموزون وتحصيله[1105] بأن نأخذ مسطرة مصحّحة غاية الصحّة، ونركّب عليها مثلثاً متساوي الساقين توازي[1106] [1107] قاعدته هذه المسطرة. ونعلّم على منتصف قاعدته علامة. ثمّ نعلّق من رأس المثلّث شاقولاً يلاصق خيطه هذه العلامة. فإذا أديرت هذه المسطرة على السطح وماسّت في جميع الدور السطح ولم يُبن بينهما ضوء ولم يفارق[1108] خيط الشاقول هذه العلامة، فالسطح[1109] [1110] هو الموزون المنطبق[1111] على الأفق. ثمّ نخطّ[1112] عليه دائرة تقاصر عن حرفه ليتبيّن[1113] مدخل الظلّ ومخرجه، ونأخذ مخروطاً طوله بحيث يقصر[1114] ظلّه عن محيطها انتصاف[1115] النهار ويتجاوز[1116] عنه في جانبيه.



[شكل ١٣]

[cxlii] الصلوة] β، γ = الصلاوات: α.

[٢] ونرسم على مركزها دائرة[1117] [1118] كقاعدة المقياس أو أكبر منها بقليلٍ بحيث لو وضعت عليها انطبقت عليها أو أحاطت بها موازية لها. ثمّ ننصّف عرض الظلّ عند دخوله وخروجه، ثمّ قوس ما بين هذين المنتصفين أو وترها[cxliii] [1119]. ثمّ نصل[1120] بين المركز ومنتصف القوس أو الوتر[cxliv] [1121] بخطّ مستقيم فإنّه خطّ نصف النهار؛ والخطّ المارّ بمركز الدائرة عموداً على خطّ نصف النهار خطّ[1122] المشرق والمغرب وخطّ الاعتدال. وهذان الخطّان يربّعان[1123] الدائرة، ثمّ نقسّم[1124] كلّ ربع بتسعين، وهذه[1125] الدائرة تُعرف بالهندية. واعلم أنّ أصلح الأوقات لأخذ الظلّ أن تكون[1126] الشمس في الانقلاب أو قريبة منه – الصيفي[cxlv] أولى – وأن يكون ارتفاعها قيد رُمحَين.

[٣] وأمّا[1127] معرفة أوقات الصلوات[1128]، فاعلم أنّ الكلّ اتّفقوا[1129] على أنّ وقت صلوة الظهر بعد الزوال ولو بدقيقة. ويُعرف[1130] بميل الظلّ عن خطّ نصف النهار إلى الشرق إن كان مستخرجاً. وإلّا، فبحدوثه إن لم يبق[1131] في انتصاف النهار وازدياده على ما كان ولو بأدنى شيء إن بقي[1132]. وهذا الباقي هو[1133] المسمّى بفيء الزوال. وأوّل العصر عند الشافعي وأئمّة الحجاز أن يحدث[1134] أو زاد على فيئ الزوال مثل المقياس، ومثلاه عند أبي حنيفة[1135] وأئمّة العراق. وأوّل المغرب يُعرف بالغروب إن[1136] ظهر، وبإقبال الظلمة من المشرق إن لم يظهر[1137]. وأوّل[1138] العشاء بغروب الشفق وهو الحمرة عند الشافعي، والبياض عند أبي حنيفة، رضي الله عنهما[1139]. وأوّل صلوة الصبح بطلوعه صادقاً.

[cxliii] أو وترها] γ ،β = —α.

[cxliv] أو الوتر] γ ،β = —α.

[cxlv] الصيفي] γ ،β = والصيفي: α.

[٤] وأمّا[1140] سمت[1141] القبلة، فهي نقطة تقاطع[1142] أفق البلد والسمتية المارّة بسمتي رأس مكّة والبلد[1143]، والواصل بينها ومركز الأفق خطّ سمت القبلة. وأمّا[1144] سمتها عن البلد المسمّى بقوس الانحراف، فهو قوس من الأفق بين تقاطعه[1145] مع السمتية المذكورة وبين إحدى النقط الأربع الشمال والجنوب والمشرق والمغرب. ولا بدّ في معرفة السمتين من معرفة طول البلد وعرضه وطول مكّة، وهو عن الجزائر سبع وسبعون[cxlvi] درجة وعشر دقائق، وعرضها، وهو إحدى وعشرون درجة وأربعون[1146] دقيقة.

[٥] فنقول: أسهل المواضع قبلةً هو الموضع المقاطر لمكّة، فإنّ سمت القبلة لا يتعيّن[1147] هناك[1148]، بل أينما تولّوا فثمّ وجه الله. وأشكلها عرض تسعين لعدم تعيين[1149] شئ من المشرق والمغرب[1150] والجنوب والشمال فيه، ويمكن[1151] أن يُعرف[1152] السمت هنالك بأرصاد حوادث فلكية كالخسوفات. وفي غير هذين الموضعين، نقول: البلد إمّا أن يوافق مكّة في الطول أو لا؛ فإن كان الأوّل، فسمت القبلة نقطة الجنوب إن كان عرضه[cxlvii] الشمالي أكثر، وإلّا نقطة الشمال. وإن كان الثاني، فإن[1153] كان ما بين الطولين مائة وثمانين[1154] درجة، فسمت القبلة نقطة الجنوب[cxlviii] إن كان عرضه الجنوبي أكثر، وإلّا نقطة الشمال[cxlix].

[٦] وفي غير ما ذكر من المواضع، نعدّ من أجزاء[1155] الدائرة الهندية من كلّ من نقطتي[1156] الجنوب والشمال بعدد فضل[1157] ما بين الطولين إلى[1158] الشرق إن كان طول مكّة أكثر، وإلى الغرب إن كان أقلّ[1159]، ونصل[1160] ما بين النهايتين. فإن كان فضل[1161] ما بين الطولين تسعين، نخرج[1162] من

[cxlvi] سبع وسبعون] β، γ = سبع وستّون: α.
[cxlvii] عرضه] β، γ = عرضها: α.
[cxlviii] الجنوب] β، γ = الشمال: α.
[cxlix] الشمال] β، γ = الجنوب: α.

نقطة المشرق على الأوّل، ومن نقطة المغرب على الثاني، خطّاً موازياً لخطّ نصف النهار. وإن كان[1163] أكثر من تسعين، نقيم تمام فضل ما بين الطولين إلى مائة وثمانين مقام فضل[1164] ما بين الطولين. ومن كلّ من نقطتي المشرق والمغرب بعدد فضل ما بين العرضين[cl] [1165] إلى الجنوب إن كان عرض مكّة أقلّ، وإلى الشمال إن كان أكثر، ونصل[1166] ما بين النهايتين. وإن لم يكن[1167] بين العرضين فضل، نأخذ خطّ[1168] المشرق والمغرب مكان الخطّ الواصل[cli] [1169]، فيتقاطع[1170] الخطّان[1171] المخرجان لا محالة، ويكون الخطّ الواصل بين المركز ومقطعهما[1172] خطّ سمت القبلة. وهذا[1173] الوجه تقريبيّ[1174] أوردناه[clii] لشهرته.[1175]

[٧] وجه آخر، وهو أن نحوّل فضل ما بين الطولين إلى الساعات[1176] وكسورها بأن[1177] نحسب كلّ خمس عشرة درجة من درجات فضل[1178] ما بين الطولين ساعة، وكلّ درجة منها أربع دقائق[1179] من دقائق الساعات. وكلّ دقيقة منها أربع ثوانٍ[1180] من ثواني الساعات، وهكذا. ونرصد يوم حلول الشمس إلى جزء من منطقة البروج ميله مساوٍ لعرض مكّة – شرفها الله تعالى[1181] – وهو الثامن من الجوزاء أو الثالث والعشرون من السرطان[cliii] [1182]. ثمّ يؤخذ في ذلك اليوم من المقياس سمت[1183] الظلّ في زمان[1184] هو بعد[cliv] [1185] نصف نهار ذلك اليوم بقدر تلك الساعات وكسورها التي[1186] حوّل إليها فضل ما بين الطولين، إن كان طول مكّة أقلّ من طول البلد، وقبل[clv] [1187] نصف

[cl] بعدد فضل ما بين العرضين] γ = –β، –α.

[cli] وإن لم يكن بين العرضين فضل نأخذ خطّ المشرق والمغرب مكان الخطّ الواصل] γ = –β، –α.

[clii] أوردناه] γ ، β = أوردنا: α.

[cliii] وهو الثامن من الجوزاء أو الثالث والعشرون من السرطان] γ = –β، –α.

[cliv] بعد] γ = قبل: β، α.

[clv] وقبل] γ = وبعد: β، α.

النهار بهذا القدر إن كان طول مكّة[1188] أكثر. ويُستخرج خطّ في ذلك السمت إلى أن يقطع الدائرة[1189] الهندية؛ فنقطة التقاطع[1190] هي نقطة السمت، أعني نقطة التقاطع التي في خلاف جهة الظلّ.

[٨] وظاهر أنّ هذا الوجه لا يفيد فيما إذا كانت الساعات المحوّلة أكثر من ساعات نصف نهار ذلك اليوم، إذ تكون[1191] الشمس وقتئذٍ تحت الأفق، فلا يمكن أخذ سمت الظلّ في هذا الوقت. فالطريق فيها أن يُرصد تحويل الشمس إلى نظير الجزء المارّ بسمت رأس مكّة، وهو الثامن من القوس أو الثالث والعشرون من الجدي. ويُؤخذ سمت الظلّ يومئذٍ بقدر الساعات المذكورة قبل نصف الليل فيما قلنا قبل نصف النهار، وبعد نصف الليل فيما قلنا بعد نصف النهار. وسمت القبلة هي نقطة التقاطع التي في جهة الظلّ.[clvi] [1192]

[clvi] أعني نقطة التقاطع التي في خلاف جهة الظلّ وظاهر أنّ هذا الوجه لا يفيد فيما إذا كانت الساعات المحوّلة أكثر من ساعات نصف نهار ذلك اليوم إذ تكون الشمس وقتئذٍ تحت الأفق فلا يمكن أخذ سمت الظلّ في هذا الوقت فالطريق فيها أن يُرصد تحويل الشمس إلى نظير الجزء المارّ بسمت رأس مكّة وهو الثامن من القوس أو الثالث والعشرون من الجدى ويُؤخذ سمت الظلّ يومئذٍ بقدر الساعات المذكورة قبل نصف الليل فيما قلنا قبل نصف النهار وبعد نصف الليل فيما قلنا بعد نصف النهار وسمت القبلة هي نقطة التقاطع التي في جهة الظلّ] γ = –β، –α.

المقالة الثالثة

في معرفة مقادير الأبعاد والأجرام

وفيه مقدمة وستّة أبواب

المقدّمة

فيما يحتاج إلى تقديمه قبل الشروع في المقاصد

[١] وهي عشر[1193] مسائل: الأولى: إنّ محيط كلّ دائرة ثلاثة[1194] أمثال قطرها ومثل سُبع قطرها، ولهذا إذا قُسّم حاصل ضرب قطر دائرة في اثنين وعشرين على سبعة، خرج محيطها. وإذا قُسّم حاصل ضرب محيطها في سبعة على اثنين وعشرين، خرج قطرها.

[٢] الثانية: تكسير كلّ دائرة مساوٍ لسطح[1195] يحيط به نصف قطرها في نصف محيطها.

[٣] الثالثة: بسيط كلّ كرة مساوٍ لما يحيط[1196] به قطرها في أعظم دائرة تحدث فيها. ولهذا[1197] يقال هو أربعة أمثال أعظم دائرة تقع[1198] عليها[1199].

[٤] الرابعة[1200]: عظم كلّ كرة مساوٍ لجسم يحصل[1201] من ضرب نصف قطرها في ثُلث بسيطها.

[٥] الخامسة: كلّ قطعة من سطح الكرة يحيط[1202] بها نصفا عظيمتين فهو مساوٍ[1203] لسطح يحيط[1204] به القطر في غاية الميل بينهما.

[٦] السادسة: بسيط القطعة التامّة من الكرة، نصفاً كانت أو أقلّ أو أكثر، يساوي دائرة نصف قطرها مساوٍ للمستقيم الخارج من قطب القاعدة[1205] إلى محيطها.[1206] [clvii]

[clvii] محيطها] γ = محيط القاعدة: β، α.

[٧] السابعة: إذا كانت أربعة مقادير متناسبة وكانت ثلاثة منها معلومة[1207]، يمكن أن يعلم الرابع المجهول؛ وطريقه أن نقسّم مسطّح الطرفين على أحد الوسطين إن كان المجهول وسطاً أو مسطّح[1208] الوسطين على أحد الطرفين إن كان المجهول طرفاً، فالخارج من القسمة مقدار[1209] المجهول.

[٨] الثامنة[1210]: وهي من فروع[1211] السابعة، تسمّى بردّ المقادير من مقياس[1212] إلى مقياس[1213]. وهي أنّه إذا علمنا نسبة مقياسين أحدهما إلى الآخر– أنّهما على نسبة أيّ عددين ولنسمّ عدد كلّ مقياس قدره[1214] [clviii] – وعلمنا ما في[1215] مقدار من أمثال أحد المقياسين أو أجزائه، وأردنا أن نعلم عدد ما في هذا المقدار بعينه من أمثال المقياس الآخر أو أجزائه، ضربنا عدد الأمثال أو الأجزاء المعلوم في قدر[1216] [clix] المقياس الأوّل وقسّمنا الحاصل على عدد[1217] المقياس الثاني، يخرج عدد الأمثال أو الأجزاء المطلوب[1218]. نوع آخر من الرد: إذا كان مقياس أو جزء منه يقدّر مقدارين وآخر أو جزء[1219] منه يقدّر أحدهما فقط ولنسمّه الأولى، فإنه يقدّر الثاني ضرورةً[1220]. وأمّا أنّه كم مرّة يقدره، فيُعلم من المقدّمة[1221] السابعة، لأنّه نسبة ما في الأوّل من أمثال المقياس إلى ما في الثاني من أمثاله كنسبة ما في الأوّل من أمثال الآخر إلى ما في الثاني من أمثاله، وهو المجهول والرابع. فإذا ضرب ما في الثاني من أمثال المقياس فيما في[1222] الأوّل من أمثال الآخر وقُسّم الحاصل على ما في الأوّل من أمثال المقياس، خرج ما في الثاني من أمثال الآخر.[1223] [clx]

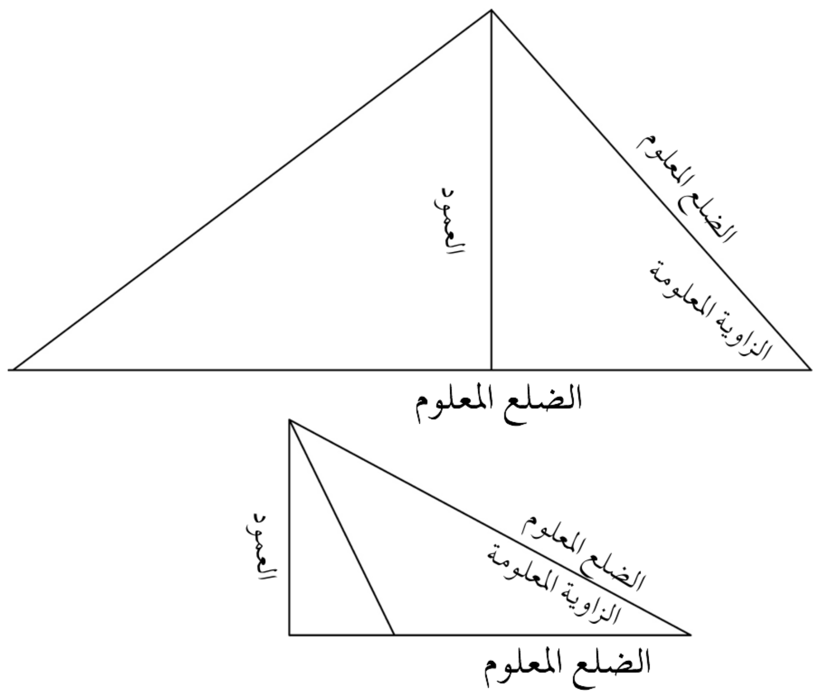
[clviii] ولنسمّ عدد كلّ مقياس قدره] γ = –β، –α.

[clix] قدر] γ = عدد: β، α.

[clx] نوع آخر من الرد إذا كان مقياس أو جزء منه يقدر مقدارين وآخر أو جزء منه يقدّر أحدهما فقط ولنسمّه الأولى فإنّه يقدّر الثاني ضرورةً وأمّا أنّه كم مرّة يقدّره فيُعلم من المقدّمة السابعة لأنّه نسبة ما في الأوّل من أمثال المقياس إلى ما في الثاني من أمثاله كنسبة ما في الأوّل من أمثال الآخر إلى ما في الثاني من أمثاله وهو المجهول والرابع فإذا ضرب ما في الثاني من أمثال المقياس فيما في الأوّل من أمثال الآخر وقُسم الحاصل على ما في الأوّل من أمثال المقياس خرج ما في الثاني من أمثال الآخر] γ = –β، –α.

[٩] التاسعة: إذا أعلم على أحد ساقي مثلّث نقطتان تفصّلان مع القاعدة خطّين متساويين وأخرج من تينك النقطتين خطّان موازيان للقاعدة، فإنّ[1224] مجموع القاعدة مع[1225] الخطّ الفوقاني يساوي ضعف[1226] الخطّ الوسطاني.

[١٠] العاشرة: في استعلام المجهول من أضلاع المثلّث وزواياه. اعلم أنّ مقدار الزاوية المستقيمة الخطّين هو مقدار القوس التي يوتّرها[1227] عند وقوع الزاوية في مركز الدائرة. والأضلاع الموتّرة للزوايا تتناسب[1228] تناسب[1229] جيوبها؛ أعني أنّ نسبة كلّ ضلع إلى آخر كنسبة جيب الزاوية التي يوتّرها الضلع الأوّل إلى جيب الزاوية التي يوتّرها الضلع الآخر. فإذا كان في مثلّث ضلع وزاويتان أو زاوية وضلعان[1230] معلومة، كان باقي الأضلاع والزوايا معلومة بالأربعة المتناسبة. لكن إذا كان المعلوم ضلعين وزاوية[1231] بينهما، لا يتمشّى[1232] هناك طريق الأربعة المتناسبة، لأنّ الزاوية المعلومة لا يوتّرها أحد[1233] الضلعين المعلومين. فحينئذٍ[1234] [1235] نقول: إن كانت الزاوية المعلومة قائمة، نأخذ جذر مجموع مربّعي الضلعين ليصير الضلع[1236] الموتّر للزاوية المعلومة معلوماً. وإن لم يكن[1237] قائمة، نخرج من إحدى الزاويتين الباقيتين عموداً على الضلع الموتّر لها ليحصل[1238] ههنا مثلّثان قائما الزاويتين، أحدهما وهو الذي إحدى زواياه هي الزاوية المعلومة يكون[1239] من القبيل[1240] الأوّل — أعني ممّا تكون[1241] زوايتان وضلع منه معلومة — وثانيهما يكون[1242] [1243] من القبيل الثالث — أعني ممّا تكون[1244] ضلعان وزاوية بينهما قائمة معلومة. فيتمشّى فيهما طريق الأربعة المتناسبة ويحصل المطلوب[1245].



العمود
الضلع المعلوم
الزاوية المعلومة
الضلع المعلوم
العمود
الضلع المعلوم
الزاوية المعلومة
الضلع المعلوم

[شكل ١٤]

الباب الأوّل[1246] [من المقالة الثالثة]

في مساحة الأرض وما يتعلق بها

[١] مقدار الدرجة[1247] من العظيمة التي تفرض على سطح الأرض على ما وجده القدماء ستّة[1248] [1249] وستّون مِيلاً وثُلثا مِيل؛ وعلى ما وجده المحدثون ستّة وخمسون ميلاً وثُلثا مِيل. والمِيل ثُلث فرسخ بالاتّفاق. وذرعانه أربعة آلاف، كلّ ذراع أربعة وعشرون إصبعاً عند المحدثين؛ وثلاثة آلاف، كلّ ذراع اثنان وثلاثون إصبعاً عند القدماء. والإصبع بالاتّفاق ستّ شعيرات ضمت[1250] بُطون بعض إلى ظهور بعض.

[٢] ولأنّ المحقّقين من أهل هذا العلم آثروا اعتبار القدماء[1251] لكون بحثهم أوفى، تابعناهم في[1252] ذلك، فنقول[1253]: إذا ضرب فراسخ درجة عند القدماء — وهي اثنان وعشرون فرسخاً وتُسعا فرسخ — في ثلاثمائة وستّين، بلغ ثمانية[1254] آلاف فرسخ، وهي قدر محيط العظيمة الأرضيّة. ولِما سبق في المقدّمة، يكون الخارج من قسمته على اثنين وعشرين بعد ضربه في سبعة قطرها[1255]، وهو ألفان[1256] وخمسمائة وخمسة وأربعون[1257] فرسخاً ونصف فرسخ تقريباً. والحاصل من ضرب قطرها في محيطها تكسير سطح الأرض، وهو عشرون ألفاً ألفاً وثلاثمائة وأربعة وستّون ألف فرسخ. وربعه تكسير الربع المسكون.

[٣] وتكسير المعمور منه وهو قطعة أحاط بها من جهة[1258] الجنوب نصف الدائرة الاعتداليّة؛ ومن الشمال نصف مدار نقطة بعدها عن[1259] خطّ الاستواء كتمام المَيل كلّه؛ ومن المشرق والمغرب قطعتان من أفق القبّة متساويتان ومساويتان لتمام[1260] الميل الكلّي. طريقه أن يُمسح أوّلاً[1261] القطعة التامّة[1262] الشمالية من الأرض التي قطبها مقطع أفق القبّة ونصف نهارها، وقاعدتها مدار النقطة المذكورة. وينقص تكسيرها من تكسير نصف[1263] بسيط الأرض ويؤخذ نصف الباقي. وقد مرّ في المقدّمة أنّ بسيط القطعة التامّة من الكرة مساوٍ لدائرة[1264] نصف قطرها مساوٍ للمستقيم الخارج من

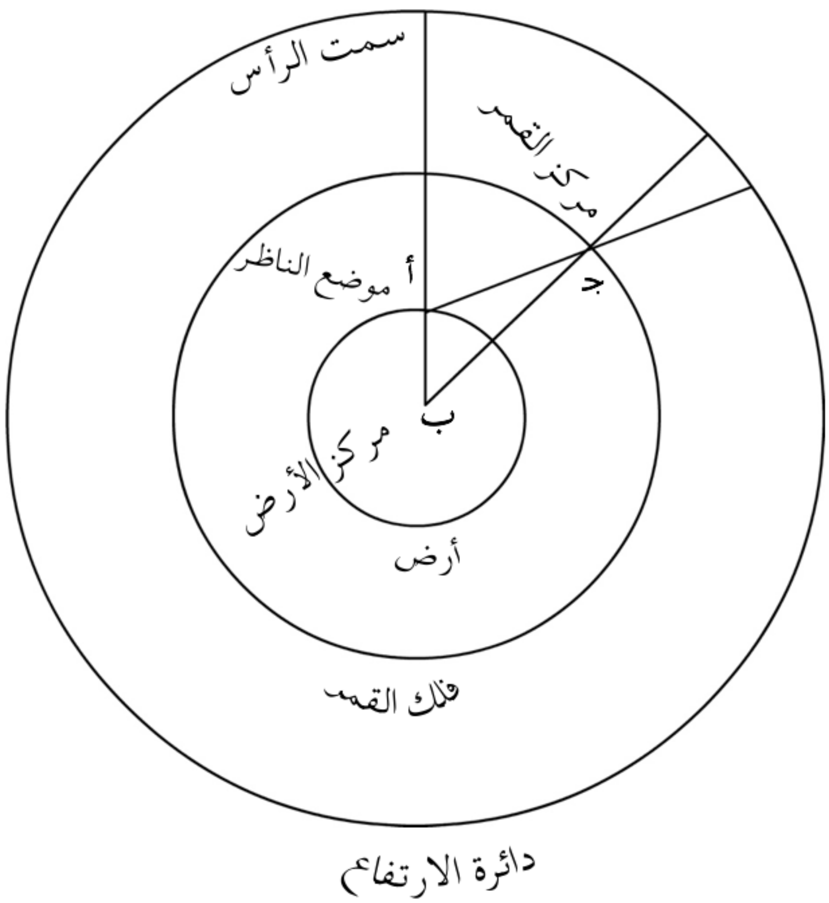
قطب القطعة إلى محيط القاعدة[1265]، أعني وتر المَيل الكلّي؛ لكن بما به قطر الدائرة مائة وأربعة[1266] عشر جزءاً، لا بما به قطر الدائرة مائة[1267] وعشرون. وطريق تحصيله أن يُؤخذ وتر الميل الكلّي من الجدول وينقص نصف عُشره، فالباقي[1268] هو المطلوب.

الباب الثاني [من المقالة الثالثة]

في[1269] معرفة أبعاد القمر عن مركز العالم بما به نصف قطر الأرض واحد ومعرفة[1270] نسبة[1271]

قطره وقطر الظلّ وقدرهما من أجزاء الدور

[١] رصد بطلميوس لمعرفة الأوّل[1272] القمر في أقلّ ارتفاعاته على نصف النهار، وكان ارتفاعه المرئي، وهو تسعة وثلاثون جزءاً[1273] وخمس دقائق، ناقصاً[1274] عن ارتفاعه الحقيقي المعلوم بالحساب بجزء وسبع دقائق، وهو اختلاف منظره. وإذا صُوّر شكله، وهو هذا:



[الشكل ١٥]

[٢] كان في[1275] مثلّث أ ب ج[1276] زاوية ج، وهي زاوية اختلاف، وزاوية ب، وهي تمام الارتفاع الحقيقي، وضلع أ ب، وهو واحد بالفرض[1277]، معلومةً، فأمكن معرفة البواقي لما مرّ في المقدّمة من أنّه إذا كان في مثلّث زاويتان وضلع معلومةً، أمكن معرفة الباقي بالأربعة المتناسبة. وقد خُرج بالحساب ب ج، وهو بُعد القمر عن[1278] مركز العالم، تسعة وثلاثين جزءاً[1279] وخمساً وخمسين دقيقة[1280] على أنّ أ ب ولنعبر عنه بالمقياس واحد.

[٣] وكان بُعده عنه حينئذٍ[1281]، بما به نصف قطر[1282] المائل ستّون، ونصف قطر تدويره[clxi] خمسة وخُمس، وما بين المركزين عشرة أجزاء وثلاث وعشرون دقيقة، أربعين جزءاً[1283] ورُبع وسُدس[1284] جزء. فنصف[1285] قطر المائل، بما به[1286] نصف قطر الأرض واحد، تسع وخمسون درجة وثماني دقائق وإحدى عشرة ثانية[1287] [clxii]؛ ونصف قطر[1288] التدوير خمس درجات وسبع دقائق[1289] وإحدى ثلاثون ثانية[1290] [clxiii]؛ وما بين المركزين عشر[1291] درجات وأربع عشرة دقيقة وثانيتان[clxiv] [1292]؛ ونصف قطر الحامل ثمان وأربعون درجة[1293] وأربع وخمسون دقيقة وتسع[1294] ثواني[1295] [clxv]. فأبعد بُعد القمر، بما به نصف قطر الأرض[1296] واحد، أربع وستّون درجة وخمس عشرة دقيقة واثنتان وأربعون ثانية[1297] [clxvi]؛ وأقربه ثلاث وثلاثون درجة واثنان[1298] وثلاثون دقيقة وستّ وثلاثون ثانية[1299] [clxvii]؛ وأوسطه بحسب المسافة ثمان[1300] وأربعون درجة[1301] وأربع وخمسون دقيقة وتسع ثواني[1302] [clxviii].

[clxi] تدويره] γ، β = التدوير: = α.

[clxii] وثماني دقائق وإحدى عشرة ثانية] γ = وخمس عشرة دقيقة: β، α.

[clxiii] وسبع دقائق وإحدى ثلاثون ثانية] γ = وثماني دقائق: β، α.

[clxiv] وأربع عشرة دقيقة وثانيتان] γ = وخمس عشرة دقيقة: β ،α.

[clxv] ثمان وأربعون درجة وأربع وخمسون دقيقة وتسع ثواني] γ = تسع وأربعون درجة : β، α.

[clxvi] وخمس عشرة دقيقة واثنتان وأربعون ثانية] γ = وثلاث وعشرون دقيقة: β، α.

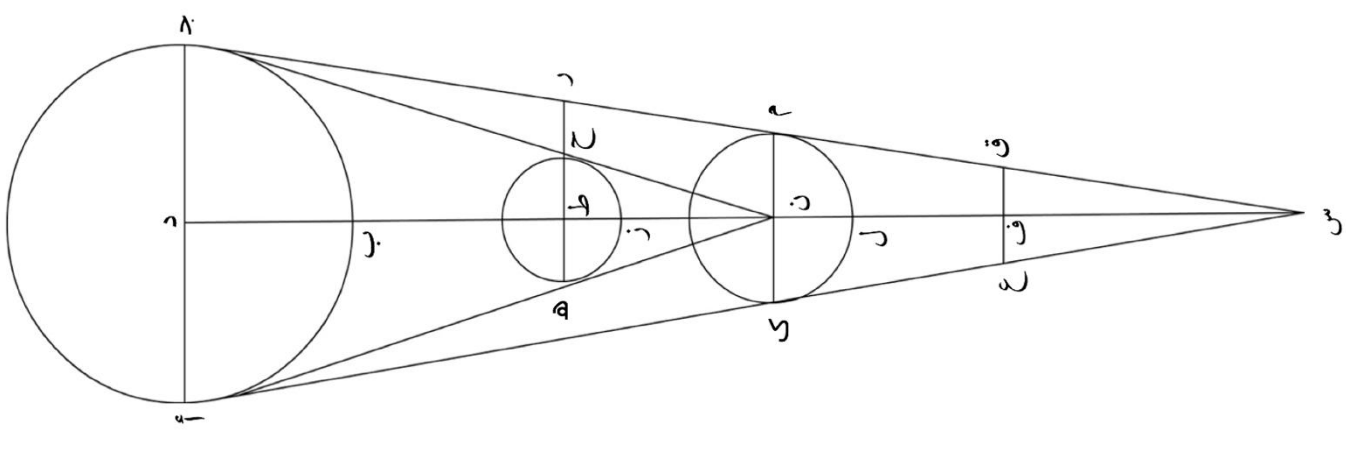
[٤] ورصد لمعرفة الثاني خسوفين كان القمر فيهما في الذروة وانخسف في أحدهما ربع قطره، وعرضه ثمان وأربعون دقيقة ونصفاً؛ وفي[1303] [1304] الآخر نصفه، وعرضه أربعون[1305] دقيقة وثُلثا دقيقة. وعرف[clxix] أنّ قطره في بُعده الأبعد أربعة أمثال الفضل، أعني إحدى وثلاثين دقيقة وثُلثاً لكون الفضل وهو سبع دقائق وخمسون ثانية ربعه، لأنّه[1306] [1307] التفاضل بين ربعه ونصفه. وإنّ عرضه في الخسوف الثاني نصف قطر دائرة الظلّ لمرورها بمركزه، وهو مثلا نصف قطر القمر وثلاثة أخماسه بالتقريب[1308]. وقد وجد في خسوفات كثيرة النسبة بينهما هذه النسبة. وأيضاً حكم بطلميوس بأنّ قطر الشمس في بُعدها[1309] الأوسط مساوٍ لقطر القمر في بُعده الأبعد.

[clxvii] اثنان وثلاثون دقيقة وستّ وثلاثون ثانية] γ = وسبع وثلاثون دقيقة: β، α.
[clxviii] ثمان وأربعون درجة وأربع وخمسون دقيقة وتسع ثواني] γ = تسع وأربعون درجة: β، α.
[clxix] وعرف] γ ،β = فعرف: α.

الباب الثالث [من المقالة الثالثة]

في معرفة مقدار قطري القمر والظلّ[1310] وبُعد الشمس الأوسط[1311] وبُعد رأس مخروط الظلّ عن مركز الأرض بما به نصف قطرها واحد

[١] فليكن[1312] أ ب جـ حول د[1313] العظيمة المارّة بمركز الشمس؛ وهـ ز ح[1314] حول ط المارّة بالقمر في بُعده[1315] الأبعد؛ وك ل م حول ن[clxx] المارّة بالأرض؛ و أ س جـ الفصل[1316] المشترك بين[1317] السطح المارّ وبين مخروط الشمس والأرض؛ وأ ن جـ الفصل[1318] المشترك بينه وبين مخروط الشمس والقمر؛ ود س[1319] المحور[1320] المشترك لهما؛ وأ جـ هـ ح ك م الخطوط المارّة بنقط[1321] التماس؛ وق ع المارّة[1322] بنقطتي تماسّ[1323] دائرة الظلّ عند أبعد بعد القمر في الاستقبال. فهذه الخطوط متوازية[1324] [clxxi] وقاطعة للمحور على قوائم ومساوية لأقطار دوائرها[1325] عند الحسّ.



[الشكل ١٦]

[clxx] ن] γ، β = جـ: α.
[clxxi] متوازية] γ = موازية: β، α.

[٢] وكلّ من ف ن ط ن، بُعد مركزي الظلّ والقمر عن مركز الأرض، أربع وستّون درجة[1326] وخمس عشرة دقيقة واثنتان وأربعون ثانية[1327] [clxxii] على أنّ نصف قطر الأرض، وهو المقايس، واحد. فلأنّ[1328] في مثلّث ن ط ح زاوية ن معلومةً من ط ح، نصف قطر القمر المعلوم بأجزاء الدور، وكذا ط القائمة فيكون في مثلّث[1329] [1330] ن ط ح زاويتان[1331] وضلع معلومةً بأجزاء الدور[1332]، فيصير[1333] سائر الأضلاع والزوايا أيضاً معلومةً، لما مرّ في المقدّمة. لكن ن ط أربع وستّون درجة[1334] وخمس عشرة دقيقة واثنتان وأربعون ثانية[1335] [clxxiii] بما به المقياس واحد، فيكون[1336] — لِما عرفت من كيفيّة ردّ المقادير من مقياس إلى آخر — ط ح ، نصف قطر القمر، بذلك[1337] المقادر سبع عشر[1338] دقيقة وأربعاً وثلاثين ثانية[clxxiv]. فنصف قطر الظلّ به خمس وأربعون دقيقة[1339] [1340] وأربعون[clxxv] [1341] ثانية. إذ نسبتها نسبة واحد إلى اثنين وثلاثة أخماس.

[٣] ولأنّ ط ف ، وهو ما بين مركزي القمر والظلّ، ضعف[1342] ط ن ، ما بين مركزي القمر والأرض، يكون — لِما مرّ في المقدّمة — مجموع ف ق ط ر ضعف ن م، نصف قطر الأرض[1343]، ولمساواتها لقطر الأرض[1344] وهو[1345] اثنان. إذا[1346] نقص ف ق ط ح ، نصفا قطري الظلّ[1347] والقمر، وهما واحد[1348] ثلاث دقائق وأربع عشرة[clxxvi] ثانية[1349]، يكون الباقي من اثنين ستّا

[clxxii] وخمس عشرة دقيقة واثنتان وأربعون ثانية] γ = وثلاث وعشرون دقيقة: β، α.
[clxxiii] وخمس عشرة دقيقة واثنتان وأربعون ثانية] γ = ثلاث وعشرون دقيقة : β، α.
[clxxiv] وأربعاً وثلاثين ثانية] γ = وثلاثا وعشرين ثانية: β، α.
[clxxv] وأربعون] γ = واثنتا عشرة: β، α.
[clxxvi] ثلاث دقائق وأربع عشرة] γ = ودقيقتان وخمس وثلاثون: β، α.

وخمسين دقيقة وستّاً وأربعين[clxxvii] ثانية[1350]، قدر[1351] ح ر. وتكون[1352] نسبة ن م الواحد إليه كنسبة ن ج إلى ج ح لتشابه مثلثي ن ج م ج ح ر، بل كنسبة ن د، بُعد الشمس الأوسط من الأرض، إلى د ط، البُعد بين النيّرين. فاذن إذا كان[1353] ن د واحداً، كان ط د ستّا[1354] وخمسين دقيقة وستّاً وأربعين[clxxviii] ثانية وط ن، أبعد[1355] بُعد القمر من الأرض، ثلاث دقائق وأربع عشرة[clxxix] ثانية.[1356]

[٤] ولأنّ هذا البُعد، بما به المقياس واحد، أربع وستّون درجة وخمس عشرة دقيقة[1357] واثنتان وأربعون ثانية[clxxx] [1358]، فلِما عرفت من طريق الردّ، يكون[1359] بُعد الشمس الأوسط، بما به المقياس واحد[1360] [1361]، ألفاً[1362] ومائة واثنين[1363] وتسعين[1364] وتسعة[1365] وعشرين دقيقة وأربع ثوان[1366][clxxxi] لأنّ نسبة ن م الواحد إلى ف ق، وهو خمس وأربعون دقيقة وأربعون[clxxxii] ثانية، كنسبة ن س، بُعد رأس مخروط ظلّ الأرض عن مركزها، إلى س ف، بُعد رأس[1367] عن مركز الظلّ، لتشابه[1368] مثلّثي س ن م س ف ق. فإذا كان س ن واحداً، كان س ق خمساً وأربعين دقيقة وأربعين[1369] [clxxxiii] [1370] ثانية، وف ن، بُعد مركز الظلّ عن مركز الأرض، أربع عشر[1371] دقيقة[1372]

[clxxvii] ستّاً وخمسين دقيقة وستّا وأربعين] γ = سبعا وخمسين دقيقة وخمسا وعشرين: β، α.
[clxxviii] ستّاً وخمسين دقيقة وستّا وأربعين] γ = سبعا وخمسين دقيقة وخمسا وعشرين: β، .α.
[clxxix] ثلاث دقائق وأربع عشرة] γ = دقيقتين وخمسا وثلاثين: β، α.
[clxxx] وخمس عشرة دقيقة واثنتان وأربعون ثانية] γ = وثلاث وعشرون دقيقة: β، α.
[clxxxi] ألفاً ومائة واثنين وتسعين وتسعة وعشرين دقيقة وأربع ثوان] γ = ألفاً أربعمائة وخمسة وتسعين: β، .α
[clxxxii] وأربعون] γ = اثنتا عشرة: β، α
[clxxxiii] وأربعين] γ = واثنتى عشرة: β، α.

وعشرين[clxxxiv] ثانية. لكن هذا البُعد، بما به المقياس واحد، أربع وستّون درجة وخمس عشرة[1373] دقيقة واثنتان وأربعون ثانية[clxxxv 1374]. فبحسبه[1375] يكون – لِما عرفت – بُعد[1376] رأس مخروط الظلّ عن مركز الظلّ[1377] [1378] مأتين وأربعة أمثال لنصف قطر الأرض [1379] وأربعاً وأربعين دقيقة[clxxxvi 1380]، وعن مركز الأرض[1381] مأتين وتسعة وستّين مثلاً[1382] لنصف قطر الأرض وثماني ثواني[clxxxvii].

[clxxxiv] وعشرين] γ = ثماني وأربعين: β، α.

[clxxxv] وخمس عشرة دقيقة واثنتان وأربعون ثانية] γ = وثلاث وعشرون دقيقة: β، α.

[clxxxvi] مأتين وأربعة أمثال لنصف قطر الأرض وأربعا وأربعين دقيقة] γ = مائة وسبعة وتسعين مثلاً لنصف قطر الأرض: β، α.

[clxxxvii] مأتين وتسعة وستّين مثلاً لنصف قطر الأرض وثماني ثواني] γ = مأتين واحداً وستّين مثلاً لنصف قطر الأرض: β، α.

الباب الرابع [من المقالة الثالثة]

في معرفة قدر قطر الشمس بما به المقياس واحد ونسبة جرمها[clxxxviii] إلى جرم الأرض

[١] قد ثبت في علم المناظر[1383] أنّ كلّ جرمين متساويين في الرؤية، مختلفين في البُعد، تكون[1384] نسبة[1385] قطر الأقرب إلى قطر الأبعد كنسبة بُعد الأقرب إلى بُعد الأبعد لإحاطة خطّين شعاعيين بهما لتساويهما في الرؤية وحدوث مثلّثين متشابهين. فإذن نسبة نصف قطر القمر، وهو سبع عشر[1386] دقيقة[1387] وأربع وثلاثون[clxxxix] ثانية، إلى نصف قطر الشمس المجهول كنسبة أبعد بعد القمر، وهو أربع[1388] وستّون درجة وخمس عشر دقيقة واثنتان وأربعون ثانية[cxc]، إلى أوسط بُعد[1389] الشمس، وهو ألف ومائة واثنان وتسعون مثلاً للمقياس وتسعة وعشرون دقيقة وأربع ثواني[cxci] بما به المقياس واحد. فضربنا الأوّل في الرابع وقسّمنا الحاصل على الثالث، خرج الثاني المجهول، وهو خمسة[1390] وتسعة[1391] وأربعون[1392] دقيقة[cxcii]. وهو مقدار نصف قطر الشمس بما به نصف قطر الأرض واحد.

[٢] وقد بيّن أقليدس في الثانية عشرة من كتابه أنّ نسبة الكرة إلى الكرة كنسبة مكعّبي قطريهما. فإذا[1393] كعّب قطر[1394] الأرض والشمس، ظهر أنّ الشمس مائة وسبعة وتسعون[cxciii] مثلاً للأرض.

[clxxxviii] جرمها] γ = جرمه: β، α.
[clxxxix] وأربع وثلاثون] γ = وثلاث وعشرون: β، α.
[cxc] وخمس عشر دقيقة واثنتان وأربعون ثانية] γ = وثلاث وعشرون دقيقة: β، α.
[cxci] ألف ومائة واثنان وتسعون مثلاً للمقياس وتسعة وعشرون دقيقة وأربع ثواني] γ = ألف وأربعمائة وخمسة وتسعون مثلاً للمقياس: β، α.
[cxcii] وهو خمسة وتسعة وأربعون دقيقة] γ = وهو ستّة وأربع وأربعون دقيقة: β، α.
[cxciii] مائة وسبعة وتسعون] γ = مائتان وأربعة وأربعون: β، α.

الباب الخامس [من المقالة الثالثة]

في معرفة باقي أبعاد الشمس وأبعاد السفليّين بما به المقياس واحد

[١] فلأنّ[1395] نسبة ما بين مركزي الشمس، وهو بحسب رصدنا الجديد درجتان ودقيقة واحدة وعشرون ثانية[cxciv]، إلى ستّين كنسبة المطلوب[1396] – أعني مقدار ما بين المركزين[1397] بما به المقياس واحد – إلى مقدار بُعدها الأوسط بهذا المقياس[1398]، وهو ألف ومائة واثنان وتسعون مثلاً للمقياس وتسعة وعشرون دقيقة وأربع ثواني[cxcv]، فإذا ضربنا الأوّل في الرابع منحطاً، حصل[1399] مقدار ما بين المركزين بما به المقياس واحد، وهو أربعون مثلاً وإحدى عشرة دقيقة وثماني وعشرون ثانية[cxcvi]. فبُعدها الأبعد ألف ومائتان واثنان وثلاثون مثلاً وأربعون دقيقة واثنان وثلاثون ثانية[cxcvii]؛ وبُعدها الأقرب ألف ومائة واثنان وخمسون وثماني عشرة دقيقة[cxcviii]. وهذا هو البُعد الأبعد للزهرة، وهو بما به نصف قطر حاملها ستّون مائة وأربع درجات ودقيقتان؛ وبُعدها الأقرب بهذه الأجزاء خمس عشرة درجة وثمانية وخمسون دقيقة. وظاهر[1400] أنّ نسبة البُعد الأبعد للزهرة إلى البُعد الأقرب لها بأجزاء قطر حاملها كنسبة مقدار البُعد[1401] الأبعد بما به المقياس واحد[1402] إلى مقدار البُعد الأقرب بهذه الأجزاء، وهو المطلوب[1403].

[cxciv] وعشرون ثانية] γ = –β، –α.

[cxcv] ألف ومائة واثنان وتسعون مثلاً للمقياس وتسعة وعشرون دقيقة وأربع ثواني] γ = ألف وأربعمائة وخمسة وتسعون: β، α.

[cxcvi] أربعون مثلاً وإحدى عشرة دقيقة وثماني وعشرون ثانية] γ = خمسون ورُبع: β، α.

[cxcvii] ألف ومائتان واثنان وثلاثون مثلاً وأربعون دقيقة واثنان وثلاثون ثانية] γ = ألف وخمسمائة وخمسة وأربعون مثلاً ورُبع مثل للمقاس: β، α.

[cxcviii] ألف ومائة واثنان وخمسون وثماني عشرة دقيقة] γ = ألف وأربعمائة وأربعة وأربعون مثلاً وثلاثة أرباع مثل: β، α.

[٢] فضربنا الثاني، وهو يه نح دقيقة[cxcix]، في الثالث، وهو[1404] يط يب يز لو[cc] دقيقة[cci]، وقسّمنا الحاصل على الأوّل، وهو أ مد ب[1405]، خرج المطلوب[1406] ب نو نا[ccii] [1407]، وهو مائة وستّة وسبعون مثلاً وإحدى وخمسون دقيقة[cciii]، وهو بعينه البُعد الأبعد لعطارد. وذلك، بما به نصف قطر حامله ستّون، أحد وتسعون درجة وثلاثون دقيقة. وبُعدها[cciv] الأقرب بهذه الأجزاء ثمانية وعشرون درجة وثلاثون دقيقة.

[٣] وقد مرّ أنّ نسبة البُعد الأبعد إلى البُعد[1408] الأقرب بأجزاء قطر الحامل كنسبة مقدار[1409] البُعد الأبعد، بما به المقياس واحد، إلى مقدار البُعد الأقرب بتلك الأجزاء. فإذا ضربنا الثاني، وهو كح ل دقيقة[ccv]، في الثالث، وهو ب نو نا دقيقة[ccvi]، وقسّمنا الحاصل على[1410] الأوّل، وهو أ لا ل دقيقة[ccvii]، خرج ما هو المطلوب[1411] — أعني مقدار بُعد مقعّر فلك عطارد بما به نصف قطر

[cxcix] دقيقة] γ، β= –α.

[cc] يط يب يز لو] γ = كد د مه: β، α.

[cci] دقيقة] γ، β= –α.

[ccii] ب نو نا] γ = جـ ما مد: β، α.

[cciii] هو مائة وستّة وسبعون وإحدى وخمسون دقيقة] γ = أعني مأتين واحداً وعشرين وأربعاً وأربعين دقيقة: β، α.

[cciv] وبُعدها] γ = بعده: β، α.

[ccv] دقيقة] γ، β= –α.

[ccvi] ب نو نا دقيقة] γ = جـ ما مد: β، α.

[ccvii] دقيقة] γ، β = –α.

الأرض[1412] واحد — نه هـ[1413] [ccviii]، أيْ[ccix] خمسة وخمسون مثلاً لنصف قطر الأرض وخمس دقائق.[ccx]

[ccviii] نه هـ] γ = آ ط جـ : β، α.

[ccix] أيْ] γ = أعني: β، α.

[ccx] خمسة وخمسون مثلاً لنصف قطر الأرض وخمس دقائق] γ = تسعاً وستّين درجة وثلاث دقائق فاضلاً على البعد الأبعد الذي خرج للقمر من حساب رصد اختلاف المنظر الذي مرّ ذكره بأربعة أمثال المقياس وأربعين دقيقة وذلك ثخانة الحوزهر للقمر: β، α (ال‹‹ درجة›› ناقص).

الباب السادس [من المقالة الثالثة]

في معرفة أبعاد[1414] العلويّة والثوابت[1415]

[١] أمّا المرّيخ، فأقرب أبعاده، بما به نصف[1416] قطر حامله ستّون، يد جـ[1417] دقائق[ccxi]، ولكونه مساوياً[1418] لأبعد أبعاد الشمس يكون مقداره بالمقياس ألفاً ومائتين واثنين وثلاثين مثلاً وأربعين دقيقة واثنين وثلاثين ثانية[ccxii]، أعني كـ لب م لب[ccxiii]. وأبعد أبعاد المرّيخ، بما به نصف قطر حامله ستّون، أ مه نز دقيقة. فنسبته إلى يد جـ دقائق[ccxiv] كنسبة المطلوب[1419] إلى كـ لب م لب[ccxv] دقيقة[ccxvi]. فقسّمنا مسطّح الطرفين[1420] على الباقي لنخرج مقدار بُعده الأبعد بالمقياس، ب لد نه ل[ccxvii] [1421]، أعني تسعة آلاف ومائتان وخمسة وتسعون مثلاً وثلاثون دقيقة[ccxviii]، وهذا هو مقدار البُعد الأبعد للمرّيخ بالمقياس.

[ccxi] دقائق] γ ، β= —α.

[ccxii] ألفاً مائتين واثنين وثلاثين مثلاً وأربعين دقيقة واثنين وثلاثين ثانية] γ = ألفاً وخمسمائة وخمسة وأربعين ورُبع مثل للمقاس: β، α.

[ccxiii] كـ لب م لب] γ = كه مه يه دقيقة: β، α (ال‹‹ دقيقة›› ناقص).

[ccxiv] دقائق] γ ، β = —α.

[ccxv] كـ لب م لب] γ = كه مه يه: β، α.

[ccxvi] دقيقة] γ ، β = —α.

[ccxvii] ب لد نه ل] γ = جـ يد يب لز دقيقة: β، α (ال‹‹ دقيقة›› ناقص).

[ccxviii] تسعة آلاف ومائتان وخمسة وتسعون مثلاً وثلاثون دقيقة] γ = أحد عشر ألفاً وستّمائة واثنين وخمسين مثلاً وسبعاً وثلاثين دقيقة: β، α (ال‹‹مثلاً›› ناقص).

[٢] وهو بعينه أقرب أبعاد المشتري، لكن هو، بما به نصف قطر حامله ستّون، مه كو دقيقة[ccxix]. وأبعاد أبعاده أ يد لد دقيقة[ccxx]. فنسبة أ يد لد إلى مه كو كنسبة المطلوب[1422] إلى ب لد نه ل[ccxxi]. فقسّمنا مسطّح الطرفين على الثاني لنخرج الثالث المطلوب[1423]، د يد يو هـ[ccxxii]، أيْ خمسة عشر ألفاً ومائتان[1424] وستّة وخمسون مثلاً وخمس دقائق[1425] [ccxxiii]، وهو مقدار البُعد الأبعد للمشتري بالمقياس.

[٣] وهو بعينه أقرب أبعاد زحل، لكن أقرب أبعاده[1426]، بما به نصف قطر حامله ستّون، مط م دقيقة[ccxxiv]. وأبعد أبعاده بهذه الأجزاء أ ي ك دقيقة[ccxxv]. ونسبة أبعد[1427] أبعاده إلى[1428] أقرب أبعاده كنسبة المطلوب[1429] إلى د يد يو هـ[ccxxvi]. فيُقسّم مسطّح[1430] الطرفين على الثاني ليخرج

[ccxix] دقيقة] γ، β = —α.
[ccxx] دقيقة] γ، β = —α.
[ccxxi] ب لد نه ل] γ = جـ يد يب لز: β، α.
[ccxxii] د يد يو هـ] γ = وهو هـ يح مد لح دقيقه: β، α (الـ‹‹ دقيقة›› ناقص).
[ccxxiii] أيْ خمسة عشر ألفاً ومائتان وستة وخمسون مثلاً وخمس دقائق] γ = أعني تسعة عشر ألفاً ومائة وأربعة وعشرين مثلاً للمقياس وثمانية وثلاثين دقيقة: β، α.
[ccxxiv] دقيقة] γ، β = —α.
[ccxxv] دقيقة] γ، β = —α.
[ccxxvi] د يد يو هـ] γ = هـ يح مد لح: β = هـ يح مد له: α.

المطلوب[1431] و ٠ د ح، أيْ أحد وعشرون ألفاً وستّمائة وأربعة أمثال المقياس وثماني دقائق[ccxxvii]، وهو[1432] مقدار بُعد مقعّر فلك الثوابت[1433] عن مركز العالم بما به نصف قطر الأرض واحد[ccxxviii][1434].

[٤] ولمعرفة مقدار نصف قطر كواكب القدر الأوّل من الثوابت بالمقياس، نقول: نسبة بُعد الثوابت إلى البُعد الأوسط للشمس كنسبة المطلوب[1435] إلى حصّة تلك الكواكب؛ وهي جزء[1436] من عشرين من نصف قطر الشمس، وهو بالمقياس — كما سبق — ه مط[1437] دقيقة.[ccxxix] قسّمناه على عشرين، خرج يز كز ثانية[ccxxx]، وهي حصّة تلك الكواكب. ضربناها في بُعد الثوابت، وقسّمنا الحاصل[1438] على البُعد الأوسط للشمس، خرج ه يو[ccxxxi]، وهو المطلوب[1439]. فبُعد محدّب فلك الثوابت، أعني مقعّر الفلك الأعظم، و ٠ ط كد[ccxxxii] دقيقة. والله أعلم ببُعد[1440] محدّب هذا[1441] الفلك، فإنّه لا سبيل للبشر إلى معرفته. وظهر ممّا ذكرنا أنّ قطر[1442] كواكب القدر الأوّل من الثوابت

[ccxxvii] و ٠ د ح أيْ أحد وعشرون ألفاً وستّمائة وأربعة أمثال المقياس وثماني دقائق] γ = –β، –α.

[ccxxviii] بما به نصف قطر الأرض واحد] γ = + وذلك سبع وعشرون ألفاً واثنان وثمانون مثلاً للمقياس واثنان وثلاثون دقيقة أعني ز لا كب مثلاً للمقياس ولب دقيقة: β، α.

[ccxxix] ه مط دقيقة] γ = و مد: β، α.

[ccxxx] يز كز ثانية] γ = ك يب: β، α.

[ccxxxi] ه يو] γ = و و: β، α.

[ccxxxii] و ٠ ط كد] γ = ز لا كح لح: β، α.

خمسة أمثال قطر الأرض[1443] وستّة عشر دقائق.[ccxxxiii] كعّبناهما ليظهر[1444] أنّ جرم هذه الكواكب[ccxxxiv] مائة وستّة وأربعون مثلاً[ccxxxv] لجرم[1445] الأرض.[ccxxxvi]

[ccxxxiii] خمسة أمثال قطر الأرض وستّة عشر دقائق] γ = ستّة أمثال قطر الأرض وستّة دقائق: β، α.

[ccxxxiv] هذه الكواكب] γ، β = هذه الكوكب: α.

[ccxxxv] مائة وستّة وأربعون مثلاً] γ = مائتان وسبعة وعشرون مثلاً: β، α.

[ccxxxvi] الأرض] γ، β = + والله أعلم: α.

Critical Apparatus

[1] ١ب: ص؛ ١ب: غ؛ ٠ب: ك؛١ ب: م.

[2] بِسۡـــمِٱللَّهِٱلرَّحۡمَٰنِٱلرَّحِيـــمِ] ص، ك، هاغ (معظم ‹‹بسم الله الرّحمن الرحيم›› غير مقروء) = + وبك ثقى يا كريم: هام.

[3] وقدّر] ص، م = وقدر: غ، ك.

[4] منازل] تاص.

[5] من أجلّ] من اجل: غ.

[6] الله تعالى] الله: غ.

[7] خدم] حد: غ.

[8] السلطان] غ (ال‹‹ن›› في الهامش).

[9] والمجاهدين] والمجاهدى: غ.

[10] العداة] العِداواةِ: ك.

[11] ٢آ: م.

[12] مُحيي] محيى: ص، غ، م = محى: ك.

[13] والإنصاف] فاص.

[14] ٢آ: ص.

[15] ٢آ: غ.

[16] المؤيَّد] الموبد: ص = المويد: ك.

[17] الأعداء] الاعدا: ك.

[18] الدنيا] الدنياه: غ.

[19] ١آ: ك.

[20] سلطان مُحَمَّد خان اسعده الله في الدارين ومهّد] سُلْطَانْ مُحَمّد خَانْ اَسعَدَ اَللّهُ تَعَالَى فِي الَدارَيْنِ وَمَهّد: ك.

[21] اندراسها] هاغ.

[22] ٢ب: م.

[23] مُخضّرة] محضرة: غ، ك = مُخْصَرَّة: م.

[24] وآضت] واضت: غ.

[25] بهائها] بهاتها: غ.
[26] خدمته] غ، ك (ال‹‹ه›› مطموس).
[27] وأجلّ] واجل: غ.
[28] ٢ب: ص.
[29] وصنفت] وصنعت: م.
[30] كبير] كثير: غ = كبر: ك.
[31] لفتح] م (يوجد ال‹‹با›› شطوباً قبل هذه العبارة).
[32] تعالى] تع: غ.
[33] ٣آ: م.
[34] ٢ب: غ.
[35] ورتّبتُه على مقدّمة وثلاثة مقالات] –غ، هام (مع رمز ‹‹صح›› وال‹‹مقدمة›› مطموس).
[36] ١ب: ك.
[37] تناهى] تناهي: م.
[38] لا غير] فقط: غ.
[39] وينتهي] وينتهى: م.
[40] بالخطّ والنقطة] بالنقطه والحط: غ.
[41] تناهى] تناهي: م.
[42] ٣آ: ص.
[43] يتساوى] يتساوي: م.
[44] ٣ب: م
[45] أقطاره] اقطارها: غ.
[46] وما] م (يوجد ال‹‹ا›› شطوباً قبل هذه العبارة).
[47] هذا] تاغ.
[48] بسطح] هاغ.
[49] فيه] فاغ.
[50] مركزه] مركزها: غ.
[51] وما] م (يوجد ال‹‹ا›› شطوباً قبل هذه العبارة).
[52] وتسمّى] وسمى: ص= ويسمى: م، ك.

[53] ٣ب: ص.
[54] ٢آ: ك.
[55] ٣آ: غ.
[56] سطح] سطحين: غ.
[57] ٤آ: م.
[58] ضلعاها] غ (ال‹‹ها›› في الهامش) = ك (ال‹‹ها›› فوق السطر).
[59] فالأصغر حادّة والأكبر منفرجة] هاغ (بخط غير الناسخ ومع رمز ‹‹صح››) = وحاده ان كاںـ اصعر من قاىمه ومىفرجه ان كاںـ اعطم مىها: هام (مع رمز ‹‹صح››).
[60] يفرض] ىعرص: ص = ىفرض: م.
[61] بزوايا متساوية] شام = ىراوىه قاىمه: هام (مع رمز ‹‹ صح››).
[62] والسطحان] + المستويان: هاغ (مع رمز ‹‹صح››).
[63] العمود على فصلهما المشترك في أحدهما مع خطّ آخر في السطح الآخر بقائمة، أو نقول إن لم يخرج العمود الخارج من نقطة في فصلهما المشترك على أحد السطحين من السطح الآخر] هاغ (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››) = كل عمودين مستقيمين يخرجان فيهما من ايّة ىقطه ىفرض على فصلهما المشترك ىقاىمه: شام.
[64] ٤ب: م.
[65] ٤آ: ص.
[66] هي] الى هي: ص (ال‹‹ الى›› مشطوب).
[67] الجهات] هام (مع رمز ‹‹صح››) = الجهتين: غ، شام.
[68] الأبعاد] غ (ال‹‹د›› في الهامش).
[69] أصلاً] هاغ.
[70] ٢ب: ك.
[71] منه هو المحاط بخطّ أو أكثر والمجسّم هو المحاط بسطح أو أكثر الدائرة شكلّ مسطّح] هاغ.
[72] ٣ب: غ.
[73] ٥آ: م.
[74] منه] منها: م.
[75] ٤ب: ص.
[76] نصفاً] نصف: ك.
[77] كانت] م (ال‹‹ن›› مشطوب وال‹‹نـ›› مكتوب بدلاً منه تحت السطر).

[78] الآخر من القطر] هاغ (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››).
[79] لها] + وايضا: غ.
[80] ٥ب: م.
[81] بها] –م.
[82] ثلاثة خطوط بها وذا أربعة أضلاع إن كانت] ثلثه خطوط وذا اربعه اضلاع ان كانت: هاك (مع رمز ‹‹صح››).
[83] ٣آ: ك.
[84] ٥آ: ص.
[85] الأضلاع] غ (ال‹‹ع›› في الهامش).
[86] خطّ] فاغ.
[87] ٤آ: غ.
[88] ٦آ: م.
[89] يكون] نكون: ص.
[90] الخارجة] هام.
[91] أقطارها كلّ واحد من الخطوط الخارجة] اقطارها والخارجة: م.
[92] تتحرّك] سحرك: ص = يتحرك: غ، ك، م.
[93] فذلك] غ (ال‹‹لك› في الهامش).
[94] مِحور] الخطّ محور: ك.
[95] قطعة] فاغ.
[96] تحيط] نحيط: ص، غ، ك = يحيط: م.
[97] ٥ب: ص.
[98] ٦ب: م.
[99] التضايق] فاغ.
[100] إذا] فاغ.
[101] مستقيم] خط مستقم: ك (ال‹‹خط›› فوق السطر).
[102] ماسّ] + ذلك الخط هذا: هاك (مع رمز ‹‹صح››).
[103] ٣ب: ك.
[104] المخروط] غ (ال‹‹ط›› في الهامش).

105 ٤ب: غ.
106 وألقي] والقى: ص = وأُلقى: غ = والقى: ك، م.
107 القاطع] + او نقول هو ما بقى من المخروط بعد ان القى منه مخروط شبيه به: ص (ال‹‹مخروط شبيه به›› فوق السطر)، هاك (مع رمز ‹‹صح››)، شام.
108 المقالة الأولى في بيان أحوال الأجرام العلويّة وهي مشتملة على ستّ أبواب] هاك (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››) = –غ.
109 ٧آ: م.
110 ٦آ: ص.
111 مركزه] تاغ.
112 تسعة] فاغ.
113 مقعّر] مقعّره: غ.
114 يساوي] فيه ساوى: ك.
115 جوفه] فاص.
116 فلك المرّيخ] هاغ.
117 ثمّ فلك المشتري ثمّ فلك المرّيخ ثمّ فلك الشمس] هاك (مع رمز ‹‹صح››).
118 ٧ب: م.
119 ٦ب: ص.
120 ومقعّر] مقعر: ك.
121 سطحي] سطحي: غ (يوجد حرفان غير مقرئان قبل ال‹‹ سطحي››).
122 ٤آ: ك.
123 المتنفّسة] فاص.
124 ٥آ: غ.
125 إليها] اليه: غ.
126 دائرتين] الدائرتن: ك.
127 السطوح] + الباب الثانى في بيان الثالث الى اح: شام (ال‹‹الثالث الى اح›› تحت السطر).
128 الباب الثاني] م (هذا الباب في الثالث ترتيباً في هذه النسخة) = الباب الثالث: ص (هذا الباب في الثالث ترتيباً في هذه النسخة).
129 ١٠آ: ص.

[130] ١١آ: م.
[131] ٥ب: غ.
[132] درجة ثمّ قسموا كلّ درجة بستّين قسماً وسمّوا كلّ قسم] هام (مع رمز ‹‹صح››).
[133] الفلك الأعظم] هام (مع رمز ‹‹صح››) = الحركة الاولى الفلك الاعطم: ك (ال‹‹ الحركة الاولى›› في الهامش، مع رمز ‹‹صح››) = الحركة الأولى: شام.
[134] وتسمّى] وسمى: ص، م = ويسمى: ك.
[135] النعش] نعش: ك.
[136] فلك الثوابت] هام (مع رمز ‹‹صح››) = الحركه الثانيه فلك الثوات: ك (ال ‹‹الحركه الثانيه›› في الهامش، مع رمز ‹‹صح››) = الحركة الثانيه: شام.
[137] وتسمّى] وسمى: ص، م = ويسمى: غ، ك.
[138] وفلك البروج أيضاً] هام (مع رمز ‹‹صح››).
[139] ٤ب: ك.
[140] النهار] + في جميع الافلاك التى نتحرك بالحركتين: شام.
[141] ١٠ب: ص = ١١ب: م.
[142] على نقطتين متقابلتين تسمّيان نقطتي الاعتدالين] هاغ (مع رمز ‹‹صح››) = + فالتى اذا جاورها الشمس صارت شماليه عن المعدل هو الاعتدال الربيعى وراس الحمل والاخرى الخريفى وراس الميزان وغاية البعد بين المنطقين كالبعد بين قطبيها الذين فى جهته ويسمى الميل الكلى: شام.
[143] الأربعة] الاربعه: فاص.
[144] المنطقتين] + واقصر قوس واقعه من هذه الدايره بين منطقتين او بين قطبيها سمى بالميل الكلى: هاك (مع رمز ‹‹صح››).
[145] من الجانب الأقرب] فاص.
[146] تسمّى] سمى: ص = يسمى: ك، م.
[147] ١٢آ: م.
[148] ١١آ: ص.
[149] تسمّى] سمى: ص، ك = يسمى: غ، م.
[150] ٦آ: غ.
[151] الكوكب] الكواكب: ك.
[152] ودائرة الميل] هاغ (يوجد ال‹‹ودائره الافق›› زائداً في السطر).

[153] تسمّى] سمى: ص = يسمى: ك، م.
[154] تسمّى] سمى: ص، ك = يسمى: م.
[155] الكوكب] الجزء: ك.
[156] قامة] –ك.
[157] ٥آ: ك.
[158] وبها] بها: غ.
[159] ١٢ب: م.
[160] ١١ب: ص.
[161] تُدعى] ىدعى: ص، ك، م = يدعى: غ.
[162] الاعتدال] غ (ال‹‹عتدال›› في الهامش).
[163] تسمّى] سمى: ص، ك = يسمى: غ، م.
[164] المشرق] + او الحزء: شام.
[165] لذلك] + لخ: فاص.
[166] أو الجزء] فام = + م: فاص.
[167] ٦ب: غ.
[168] تسمّى] سمى: ص، ك = يسمى: غ، م.
[169] النهار] فاص.
[170] ١٣آ: م.
[171] وتنصّف] وىنصف: ص، م = وينصف: ك.
[172] ١٢آ: ص.
[173] وتسمّى] وسمى: ص، غ، ك = ويسمى: م.
[174] ووَتِدَ] غ (ال‹‹تِدَ›› في الهامش).
[175] وتسمّى] وسمى: ص، م = ويسمى: غ، ك.
[176] المعدّل] فاص.
[177] ٥ب: ك.
[178] تسمّى] سمى: ص، غ = يسمى: ك، م.
[179] ودائرة] غ (ال‹‹ة›› في الهامش).
[180] وتسمّى] سمى: ص، غ = يسمى: ك، م.

181 السموت] السموآت: ك.
182 والمغرب] هاغ (مع رمز ‹‹صح››).
183 سماء] فام.
184 الرؤية] فاص، ك (ال‹‹ا›› فوق السطر).
185 بسمتي] ويسمى: ك.
186 ١٣ب: م.
187 ٧آ: غ.
188 ١٢ب: ص.
189 تسمّى] فاغ.
190 فلك] الفلك: غ، م.
191 البروج] هام (مع رمز ‹‹صح››) = –غ.
192 وتقطع] ويطع: ص = ونقطع: ك = ويقطع: م.
193 نقطتين] + متقابلتين لكونهما عظيمتين: هاك (مع رمز‹‹صح››).
194 تسمّى] سمى: ص، غ = يسمى: ك، م.
195 خطّ السمت] خطّ استواء السمت: ك (ال‹‹استواء›› في الهامش، مع رمز ‹‹صح››).
196 والقوس] غ (ال‹‹القوس›› فوق السطر، مع رمز ‹‹صح››).
197 تسمّى] سمى: ص = يسمى: ك، م.
198 ١٤آ: م.
199 تسمّى] سمى: ص، ك = يسمى: غ، م.
200 ٦آ: ك.
201 الصغار] فاص.
202 وتسمّى] وسمى: ص = ويسمى: ك، م.
203 المدارات] مدارات: ك.
204 وهي] وتسمى: غ.
205 صغار] صغاراً: غ.
206 ١٣آ: ص.
207 ويسمّى] فسمى: ص = وسمى: ك، م.
208 ما يقع] ما يع: فاص.

209 ١٤ب: م.
210 ٧ب: غ.
211 منه] فام.
212 ومدارات] ك (ال ‹‹وم›› مشطوب).
213 ١٣ب: ص.
214 المفروضة] + المتحركة: هاك.
215 صغار] صغاير: غ.
216 الأفق] غ (توجد كلمة غير مقروءة فوق هذه الكلمة).
217 ٦ب: ك
218 ١٥آ: م.
219 النهار] غ (ال‹‹ ر›› في الهامش).
220 الفوقانيين] هاغ (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››).
221 مع] مبداءها مع: غ (ال‹‹اءها›› مشطوب).
222 نهار] النهار: ك.
223 مبدأها تقاطع مبدأ العمارة] —م.
224 العمارة] + مبدأها تقاطع مبدأ العمارة: هام (مع رمز ‹‹ صح››).
225 طلع] بطلع: ص، ك.
226 أو مركز كوكب] هام (مع رمز ‹‹ صح››).
227 ١٤آ: ص = ٨آ: غ.
228 مركز] طاك.
229 أو مركز هذا الكوكب] هام (مع رمز ‹‹ صح››).
230 ٨آ: م.
231 الباب الثالث] م (هذا الباب في الثاني ترتيباً في هذه النسخة) = ص (هذا الباب في الثاني ترتيباً في هذه النسخة) = الباب الثاني في بيان: شام (يوجد ال ‹‹الثالث الى اح(؟)›› شطوباً تحت السطر).
232 ٧آ: ص.
233 حركتيهما] غ، م = وحركتهما: ص، ك.
234 به] بهما: ص (بعد هذه الكلمة، يوجد ال‹‹س›› مع خطّان صغيران ملتقيان له من تحته)، م.
235 ٧ب: ص.

[236] ٨ب: م.
[237] من] تاص.
[238] ٧آ: ك.
[239] كما سبق ذكره] هام (مع رمز ‹‹ صح››) = وسمى معدل النهار: شام
[240] الثامن] + ويسمى منطقه البروج وفلك البروج ايضا: شام.
[241] على نقطتين] + سمسان نقطتى الاعتدالين: شام.
[242] وقعت] ووقعت: ك.
[243] الربيعي] الحريفى: شاك.
[244] تسمّى] سمى: ص، م = يسمى: ك.
[245] ٧ب: ك.
[246] الدائرتين] ص (ال‹‹تين›› في الهامش).
[247] ٨آ: ص.
[248] كج ل يز] + ثانية: غ.
[249] ٩آ: م.
[250] ٨ب: غ.
[251] عندهما] غ (يوجد ال‹‹سماع›› شطوباً بين ال‹‹عند›› وبين ال‹‹هما››).
[252] فتنقسم] فينقسم: غ، ك، م = فنقسم: ص.
[253] النقط] النقطة: ك.
[254] ومدّة] ومدت: ك.
[255] الشمس] هاص (مع رمز ‹‹ص››).
[256] ٨ب: ص.
[257] تمرّ] بمر: ص، ك، م = يمر: غ.
[258] ٩ب: م.
[259] النقط] النقطة: ك.
[260] ٨آ: ك.
[261] ٩آ: غ.
[262] ٩آ: ص.

[263] توالي] غ (ال‹‹لي›› في الهامش).
[264] تحرّك] فاك.
[265] ١٠آ: م.
[266] الكثرة] الكرة: ك.
[267] التي] فاص.
[268] الخطوط] فاص.
[269] ١٠ب: م.
[270] أرادوا] ص (ال‹‹دوا›› فوق السطر) = غ (ال‹‹وا›› تحت السطر) = ارادو: ك.
[271] ٩ب: ص.
[272] ٨ب: ك.
[273] صورة] —م.
[274] منها] منه: م.
[275] أرادوا] ص (ال‹‹دوا›› فوق السطر).
[276] اليد] الرحل اليد: ك (ال‹‹الرحل›› مشطوب).
[277] ٩ب: غ.
[278] ١٥ب: م.
[279] محدّب سطحيه] هاغ (مع رمز ‹‹صح››).
[280] المركز] فاص.
[281] ١٤ب: ص = ١٠آ: غ = ١٦آ: م.
[282] ٩آ: ك.
[283] يتساوى] ساوى: ص = تساوي: ك، م.
[284] يماسّ] هام (مع رمز ‹‹صح››).
[285] نقطة مشتركة] هام (مع رمز ‹‹صح››) = نقطتين مشتركين: شام.
[286] ١٥آ: ص = ٩ب: ك = ١٦ب: م.
[287] محيطاً] محيط: غ.
[288] ١٥ب: ص = ١٠ب: غ = ١٧آ: م.
[289] ١٦آ: ص.
[290] أيضاً من فلك آخر] فاص.

[291] مركزه] هاغ (مع رمز ‹‹صح››).
[292] ١٧ب: م.
[293] بالممثّل] + ومركز: شام.
[294] وهذا الفلك] شام.
[295] المنفصل] + خارج عن مركز العالم و: شام.
[296] ١٠آ: ك.
[297] بالحضيض] + وهذا الفلك اعنى الفلك الذي سفصل عن الممثل: شام.
[298] أحدهما] فاص = احدهما: ك.
[299] ١١آ: غ (مكتوب بخطّ مختلف حتّى ١٢آ في الورقة المضافة فيما بعد).
[300] مقعّري] مقعّر: غ.
[301] لها] له: غ.
[302] حضيضه] فاك.
[303] ١٦ب: ص = ١٨آ: م.
[304] ١٠ب: ك.
[305] تسمّى] يسمى: ك = سمى: ص، م.
[306] إلّا أوج] الاوج: ك.
[307] وثماني] وثمانون: غ.
[308] ٧آ: ص = ١٨ب: م
[309] ١١ب: غ.
[310] تسع] تسعون: غ.
[311] ثواني] ثوان: غ.
[312] ١١آ: ك.
[313] أعلاها] اعلها: م.
[314] تكون] نكون: ص، ك = يكون: غ، م.
[315] ١٩آ: م.
[316] كانت] هاص.
[317] ١٧ب: ص.
[318] تكون] نكون: ص = يكون: غ، ك، م.

[319] تعتبر] بعبر: ص، ك، م = يعتبر: غ.
[320] أعلاها] اعاليها: ص، ك، م.
[321] وتُعدّ] وبعد: ص، ك = ويعد: غ، م.
[322] عشرة] عشر: ص، غ.
[323] فضل] فصل: ص، ك.
[324] دقيقة وثلاث وخمسون ثانية ولعطارد ثلاث] –ك
[325] ثوانٍ] ثوانى: ك.
[326] ثانية ولعطارد ثلاث درجات وستّ دقائق وأربع ثوان] هاغ (مع رمز ‹‹صح››).
[327] ١٩ب: م.
[328] ١٨آ: ص.
[329] الباب السادس فيما يعرض للكواكب وهو أربعة فصول الفصل الأوّل فيما يعرض للكواكب في الطول] هاغ (مع رمز ‹‹صح››) = + في الطول: غ.
[330] ١٢آ: غ.
[331] التوالي] الثوانى: ك.
[332] ١١ب: ك.
[333] تقاطع] غ (ال‹‹طع›› في الهامش).
[334] والحركة] غ (ال‹‹كة›› في الهامش).
[335] ٢٠آ: م.
[336] جميعاً] + عبر: م.
[337] تكون] بكون: ص، ك = يكون: غ، م.
[338] ١٨ب: ص.
[339] والتعديلات] غ (ال‹‹يلات›› في الهامش).
[340] مركزه] مركز: ك.
[341] فتختلف] فحىلف: ص، ك، م = فيخلف: غ.
[342] متشابهة] غ (ال‹‹ بهة›› في الهامش).
[343] ١٢ب: غ.
[344] ٢٠ب: م.
[345] تتشابه] شابه: ص، ك = يتشابه: غ = يشابه: م.

[346] ١٢آ: ك.
[347] ١٩آ: ص.
[348] وإن كان القياس يقتضي أن تتشابه حركة حول مركزه الذي هو خارج عن مركز العالم لكن علموا بالرصد والحساب أنّ حركته متشابهة حول مركز العالم] هاغ (في المربّع مع الأضلاع الحمراء).
[349] تختلف] نحلف: ص، ك = نختلف: غ = يختلف: م.
[350] تكون] نكون: ص، ك = يكون: غ، م.
[351] ٢١آ: م.
[352] وهذا أيضاً من مشكلات هذا الفن] هام (مع رمز ‹‹صح››).
[353] ١٩ب: ص.
[354] مركز نفسه] مركزه: غ = مركزه نفسه: ك (ال‹‹ه›› مشطوب).
[355] ١٢ب: ك
[356] ١٣آ: غ.
[357] تتشابه] نسابه: ص = يتشابه: غ، م = نشابه: ك.
[358] ٢١ب: م.
[359] تسمّى] سمى: ص، م = يسمى: ك.
[360] وهذا أيضاً من مشكلات هذا الفن] هام (مع رمز ‹‹صح››).
[361] ٢٠آ: ص.
[362] فتختلف] فحلف: ص، ك = فيحتلف: غ = فختلف: م.
[363] الوسطي] + في القمر: شام.
[364] ١٣آ: ك
[365] تتشابه] —ص = يتشابه: غ = نسابه: ك، م.
[366] إن كانت حركته متشابهة حوله كما في القمر وإلّا خطّ يخرج من مركز العالم موازياً لخطّ يخرج من نقطة تتشابه حركة مركز التدوير أو الكوكب حولها ويمرّ به كما في سائر السيّارة] ان كانت حركه متشابهه حوله كما فى القمر والا حط نحرح مں مركز العالم موازيا لحط نحرح مں نقطه نسابه حركه مركز السمس او مركز الندوير حولها ويمر به كما فى سار السياره: هام (مع رمز ‹‹صح››) = وينتهى الى منطقه المائل وفى الشمس خط نخرج من مركز العالم موازيا لخط نخرج من مركز الفلك الخارج المركز الى مركز الشمس وفى المتحيره خط نخرج من مركز العالم موازيا لخط نخرج من مركز المعدل للمسير الى مركز التدوير: شام.
[367] ٢٠ب: ص = ٢٢آ: م.

368 والحركة] –ك.
369 فضل] فصل: ك.
370 ١٣ب: غ.
371 فضل] فصل: ك.
372 التعديلات] ص (ال‹‹ت›› في الحامش).
373 ٢١آ: ص = ٢٢ب: م.
374 ٢١ب: ص = ١٣ب: ك = ٢٣آ: م.
375 ١٤آ: غ.
376 وتسمّى] سمى: ص، م = ويسمى: ك.
377 يسمّونها] سمونه: م.
378 وأنا أريد] هام (مع رمز ‹‹صح››) = والمراد: شام.
379 قوساً] م (ال‹‹س›› مشطوب مع خطّان صغيران تحت الحرف وال‹‹سا›› فوق السطر).
380 ٢٢آ: ص.
381 ٢٣ب: م.
382 على التوالي] هام (مع رمز ‹‹صح››).
383 ١٤آ: ك.
384 الكوكب] غ (ال‹‹ال›› مشطوب).
385 ٢٢ب: ص.
386 ٢٤آ: م.
387 ١٤ب: غ.
388 تختلف] تحلف: ص، ك = يختلف: غ = نختلف: م.
389 وكبراً] واكبرا: ك.
390 التدوير] غ (ال‹‹ير›› في الهامش).
391 ازديادها] م (ال‹‹د›› الثاني تحت السطر) = ازدياءها: ك.
392 ٢٣آ: ص.
393 ٢٤ب: م.
394 تعديلاً أوّل وتعديلاً مفرداً أيضاً ثمّ استخرجوا إزديادها بحسب كون مركز التدوير في جزء جزء من الحامل وسمّوا هذه الزيادة] هاغ (في المربّع مع الأضلاع الحمراء في الهامش ومع رمز ‹‹صح››).

395 ١٤ب: ك.

396 تدويره] غ (ال‹‹يره›› في الهامش).

397 المركز المعدّل] الوسط: م.

398 منه] من الوسط: م.

399 ٢٣ب: ص.

400 ٢٥آ: م.

401 ١٥آ: غ.

402 قلنا] ذكرنا: م.

403 ١٥آ: ك.

404 ١٥ب: غ.

405 بها خطّ] –ك.

406 ٢٥ب: م.

407 ٢٤آ: ص.

408 ٢٦آ: م.

409 ٢٤ب: ص.

410 مركز] هام (مع رمز ‹‹صح››).

411 الدائرة] غ (ال‹‹يرة›› في الهامش).

412 ويتساوى] ويتساوي: م.

413 أيضاً] هاص (مع رمز ‹‹صح››).

414 ١٥ب: ك.

415 تكون] ىكون: ص، ك = يكون: غ، م.

416 ١٦آ: غ.

417 إلى] + نقطه نعىها لكن الارصاد شهدت على: شاك.

418 بمركزي] بمر كزى: ك.

419 ٢٦ب: م.

420 ٢٥آ: ص.

421 افترقت] افىرق: ص، ك.

422 للمسير] المسير: ك.

423 ذكرنا] غ (ال‹‹كرنا›› في الهامش).
424 تتّحد] نتحد: ص، غ، ك = يتحد: م.
425 وكذا الحضيضان عند كون مركز التدوير] هاك (مع رمز ‹‹صح››).
426 ١٦آ: ك.
427 ٢٧آ: م.
428 ٢٥ب: ص.
429 يستعلم] لا يستعلم: م (ال‹‹لا›› مشطوب).
430 ١٦ب: غ.
431 ٢٧ب: م.
432 الذروتين] غ (ال‹‹ تين›› في الهامش).
433 ٢٦آ: ص.
434 يزد] نزد: ص.
435 ١٦ب: ك.
436 على التوالي] هاص.
437 أنّ] تاغ.
438 التوالي] غ (ال‹‹ لي›› في الهامش).
439 ٢٨آ: م.
440 فتبطؤ] فبطو: ص، م = فيبطو: غ = فسطو: ك.
441 حينئذٍ] ح: غ.
442 فضل] فصل: ك.
443 ٢٦ب: ص.
444 خلاف] غ (ال‹‹ ف›› في الهامش).
445 تسرع] سرع: ص، ك، م = يسرع: غ.
446 ١٧آ: غ.
447 على التوالي] –غ = هام (مع رمز ‹‹صح››).
448 أزيد] غ (ال‹‹يد›› في الهامش).
449 ترى] ىرى: ص، ك، م = يرى: غ.
450 أن] فاغ، –ك.

451 تفضل] نفضل: ص، ك، م = يفضل: غ.
452 ١٧آ: ك = ٢٨ب: م.
453 ٢٧آ: ص.
454 وتعود] ونعود: ص، ك، م = ويعود: غ.
455 ٢٩آ: م.
456 أحوالها] اجوالها: ك.
457 ١٧ب: غ.
458 ٢٧ب: ص.
459 ١٧ب: ك.
460 ببُعد] سعد: ص، ك، م.
461 ٢٩ب: م.
462 ٢٨آ: ص.
463 خطّ] خطا: ك (ال‹‹ا›› مشطوب مع الخطّان الصغيران).
464 مستعلٍ] مستعلي: ص = مستعلى: ك، م.
465 منخفض] فام.
466 ومن هذين الشكلين يسهل تصوّر ما ذكرنا] هاص (مع رمز ‹‹صح››).
467 ١٨آ: ك = ٣٠آ: م.
468 واحدة] فام (مع رمز ‹‹صح››).
469 بما به نصف قطر الخارج ستّون] هام (مع رمز ‹‹صح››).
470 ٢٨ب: ص.
471 قطر] فام.
472 عشر] عشره: ص، ك
473 عشرة] عشر: ص، ك.
474 ١٨ب: ك
475 ٣٠ب: م.
476 منهما] + ىلاب: شاص (فوق السطر).
477 يدير] ىدىر: هاص.
478 ٢٩آ: ص.

479 ٣١آ: م.

480 وإحدى] واحدي: م.

481 ١٩آ: ك.

482 درجة] + واثنتا دقيقه: شام.

483 وعشر دقائق] هام

484 ونحن نختم هذا الباب بذكر مقادير أقطار التداوير وما بين المراكز فنقول بعد مركز خارج مركز الشمس عن مركز العالم درجتان ودقيقة واحدة وعشرون ثانية بما به نصف قطر الخارج ستّون وبعد مركز حامل القمر عن مركز العالم بما به نصف قطر المائل ستّون عشر درجات وثلاث وعشرون دقيقة وبتلك الأجزاء نصف قطر تدوير القمر خمس درجات واثنتا عشر دقيقة وبعد مركز الحامل عن مركز العالم لزحل ثلاث درجات وتسع وعشرون دقيقة وللمشتري درجتان وسبع وأربعون دقيقة وللمرّيخ ست درجات وأربع عشرة دقيقة وللزهرة اثنتان وخمسون دقيقة أمّا بُعد مركز حامل عطارد عن مركز العالم فهو متفاوت يزيد وينقص من تسع درجات إلى ثلاث درجات بيان ذلك أن بُعد مركز حامله عن مركز المدير ثلاث درجات وكذلك بُعد مركز المدير عن مركز معدّل المسير وبُعد مركز معدّل المسير عن مركز العالم كلّ منهما ثلاث درجات لكن المدير يدير مركز الحامل حول مركز نفسه على مدار يسمّى مدار مركز الحامل فيلزم أن ينطبق مركز الحامل على مركز معدّل المسير في دورة مرة وحينئذٍ يكون بُعده عن مركز العالم ثلاث درجات ويقاطره مرة أخرى وحينئذٍ يكون بُعده عن مركز العالم تسع درجات وفي باقي الأحوال يكون بين ثلاث درجات وتسع درجات كلّ ذلك بما به نصف قطر حامل ذلك الكوكب ستّون وبهذه الأجزاء نصف قطر التدوير لزحل ستّ درجات وإحدى وخمسون دقيقة وللمشتري إحدى عشرة درجة وسبع وأربعون دقيقة وللزهرة ثلاث وأربعون درجة وعشر دقائق وللمرّيخ تسع وثلاثون درجة] –غ.

485 ١٨آ: غ.

486 اثنتان] اثنتا: ك.

487 ٢٩ب: ص.

488 ٣١ب: م.

489 الزهرة] + هي: شام.

490 ٣٠آ: ص.

491 ١٩ب: ك = ٣٢آ: م.

492 ١٨ب: غ.

493 مجاوزتهما] غ (ال‹‹وز›› تحت السطر).

494 أمّا] –ك.

495 للزهرة فإلى الشمال وأمّا لعطارد فإلى الجنوب وهذا الميل يتزايد إلى ان يبلغ مركز التدوير] هاك (مع رمز ‹‹صح››).

496 وتنطبق] سطبق: ص = وينطبق: غ = وسطبق: ك، م.

497 ٣٠ب: ص.

498 التدوير] –ك.

499 ٣٢ب: م.

500 تتطابق] تتطابق: ص = يتطابق: غ، م = سطابق: ك.

501 وتعود] وبعود: ص = ويعود: غ، ك، م.

502 القطر] طاغ.

503 .٢آ: ك

504 ٣٣آ: م.

505 ١٩آ: غ.

506 ٣١آ: ص.

507 الميل] –م.

508 مركز] غ (ال‹‹كز›› في الهامش).

509 ٣٣ب: م.

510 الرأس] غ (ال‹‹س›› في الهامش).

511 وتعود] وبعود: ص، ك، م = ويعود: غ.

512 ٣١ب: ص.

513 تكون] نكون: ص = يكون: غ = نكون: ك، م.

514 الذروة] الذوروة: غ.

515 تبتدئ] سدى: ص، ك، م = يبتدىَ: غ.

516 .٢ب: ك.

517 ويبلغ] طاغ.

518 ١٩ب: غ.

519 الرسم] الراس: غ.

520 ٣٤آ: م.

[521] ٣٢آ: ص.
[522] يسمّى] سمى: ص، ك، م = تسمّى: غ.
[523] والإلتِفاف] والالنفاءف: ك (ال‹‹ف›› فوق السطر).
[524] القطر المارّ بالبعدين الأوسطين أعني القطر المقاطع] –ك.
[525] ٣٤ب: م.
[526] ٣٢ب: ص.
[527] التدوير] غ (ال‹‹ير›› في الهامش).
[528] ٢١آ: ك.
[529] ٢٠آ: غ.
[530] وتعود] وبعود: ص، ك، م = ويعود: غ.
[531] وغاية] وغاسه: ك.
[532] وإحدى] واحدي: م.
[533] ٣٥آ: م.
[534] عليه الصلاة والسلام] ص (ال‹‹م›› في الهامش) = ع م: غ.
[535] ٣٣آ: ص.
[536] السرطان] غ (ال‹‹ن›› في الهامش).
[537] واثنتين] واثنين: غ.
[538] إحدى] احدي: م.
[539] اثنتين] اثنين : غ، ك.
[540] ٢١ب: ك.
[541] درجات] غ (ال‹‹جات›› في الهامش).
[542] زحل] + متقدم على اوجه بماسه وخمسين دقمه وذنبه متاحر عن اوجه بثلثن درحة: هام (مع رمز ‹‹اصح››).
[543] ٣٥ب: م.
[544] ٢٠ب: غ.
[545] باثنتين] باثنين: غ.
[546] ٣٣ب: ص.
[547] في الطول والعرض معاً قد يعرض للكواكب] هاك (مع رمز ‹‹صح››).
[548] مواضعها الحقيقية] هام (مع رمز ‹‹صح››) = موضعه الحمقى: شام.

549 مواضعها] موضعها: غ.
550 مواضعها المرئية] هام (مع رمز ‹‹صح››) = موضعه المرى: شام.
551 الأبصار] غ (ال‹‹بصار›› في الهامش).
552 إلى مركز الكوكب] هاك (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››).
553 ٣٦آ: م.
554 بينهما] منهما: غ.
555 تسمّى] سمى: ص، غ = يسمى: ك، م.
556 زاوية] فاص.
557 ٢٢آ: ك.
558 ٣٤آ: ص.
559 والقوس التي تنحصر بينهما من دائرة الارتفاع تسمّى قوس اختلاف المنظر] -غ.
560 ٢١آ: غ.
561 قرب] اقرب: ك (ال‹‹ا›› مشطوب).
562 ٣٦ب: م.
563 تنحصر] سحصر: ص = ينحصر: غ = سحصر: ك، م.
564 ارتفاعه] ارتفاع: ك.
565 ٣٤ب: ص.
566 أجيز] احىر: ص، ك، م = اخيز: غ.
567 بموضعي] بموضع: غ، ك.
568 ٢١ب: غ.
569 ٢٢ب: ك.
570 وحينئذٍ] وح: غ.
571 ٣٧آ: م.
572 تتقاطع] سماطع: ص = يتقاطع: غ = يمقاطع: ك = سقاطع: م.
573 بموضعيه] بموضعه: غ.
574 فتتقاطعان] فىماطعان: ص = فيقاطعان: غ = فىقاطعان: ك، م.
575 ينحصر] سحصر: ص، ك، م.
576 ٣٥آ: ص.

577 نور] فاص.
578 المضيء] + نصفه بل: شام.
579 تقريباً] هام (مع رمز ‹‹صح››).
580 ٣٧ب: م.
581 نصفه] + المحا: شاغ.
582 ٣٥ب: ص.
583 ٢٣آ: ك.
584 بينهما] + و: غ.
585 ٢٢آ: غ.
586 نصفه] نصف: ك.
587 شيء] فام.
588 ٢٢ب: غ = ٣٨آ: م.
589 ٣٦آ: ص.
590 حواليهما] غ (توجد كلمة غير مقروءة شطوباً بعد هذه الكلمة).
591 خسوفه] خسوف القمر: م.
592 ٣٨ب: م.
593 ٢٣ب: ك.
594 طرفه] طرفى: ك.
595 الانجلاء] انجلاء: ك.
596 ٣٦ب: ص = ٣٩آ: م.
597 يتحرّك] بحرك: ص، ك = بتحرك: غ = سحرك: م.
598 التدوير] ص (ال‹‹ير›› فوق السطر)، ك (يوجد ال‹‹ه›› شطوباً بعد هذه الكلمة).
599 ٢٤آ: ك.
600 كدكب] –ك (يوجد مكان ولكن لا تكتب هذه الحروف الأبجدية).
601 يا يب] –ك (يوجد مكان ولكن لا تكتب هذه الحروف الأبجدية).
602 ويردّان] ويرد: غ.
603 المقدار] لمقدار: ك.

604 ٣٧آ: ص.

605 يج ي] –ك (يوجد مكان ولكن لا تكتب هذه الحروف الأبجدية).

606 دقائق] + فسقى نعد مركز الدوىر عن الشمس ىحى دقاىق: شاص.

607 ٢٣آ: غ.

608 نط ٠] –ك (يوجد مكان ولكن لا تكتب هذه الحروف الأبجدية).

609 بُعدها] بعد الشمس: م.

610 تدويره] التدوره: ك.

611 يب يا] –ك (يوجد مكان ولكن لا تكتب هذه الحروف الأبجدية).

612 دقيقة] –م.

613 ٣٩ب: م.

614 عن الشمس ويلزم ممّا ذكرنا أن يكون مركز التدوير] –غ.

615 التوسّط] غ (ال‹‹سط›› في الهامش) = النوسط: ك.

616 وذلك] + وذلك: غ.

617 حامله] حوامله: ك (ال ‹‹ مله›› فوق السطر).

618 ٣٧ب: ص.

619 وحرّك] وحرك: ص، م = وحركت: ك.

620 ٢٤ب: ك.

621 ٤٠آ: م.

622 مراكز] مركز: ك.

623 مراكز العلويّة عن] مركزها عند: غ.

624 ذرى] ذري: م.

625 تداويرها] + مثل بعد مراكز تداويرها: شاغ (ال‹‹يرها›› في الهامش).

626 ٢٣ب: غ.

627 تداويرها] تدويرها: ك.

628 مركز] مراكز: ك (ال‹‹ا›› مشطوب).

629 الشمس] فاك.

630 ٣٨آ: ص.

[631] يُبيّن] + مما دكرنا من مقادر اقطار الداور وما سن المراكز: هاك (مع رمز ‹‹صح››)، هام (مع رمز ‹‹صح››).
[632] يُبيّن] سن: ص = تبين: ك، م.
[633] في مباحث الأبعاد والأجرام] شاك، شام.
[634] والاجرام] فاص.
[635] المرّيخ] + لان بعد حضض بدور المرح عند كونه فى اوح الحامل كو لا بما به نصف قطر حامله سون وصعفه اعظم من قطر ممل السمس مع ثخانه ممم المرح مع انه اصغر من قطر بدور المرح لانه عط كو بالاجراء المدكوره: هاك (مع رمز ‹‹ه منه›› وتحتها عبارة ال‹‹هذه الحاشية خط المصنف رحم الله تعال››)، هام (مع رمز ‹‹منه››).
[636] ٤٠ب: م.
[637] يبعد] سعدان: م.
[638] مركز السفليّين عنه] عنها: م.
[639] قطر التدوير] التدوير: غ.
[640] التدوير] غ (ال‹‹ير›› في الهامش).
[641] الصناعة] الصنادعته: غ.
[642] تزول] برول: ص، ك، م = يزول: غ.
[643] المقالة الثانية] –ك (يوجد مكان ولكن لا يُكتب العنوان).
[644] هيئة] ما هيىة: غ.
[645] ٢٥آ: ك.
[646] الباب الأوّل] –ك (يوجد مكان ولكن لا يُكتب العنوان).
[647] هيئة] ما هيئة: غ (ال‹‹ما›› فوق السطر).
[648] الأرض] + وعرضها وطولها: شام.
[649] وقسمتها] وقسمها: ك.
[650] الأقاليم] غ (ال‹‹قاليم›› في الهامش).
[651] وتبتني] وبتنى: ص، ك، م = ويبتنى: غ.
[652] تيسّر] يتسير: غ.
[653] ٣٨ب: ص.
[654] ثلاث] ثلاثه: ك، م.
[655] أحدهم] احدها: غ.

[656] ٢٤آ: غ.
[657] ٤١آ: م.
[658] كانت] كان: ص، غ، ك، م.
[659] وأيّام] غ (ال‹‹م›› في الهامش).
[660] وتتفرّع] وسفرع: ص، ك، م = ويتفرع: غ.
[661] غريبة] العربه: ك.
[662] هل] فام (مع رمز ‹‹صح››).
[663] ممّا] ما: غ.
[664] ويُفرض] وبفرض: ك = وبعرض: م.
[665] الاستواء] غ (ال‹‹ستواء›› في الهامش).
[666] ٣٩آ: ص.
[667] تقطع] وبعطع: ص، ك، م = يقطع: غ.
[668] ٢٥ب: ك = ٤١ب: م.
[669] تنصّف] بنصف: ص = ينصف: غ، م = بصف: ك.
[670] واحد من] هام (مع رمز ‹‹صح››).
[671] فتصير] فيصير: ص، غ، م = فصير: ك.
[672] معمور] ك (ال‹‹ر›› فوق السطر).
[673] درجة] –غ، هام (مع رمز ‹‹صح››).
[674] ٢٤ب: غ.
[675] بجزائر] بالجزائر: ك.
[676] تقطع] بعطع: ص = يقطع: غ = نقطع: ك، م.
[677] ٣٩ب: ص.
[678] تسمّى] سمى: ص، م.
[679] ٤٢آ: م.
[680] المعمورة] المعمور: م.
[681] درجات] غ (ال‹‹ت›› في الهامش).
[682] تسمّى] سمى: ص، م = يسمى: ك.
[683] مقدارهما] مقدارها: غ.

[684] النهار] غ (ال‹‹ر›› في الهامش).
[685] ٢٦آ: ك.
[686] ٤٠آ: ص.
[687] ٤٢ب: م.
[688] ساعة] درجه : م.
[689] ٢٥آ: غ.
[690] درجة] —م.
[691] ورُبع وخُمس] هاغ (كتب في خط مختلف ومع رمز ‹‹صح››) = + حمس: غ.
[692] السادس] السالس: ص.
[693] ٤٣آ: م.
[694] ثمان] ىمانى: ص = ثمانى: ك = ثماني: م.
[695] ٤٠ب: ص.
[696] ٢٦ب: ك.
[697] يليه] ىلىه: ص، غ = ىليه: ك.
[698] وأواسطها] غ (ال‹‹ سطها›› في الهامش).
[699] يسهل] سهل: ص، ك، م.
[700] ٢٥ب: غ.
[701] الباب الثاني] —ك (يوجد مكان ولكن لا يُكتب العنوان).
[702] الاستواء] غ (ال‹‹اء›› في الهامش).
[703] ٤٣ب: م.
[704] وقطباه] وقطباها: م.
[705] الاستوائيّة] غ (ال‹‹ئية›› في الهامش).
[706] تقطع] ىقطع: ص، ك، م.
[707] تتساوى] ىساوى: ص = يتساوى: غ، ك، م
[708] ٤١آ: ص.
[709] يكون] ىكون: ص.
[710] ٢٧آ: ك.
[711] يكون] ىكون: ص.

712 يزيد] ىرىد: ص، غ = يرىد: ك = ىزيد: م.
713 تكون] ىكون: ص = ىكون: غ = يكون: ك، م.
714 ٤٤آ: م.
715 ٤١ب: ص.
716 ٢٦آ: غ.
717 ويكون] وىكون: ص.
718 تسمّى] ىسمى: ص، ك، م = يسمى: غ.
719 افاقها] غ (ال‹‹قها›› في الهامش).
720 بآفاق] بآفاقا: ك (يوجد ال‹‹ا›› الثاني شطوباً).
721 رضي الله عنه] رض: غ.
722 والامام العلامة فخر الدين الرازي رضي الله عنه حكم بان اعدل البقاع] –ك.
723 المحقّق] فاص.
724 الطوسي] طوسى: ك.
725 ٤٤ب: م.
726 اعتدال] الاعتدال: ك.
727 يقتضيه] ىقتصه: ص.
728 ٤٢آ: ص.
729 خَلقاً] حلقا: ك.
730 وخُلقاً] وحلقا: ص، ك.
731 تدلّ] ىدل: ص، ك، م.
732 ٢٧ب: ك.
733 كلّ] غ (توجد عبارة مطشوبة زغير مقروئة بعد هذه الكلمة).
734 يكون] ىكون: ص، ك.
735 يسمّى] ىسمى: ص، ك، م.
736 الميل] –غ.
737 ٢٦ب: غ.
738 ٤٥آ: م.
739 يساوي] ساوى: ص، م = تساوى: ك.

740 الميل الكلّي واقل من تمامه والرابع ما عرضه يساوي تمامه والخامس ما عرضه أكثر من] هاغ (كتب في خط مختلف ومع رمز ‹‹صح››).
741 ن] طاغ (في الهامش).
742 الاعتدالينٍ] غ (ال‹‹لين›› في الهامش).
743 تساوي] ساوى: ص، ك، م.
744 وتقطع] ىعطع: ص = يقطع: ك = ىقطع: م.
745 ٤٢ب: ص.
746 يكون] ىكون: ص.
747 يكون] ىكون: ص.
748 يكون] ىكون: ص.
749 يكون] ىكون: ص، ك، م.
750 ٤٥ب: م.
751 ٢٨آ: ك.
752 مدارين] + ابد: شاغ.
753 اجزاء] اجزاءا: ص، م.
754 ٤٣آ: ص.
755 يكون] ىكون: ص، غ.
756 يقطع] ىعطع: ص = ىقطع: م.
757 ٢٧آ: غ.
758 يقطع] ىعطع: ص.
759 ٤٦آ: م.
760 الأفق] غ (ال‹‹فق›› في الهامش).
761 يماسّ] —غ.
762 يقطعه] ىعطع: ص = ىقطعه: م.
763 يقطعه] ىقطعه: ص، م.
764 يكون] ىكون: ص.
765 يساوي] ساوى: ص، غ = تساوى: ك = ساوي: م.
766 ٤٣ب: ص.

[767] نقطتين] هاغ (مع رمز ‹‹صح››).
[768] يكن] ىكن: ص، م.
[769] ٢٨ب: ك.
[770] ٤٦ب: م.
[771] تكون] ىكون: ص، م = يكون: ك.
[772] ٢٧ب: غ.
[773] القطب] –غ.
[774] الظاهر] الظ: غ.
[775] وكان] وى كان: غ (ال‹‹ى›› مشطوب).
[776] ٤٤آ: ص.
[777] تمرّ] ىمر: ص، ك، م.
[778] الظاهر] الظ: غ.
[779] ٤٧آ: م.
[780] ويكون] وىكون: ص.
[781] النقصان] النقضان: غ.
[782] القطب] هاغ (مع رمز ‹‹صح››).
[783] الظاهر] الط: فاغ.
[784] جانب] –غ.
[785] في] فام.
[786] الظاهر] الظ: م.
[787] ٢٩آ: ك.
[788] يبلغ] سلع: ص = سلغ: ك، م.
[789] تسعين] غ (يوجد ‹‹تسعين›› آخر في الهامش).
[790] الظاهر] الط: غ.
[791] وقت] غ (ال‹‹قت›› في الهامش).
[792] الظاهر] الط: غ.
[793] ويكون] ىكون: ص، ك
[794] الظاهر] الظ: غ.

795 ٢٨آ: غ.
796 ٤٧ب: م.
797 ٤٤ب: ص.
798 الظاهر] الظ: غ.
799 فللشمس] للشمس: غ.
800 الظاهر] الطا: فاغ.
801 يصل] بصل: ص، ك، م.
802 المنقلبان] غ (ال‹‹ن›› في الهامش).
803 الظاهر] الطا: غ.
804 وينطبق] وسطبق: ص = وسطبق: ك، م.
805 ٤٨آ: م.
806 ٤٥آ: ص.
807 ٢٩ب: ك.
808 يتوسّطه] سوسطه: ص = يتوسط: غ = بوسطه: ك، م.
809 الظاهر] الط: غ.
810 جزء بعد جزء] هام (مع رمز ‹‹صح››).
811 ٢٨ب: غ.
812 ويكون] وبكون: ص، م.
813 وزيادة] غ (ال‹‹دة›› في الهامش).
814 يصير] بصر: ك، م.
815 ٤٨ب: م.
816 دورتين] دروتين: غ.
817 ٤٥ب: ص.
818 يمكن] بمكن: ص، ك، م.
819 يبلغ] سلغ: ص = بلغ: ك = سلغ: م.
820 وينتهي] وسهى: ص = وينتهى: غ، ك = وبتهى: م.
821 الأبديّة] هام (مع رمز ‹‹صح››).
822 الظاهر] الظ: غ.

[823] يساوي] ساوى: ص، م = تساوى: ك.
[824] ٣٠آ: ك.
[825] يقطع] ىقطع: ص = ىقطع: ك، م.
[826] وتنقسم] وىقسم: ص = وينقسم: غ، ك = وىنقسم: م.
[827] إحداها] احديهما: ص، ك = احدها: م
[828] ٤٩آ: م.
[829] الأطول] هاص (مع رمز ‹‹صح››).
[830] أبديّة] ابدي: ك.
[831] كون] غ (ال‹‹ن›› في الهامش).
[832] ٢٩آ: غ.
[833] الأولى] هام (مع رمز ‹‹صح››).
[834] يغربان] ىعربان: ص، ك = ىغربان: غ، م.
[835] ٤٦آ: ص.
[836] يماسّان] ىماسان: ص، غ، ك، م.
[837] يطلعان] ىطلعان: ك.
[838] الحمل] هاغ (مع رمز ‹‹صح››) = + لكل: غ.
[839] تطلع] ىطلع: ص، م = يطلع: ك.
[840] وتغرب] وىغرب: ص = وىعرب: ك، م.
[841] وتطلع] وىطلع: ص، م = او يطلع: غ = ويطلع: ك.
[842] وتغرب] وىعرب: ص، ك = ويغرب: غ = وىغرب: م.
[843] ارتفاعان] غ (ال‹‹ن›› في الهامش).
[844] ٤٩ب: م.
[845] وهو] ك (ال‹‹و›› فوق السطر).
[846] الظاهر] الظ: غ.
[847] ويكون] وىكون: ص.
[848] ٤٦ب: ص.
[849] ٣٠ب: ك.
[850] ٢٩ب: غ.

851 وتصير] وبصر: ص، ك، م = ويصير: غ.
852 ٥٠آ: م.
853 الظاهر] الطا: غ.
854 النصف] بصف: ك.
855 فتكون] فكون: ص = فيكون: غ، ك، م.
856 ويفضل] وبفصل: ك.
857 ٤٧آ: ص.
858 بطؤ] بطو: ص، غ، ك، م.
859 ويكون] وكون: ص.
860 بلياليها] غ (ال‹‹ليها›› في الهامش).
861 وتكون] وكون: ص، ك = ويكون: غ، م.
862 أيّامنا] غ (ال‹‹منا›› في الهامش).
863 وتكون] وكون: ص = ويكون: غ، ك، م.
864 ٥٠ب: م.
865 ١٣١آ: ك.
866 وتختلف] تحلو: ص = ويختلف: غ = تحلف: ك، م.
867 ٣٠آ: غ.
868 ٤٧ب: ص.
869 يزيد] بزيد: ص، ك، م.
870 أبديّ] غ (ال‹‹ي›› في الهامش).
871 بلياليها] بليالها: غ.
872 لنا] فام = للشمس: شام.
873 ١٥١آ: م.
874 جهتنا] + لشمس: شام.
875 أظلم هذا الوجه] هام (مع رمز ‹‹صح››).
876 لوقوع] م (ال ‹‹ل›› وال ‹‹و›› مضاف بعده).
877 الصادق] غ (ال‹‹دق›› في الهامش).
878 عرفهم] غ (يوجد ال‹‹ في›› المشطوب بين ال‹‹عر›› وال‹‹فهم››).

879 الصحارى] الصحار: ك = الصحاري: م.
880 ٤٨آ: ص = ٣١ب: ك.
881 خلال] قلل: غ = حلل: ك = خلل: م.
882 والعمران] والعُمرَانِ: غ.
883 ويقبل] وىقبل: ص، م = وىىىل: ك.
884 يستضيء] سعى: ك.
885 ويكون] وىكون: ص.
886 ٣٠ب: غ.
887 ٥١ب: م.
888 ويستدقّ] غ (ال‹‹ق›› في الهامش).
889 قربت] + الشمس: شاغ.
890 ما] فاغ.
891 ٤٨ب: ص.
892 تكون] ىكون: ص، غ = يكون: ك، م.
893 ويكون] وىكون: ص.
894 ٥٢آ: م.
895 الأفق] طام.
896 فلذلك] غ (ال‹‹لك›› في الهامش).
897 ٣٢آ: ك.
898 يلي] ىلى: ص، ك، م.
899 ٤٩آ: ص = ٥٢ب: م.
900 بالتجربة] ىالىحرىه: ص، غ، ك، م.
901 انحطاط] غ (ال‹‹ط›› الثاني في الهامش).
902 ٣١آ: غ.
903 يكون] ىكون: ص.
904 ٣٢ب: ك.
905 تكون] ىكون: ص = يكون: غ، ك، م.
906 ويحس] وىحس: ص، غ، ك.

907 ٥٣آ: م.
908 ٤٩ب: ص.
909 التفاوت ويحس به في أيّام كثيرة واهل الحساب لمّا اضطروا إلى] هاغ.
910 تعديل] غ (ال‹‹يل›› في الهامش).
911 مبادئ] ك (توجد نقطة شطوباً فوق ال‹‹ب››).
912 ٣١ب: غ.
913 ٥٣ب: م.
914 ٥٠آ: ص.
915 ٣٣آ: ك.
916 معاودته] معاوده: ك.
917 من] + هذه: شاغ.
918 برج] بروج: غ.
919 ٥٤آ: م.
920 برج] بروج: غ.
921 ٥٠ب: ص.
922 ٣٢آ: غ.
923 عن] فاص، فام.
924 ٣٣ب: ك.
925 وستون] غ (ال‹‹ن›› في الهامش).
926 ٥٤ب: م.
927 ٥١آ: ص.
928 كلّ] + يوم: شاغ.
929 لاجتماع] الاجتماع (ال‹‹ا›› مشطوب).
930 هذه] هاغ.
931 ٣٢ب: غ.
932 حركات] فاص.
933 ٥٥آ: م.
934 ٥١ب: ص.

935 ٣٤آ: ك.
936 وهكذا يأخذون شهراً ثلاثين وشهراً تسعة وعشرين] –ك.
937 يأخذون] ىاحدون: ص = ىاخدون: ك = ىاخدون: م.
938 والثامنة] والثانيه: غ.
939 والعشرين] + والىاىعه والعشرىن: شاص.
940 ٥٥ب: م.
941 الأمر] هاغ (مع رمز ‹‹صح››).
942 ٥٢آ: ص.
943 الصلوة] غ (ال‹‹ة›› في الهامش).
944 ٣٣آ: غ.
945 الاثنا] م (ال‹‹ى›› مشطوب وال‹‹ا›› مضاف بدلاً منها).
946 اسفندارمذ] + وكذا شهورهم: شام.
947 ثلاثون] + ىلىو: شاغ.
948 تسمّى] سمى: ص = يسمى: ك، م.
949 آبان] غ (ال‹‹ن›› في الهامش).
950 يختلف] ىحلو: ص = ىحلف: ك = ىحتلف: م.
951 ٣٤ب: ك = ٥٦آ: م.
952 ٥٢ب: ص.
953 ٣٣ب: غ.
954 ٥٦ب: م.
955 بالاعتدالين] غ (ال‹‹الين›› في الهامش).
956 الكلّي] فام.
957 ٥٣آ: ص.
958 يتساوي] ىتساوي: ص، م.
959 الرؤية] غ (ال‹‹ية›› في الهامش).
960 فيتساوي] فساوى: ص.
961 حينئذٍ] ح: غ.
962 ٣٥آ: ك.

963 مركز] المركز: ك.
964 سطح] السطح: ك.
965 ينتهي] ىنتهى: ص = ىتهى: ك.
966 تقاطعي] ىقاطعى: ص = ىقاطعى: ك.
967 ٥٧آ: م.
968 يكون] ىكون: ص، ك.
969 بقطبي] وبين بقطبى: م (ال ‹‹بين›› مشطوب).
970 ٣٤آ: غ.
971 به] + كراس: شاص.
972 تكون] ىكون: ص، م = يكون: غ.
973 ٥٣ب: ص.
974 وهي تكون درجة الكوكب بعينها إذا لم يكن للكوكب] –ك.
975 تكون] ىكون: ص = يكون: غ، ك، م.
976 درجته] درجتها: ص، ك.
977 يكون] ىكون: ص، ك = يكون: غ، م.
978 أخرى] غ (ال‹‹ى›› في الهامش).
979 الممرّ] + وما بين دارتى ميل الكوكب: شام.
980 والقوس من المعدل التي بين نصف الميلية المذكور ونصف من العرضية متحدد بقطبي البروج مار برأس الخط المذكور] هام (مع رمز ‹‹صح››).
981 تسمّى] ىسمى: ص = يسمى: ص، ك، م.
982 درجة] درحه: هاص.
983 والتي] هام (مع رمز ‹‹صح››) : التى: غ، ك.
984 تسمّى] يسمى: ك.
985 من المعدل بين اول الحمل وهذا النصف من الميلية على التوالي تسمّى مطالع ممرّ الكوكب] هام (مع رمز ‹‹صح››).
986 ٥٧ب: م.
987 قطبي] قطب: ك.
988 من قطبي العالم] هام (مع رمز ‹‹صح››).

989 ويمرّ] ويمر: ص، ك، م.
990 ٣٥ب: ك.
991 ان] كانت: ص، ك.
992 يمرّ] يمر: ص، ك، م.
993 ٥٤آ: ص.
994 عرضه] هام (مع رمز ‹‹صح››) = درجته: شام.
995 الظاهر] الظ: غ.
996 قطبي] قطب: ك.
997 ٣٤ب: غ.
998 القطب] + الظ من قطبي العالم وقبل درجته ان كان عرضية في جهة القطب: غ.
999 يكون طلوع الكوكب وغروبها كمرورها على نصف النهار في سائر الآفاق أعني] هام (مع رمز ‹‹صح››).
1000 الانقلابين] غ (ال‹‹بين›› في الهامش) = + وفى بلد ىىقص عرضه من الميل الكلى اذا كان درجة الكوكب احدى النقطتين اللتين ىمران ىسمت راس البلد وينقسم منطقه البروج بهما الى قوسين عظمى وصغرى وفىما ساوي عرضه الميل الكلى اذا كان درجة الكوكب المنقلب الصيفى: شام.
1001 ولم يكن الكوكب بين القطبين] هام (مع رمز ‹‹صح››).
1002 ٥٨آ: م.
1003 درجته] + وفى خط الاستواء: شام.
1004 الصيفيّ] + وفيما ينقص عرضه اذا كان الكوكب فى القوس العظمى وفىما ساوي عرضه الميل الكلى اذا لم يكن الكوكب فى المنقلب الصيفى وفىما ىزىد عرضه على الميل الكلى مطلقا: شام.
1005 ٥٤ب: ص.
1006 ويغرب] هام (مع رمز ‹‹صح››).
1007 درجته] + وىغرب بعدها: شام.
1008 الظاهر] الظا: غ.
1009 ويطلع] فىطلع: ص = وىطلع: م.
1010 ويغرب] وىغرب: فام.
1011 درجته] + وىغرب قىلها: شام.
1012 الخفيّ] + وفى خط الاستواء: شام.
1013 ٥٨ب: م.

1014 النصف] بصف: ك.
1015 الشتويّ] + وفيما ىقص عرضه من الملى الكلى اذا كان الكوكب في القوس الصغرى: شام.
1016 ويغرب] فام (مع رمز ‹‹صح››).
1017 بعد] فام.
1018 درجته] + وبغرب قبلها: شام.
1019 عرض] فام.
1020 جانب] فاص.
1021 الظاهر] الط: غ.
1022 ويغرب] هام (مع رمز ‹‹صح››).
1023 ويغرب قبل درجته] + ويغرب بعدها: شام.
1024 الخفيّ] + الخفى: شاص، شام.
1025 وفيما زاد عرض البلد] وفى بلد ىزيد عرضه: هام.
1026 يطلع] ىطلع: هام.
1027 ٣٦آ: ك.
1028 ويغرب] غ (ال‹‹ب›› في الهامش).
1029 ٣٥آ: غ.
1030 الظاهر] الط: غ.
1031 وبالعكس] بالعكس: ك.
1032 جانب] الجانب: ك.
1033 بعد] فاك.
1034 يغرب] وىعرب: هام.
1035 يساوي] هام.
1036 الاعتدال] هام = الاعتدالى: غ.
1037 يطلع] ىطلع: هام.
1038 ويغرب] وىعرب: هام.
1039 الظاهر] الظ: غ.
1040 الجانب] جانب: ك.
1041 كانت] كان: ك.

[1042] يغرب] نغرب: هام.
[1043] ويطلع] وبطلع: هام.
[1044] القطب] قطب: ك.
[1045] الظاهر] الط: غ.
[1046] ان] فاغ (مع رمز ‹‹صح››).
[1047] جزءا] هام.
[1048] آخر] الآخر: ك.
[1049] ينقص] وىمص: هام.
[1050] تساوي] ساوى: هام.
[1051] يحصلان] بحصلان: هام.
[1052] تمرّان] بمران: هام.
[1053] لاعتدال] غ (ال‹‹ل›› في الهامش).
[1054] الربيعيّ] + اعنى طرفها الممدم فى الطلوع: شام (هذه العبارة في الهامش).
[1055] يغرب] نغرب: هام.
[1056] يطلع] وبطلع: غ، ك، هام.
[1057] ٣٥ب: غ.
[1058] إحدى نظيرتي] نظيرتى احدى: غ.
[1059] الطرفين] + هاس المطىن: شام (هذه العبارة في الهامش).
[1060] يطلع] بطلع: هام.
[1061] ويغرب] وىعرب: هام
[1062] ٣٦ب: ك.
[1063] جزء] جزءا: ك، هام.
[1064] يطلع] بطلع: هام.
[1065] ويغيب] وىعىب: هام.
[1066] يطلع] بطلع: هام.
[1067] ويغيب] وىعىب: هام.
[1068] جزء] ـك.
[1069] آخر] غ (ال‹‹خر›› في الهامش).

[1070] يطلع] بطلع: ك، هام.
[1071] ويغيب] وبعب: ك، هام.
[1072] القطب] قطب: ك.
[1073] الظاهر] الطا: غ.
[1074] قطبي] قطب: ك.
[1075] منهما] منها: ك.
[1076] المذكورة] المذكور: ك.
[1077] يغرب] هام.
[1078] ويطلع] وبطلع: هام.
[1079] كانت] كان: ك.
[1080] نظيرتي] + هاتين النقطتين: شام (هذه العبارة في الهامش).
[1081] يطلع] هام.
[1082] ويغرب] وبعروب: ك = وبغرب: هام.
[1083] جزء] جزءا: ك.
[1084] يطلع ويغيب] هام.
[1085] هذه] فاك.
[1086] يطلع ويغيب] بطلع وبعب: هام.
[1087] الكوكب] + نظيرة: شاغ.
[1088] جزء] جزء ا: ك.
[1089] آخر] هاغ (مع رمز ‹‹صح››).
[1090] ٣٦آ: غ.
[1091] يطلع] بطلع: ك، هام.
[1092] ويغرب] وبعرب: ك، هام.
[1093] يتّفق] سفق: هام.
[1094] القريبة] الغربية: غ.
[1095] يزيد] بريد: هام.
[1096] عروضها] عرضها: غ.
[1097] تطلع] بطلع: غ، هام.

[1098] انه يغرب] هاطام.
[1099] وتغرب] ويغرب: ص، غ، ك = وبعرب: هام.
[1100] أنّه] طام (هذه الكلمة في الهامش).
[1101] يطلع] بطلع: هام.
[1102] وفي هذا البلد قد يتّفق للكواكب القريبة من القطب أعني التي يزيد عروضها على تمام الميل الثاني لدرجتها أن تطلع مع نظيرة درجتها فيما قلنا أنّه يغرب مع درجته ويغرب مع نظيرة درجتها فيما قلنا أنّه يطلع مع درجته على عكس ما قلنا. وهذا دقيق نفيس جداً] –ك.
[1103] على الميل الكلّي يطلع الكوكب قبل درجته ويغرب بعدها إن كان في جانب القطب الظاهر من قطبي العالم وبالعكس إن كان في جانب الآخر أيْ يطلع بعد درجته ويغرب قبلها وفي بلد يساوي عرضه الميل الكلّي إذا كان درجة الكوكب الاعتدال الخريفيّ يطلع الكوكب مع درجته أيّ جانب كان عرضه ويغرب بعدها إن كان في جانب القطب الظاهر وقبلها إن كان في الجانب الآخر وإن كانت درجته الاعتدال الربيعيّ يغرب الكوكب مع درجته أيّ جانب كان عرضه، ويطلع قبلها إن كان في جانب القطب الظاهر وبعدها إن كان في الجانب الآخر وإذا كان درجة الكوكب جزء آخر غير ما ذكرنا من أجزاء منطقة البروج فالحكم ما ذكرنا فيما زاد عرضه على الميل الكلّي وفي بلد ينقص عرضه من الميل الكلّي إذا كان درجة الكوكب أحد طرفي قوس تساوي أصغر قسمي منطقة البروج اللذين يحصلان من النقطتين اللتين تمرّان بسمت الرأس وعلى منتصفها الاعتدال الربيعيّ فالكوكب يغرب مع درجته ويطلع قبلها وإن كان درجة الكوكب إحدى نظيرتي هذين الطرفين فالكوكب يطلع مع درجته ويغرب بعدها وإن كان درجة الكوكب جزء من أجزاء هذه القوس فالكوكب يطلع ويغيب قبل درجته وإذا كان درجة الكوكب نظيرة جزء من أجزاء هذه القوس فالكوكب يطلع ويغيب بعد درجته وإن كان درجة الكوكب جزء آجر من أجزاء منطقة البروج غير ما ذكرناه فالكوكب يطلع قبل درجته ويغيب بعدها هذا كلّه إن كان عرض الكوكب في جانب القطب الظاهر من قطبي العالم وإن كان عرضه في جانب القطب الخفيّ منهما وكان درجة الكوكب أحد طرفي القوس المذكورة فالكوكب يغرب مع درجته ويطلع بعدها وإن كانت درجة الكوكب إحدى نظيرتي هذين الطرفين فالكوكب يطلع مع درجته ويغرب قبلها وإن كان درجة الكوكب جزء من أجزاء هذه القوس فالكوكب يطلع ويغيب بعد درجته وإن كانت درجة الكوكب نظيرة جزء من أجزاء هذه القوس فالكوكب يطلع ويغيب قبل درجته وإن كانت درجة الكوكب جزء آخر من أجزاء منطقة البروج غير ما ذكرنا فالكوكب يطلع بعد درجته ويغرب قبلها وفي هذا البلد قد يتّفق للكواكب القريبة من القطب أعني التي يزيد عروضها على تمام الميل الثاني لدرجتها أن تطلع مع نظيرة درجتها فيما قلنا أنّه يغرب مع درجته ويغرب مع نظيرة درجتها فيما قلنا أنّه يطلع مع درجته على عكس ما قلنا. وهذا دقيق نفيس جداً] هام (مع رمز ‹‹صح››).
[1104] ٥٥آ: ص.

[1105] ٣٧آ: ك.
[1106] توازي] بوارى: ص، ك، م = يوازى: غ.
[1107] ٥٩آ: م.
[1108] يفارق] غ (ال‹‹رق›› في الهامش).
[1109] فالسطح] فاسطح: ك.
[1110] ٥٥ب: ص.
[1111] المنطبق] المنطقه: غ.
[1112] نخطّ] نخط: ك.
[1113] ليتبيّن] لنتبين: ص = لنتبين: ك.
[1114] يقصر] نقصر: ص، م = نقصر: ك.
[1115] ٣٦ب: غ.
[1116] ويتجاوز] ونتحاوز: ك.
[1117] دائرة] غ (ال‹‹ة›› في الهامش).
[1118] ٥٩ب: م.
[1119] أو وترها] غ (ال‹‹ها›› في الهامش)، هام (مع رمز ‹‹صح››).
[1120] نصل] نصل: ك، م.
[1121] أو الوتر] هام (مع رمز ‹‹صح››).
[1122] ٣٧ب: ك.
[1123] يربّعان] + في: شام.
[1124] نقسّم] نقسم: ك.
[1125] ٥٦آ: ص.
[1126] تكون] نكون: ص = يكون: غ، ك، م.
[1127] ٦٠آ: م.
[1128] الصلوات] الصلوة: ك.
[1129] اتّفقوا] —ك.
[1130] ويُعرف] ويغرب: غ.
[1131] يبق] سق: ص، ك = سق: م.
[1132] بقي] سقى: ك.

[1133] ٣٧آ: غ.
[1134] يحدث] بحدب: ص، ك، م = بحدث: غ.
[1135] حنيفة] غ (توجد علامتان غير مقروئتان قبل وبعد هذه الكلمة).
[1136] ٥٦ب: ص.
[1137] يظهر] بطهر: ص، ك، م.
[1138] وأوّل] واو: ك.
[1139] رضي الله عنهما] رض: غ.
[1140] وأمّا] غ (ال‹‹ما›› في الهامش).
[1141] ٦٠ب: م.
[1142] تقاطع] بقاطع: ص، ك، م.
[1143] والسمتية المارّة بسمتي رأس مكّة والبلد] –ك.
[1144] ٣٨آ: ك.
[1145] تقاطعه] بقاطعه: ص = نقاطعه: ك.
[1146] ٥٧آ: ص.
[1147] تتعيّن] هاغ.
[1148] ٣٧ب: غ.
[1149] تعيين] بعس: فام.
[1150] ٦١آ: م.
[1151] ويمكن] وىمكن: ص، ك، م.
[1152] يُعرف] تعرف: ص = نعرف: ك.
[1153] فإن] فا: غ.
[1154] وثمانين] ك (يوجد ال‹‹بو›› شطوباً بين ال‹‹وثما›› وال‹‹نين››).
[1155] ٥٧ب: ص.
[1156] نقطتي] نقطة: ك.
[1157] فضل] فصل: ص = فصل: ك، م.
[1158] ٣٨ب: ك.
[1159] ٦١ب: م.
[1160] ونصل] وىصل: ص.

[1161] فضل] فصل: ص.
[1162] نخرج] بحرح: ص، غ = بحرج: ك = نخرح: م.
[1163] كان] غ (ال‹‹ن›› في الهامش).
[1164] ٣٨آ: غ.
[1165] بعدد فضل ما بين العرضين] هام (مع رمز ‹‹صح››).
[1166] ونصل] وبصل: ص، م = ويصل: ك.
[1167] يكن] بكن: غ.
[1168] خطّ] فاغ (ال‹‹صح›› في الهامش).
[1169] وإن لم يكن بين العرضين فضل نأخذ خط المشرق والمغرب مكان الخط الواصل] هام (مع رمز ‹‹صح››).
[1170] فيتقاطع] فمقاطع: ص = فنماطع: ك = فمقاطع: م.
[1171] الخطّان] تاغ (مع رمز ‹‹صح››).
[1172] ومقطعهما] ومقطعها: ص.
[1173] ٥٨آ: ص.
[1174] تقريبي] تقربى: ص، ك = تقربى: م.
[1175] أوردناه] غ (ال‹‹ناه›› في الهامش).
[1176] الساعات] غ (ال‹‹عات›› في الهامش).
[1177] ٦٢آ: م.
[1178] فضل] فصل: ص، م.
[1179] دقائق] دققايق: غ.
[1180] ثوان] ثوانى: ص، ك = ثواني: م.
[1181] تعالى] تع: غ.
[1182] وهو الثامن من الجوزاء أو الثالث والعشرون من السرطان] هام (مع رمز ‹‹صح››).
[1183] ٣٩آ: ك.
[1184] زمان] غ (ال‹‹ن›› في الهامش).
[1185] بعد] فام = قبل: شام.
[1186] ٣٨ب: غ.
[1187] وقبل] فام = وبعد: شام.
[1188] ٥٨ب: ص.

[1189] الدائرة] غ (ال‹‹ة›› في الهامش).
[1190] ٦٢ب: م.
[1191] تكون] يكون: غ = نكون: هام = ـص، ـك.
[1192] أعني نقطة التقاطع التي في خلاف جهة الظلّ وظاهر أنّ هذا الوجه لا يفيد فيما إذا كانت الساعات المحوّلة أكثر من ساعات نصف نهار ذلك اليوم إذ تكون الشمس وقتئذٍ تحت الأفق فلا يمكن أخذ سمت الظلّ في هذا الوقت فالطريق فيها أن يُرصد تحويل الشمس إلى نظير الجزء المارّ بسمت رأس مكّة وهو الثامن من القوس أو الثالث والعشرون من الجدى ويُؤخذ سمت الظلّ يومئذٍ بقدر الساعات المذكورة قبل نصف الليل فيما قلنا قبل نصف النهار وبعد نصف الليل فيما قلنا بعد نصف النهار وسمت القبلة هي نقطة التقاطع التي في جهة الظلّ] هام (مع رمز ‹‹صح››).
[1193] عشر] عشرة: ص، غ، م.
[1194] ٣٩آ: غ.
[1195] لسطح] لسظح: ص.
[1196] يحيط] نحيط: ص، م = نحط: ك.
[1197] ٥٩آ: ص.
[1198] تقع] نقع: ص = يقطع: ك.
[1199] عليها] اعليها: غ.
[1200] ٦٣آ: م.
[1201] يحصل] نحصل: ص، ك، م.
[1202] يحيط] نحط: ص = نحيط: ك، م.
[1203] ٣٩ب: ك.
[1204] يحيط] نحط: ص، ك، م = نحيط: غ.
[1205] القاعدة] + القطعه: فام.
[1206] محيطها] = محيط القاعده: م.
[1207] معلومة] هام (مع رمز ‹‹صح››).
[1208] ٣٩ب: غ.
[1209] ٥٩ب: ص.
[1210] ٦٣ب: م.
[1211] فروع] فروغ: غ.

[1212] مقياس] غ (يوجد ال‹‹دير›› المشطوب بين ال‹‹مقيا›› وال‹‹س››).
[1213] إلى مقياس] –ك.
[1214] لنسمّ عدد كلّ مقياس قدره] هام (مع رمز ‹‹صح››).
[1215] في] + مقادير: شاغ.
[1216] قدر] فام = عدد: شام.
[1217] عدد] شام = قدر: فام.
[1218] المطلوب] المط: غ.
[1219] وأجزا وجزء] واآحر او جرء: هام.
[1220] ضرورةً] هاغ.
[1221] المقدّمة] مقدمة: غ.
[1222] ٤٠آ: غ.
[1223] نوع آخر من الرد إذا كان مقياس أو جزء منه يقدر مقدارين وآخر أو جزء منه يقدّر أحدهما فقط ولنسمّه الأولى فإنّه يقدّر الثاني ضرورةً وأمّا أنّه كم مرّة يقدّره فيُعلم من مقدّمة السابعة لأنّه نسبة ما في الأوّل من أمثال المقياس إلى ما في الثاني من أمثاله كنسبة ما في الأوّل من أمثال الآخر إلى ما في الثاني من أمثاله وهو المجهول والرابع فإذا ضرب ما في الثاني من أمثال المقياس فيما في الأوّل من أمثال الآخر وقُسم الحاصل على ما في الأوّل من أمثال المقياس خرج ما في الثاني من أمثال الآخر] هام (مع رمز ‹‹صح››).
[1224] ٦٤آ: م.
[1225] ٤٠آ: ك.
[1226] ٦٠آ: ص.
[1227] يوتّرها] بورها: ص، ك، م = توترها: غ.
[1228] تتناسب] ساسب: ص = يتناسب: غ = نتاسب: ك، م.
[1229] تناسب] –ك.
[1230] وضلعان] غ (ال‹‹ن›› في الهامش).
[1231] ٦٤ب: م.
[1232] يمشي] تمشي: ص، م = ىمش: ك.
[1233] ٤٠ب: غ.
[1234] فحينئذٍ] فح: غ.
[1235] ٦٠ب: ص.

[1236] الضلع] فاص.
[1237] يكن] لكن: ص، غ، م.
[1238] ليحصل] لنحصل: ص، ك.
[1239] يكون] نكون: ص.
[1240] القبيل] غ (ال‹‹ق›› مطموس).
[1241] تكون] نكون: ص = يكون: غ، ك، م.
[1242] يكون] نكون: ص، م.
[1243] ٤٠ب: ك.
[1244] تكون] نكون: ص: يكون: غ، ك، م.
[1245] ٦٥آ: م.
[1246] الباب الأوّل] –ك.
[1247] ٦١آ: ص.
[1248] ستّة] + الارض: شاك.
[1249] ٤١آ: غ.
[1250] ضمت] صمت: ص، ك، م.
[1251] القدماء] غ (ال‹‹ماء›› في الهامش).
[1252] ٦٥ب: م.
[1253] فنقول] فمول: ص، ك = فنقول: م.
[1254] ٦١ب: ص.
[1255] ٤١آ: ك.
[1256] ألفان] غ (ال‹‹ن›› في الهامش).
[1257] وأربعون] + في: شاغ.
[1258] ٤١ب: غ.
[1259] ٦٦آ: م.
[1260] بيان لتمام] ننان لهما: ك.
[1261] أوّلاً] م (توجد ال‹‹ا›› شطوباً بين ال‹‹او›› وال‹‹لا››) = ولا: ك.
[1262] ٦٢آ: ص.
[1263] نصف] النصف: ك.

[1264] لدائرة] غ (ال‹‹ة›› في الهامش).
[1265] القاعدة] غ (ال‹‹عدة›› في الهامش).
[1266] وأربعة] واربع: ك.
[1267] ٦٦ب: م.
[1268] فالباقي] غ (ال‹‹قي›› في الهامش).
[1269] ٤١ب: ك.
[1270] ومعرفة] معرفه: ك.
[1271] ٦٢ب: ص.
[1272] ٤٢آ: غ.
[1273] جزءاً] جراء: ك = جزء: م.
[1274] ناقصاً] غ (ال‹‹قصا›› في الهامش).
[1275] في] —غ.
[1276] ٦٧آ: م.
[1277] ٦٣آ: ص.
[1278] عن] فام.
[1279] جزءاً] جزء: غ = جزاء: ك.
[1280] ٤٢ب: غ.
[1281] حينئذٍ] ح: غ.
[1282] ٤٢آ: ك.
[1283] جزءاً] جزء: غ.
[1284] وسُدس] وسدسدَ: غ.
[1285] ٦٧ب: م.
[1286] به] هاغ.
[1287] عشرة ثانية] فام = + نطح ىا: هام.
[1288] قطر] —غ.
[1289] دقائق] غ (ال‹‹ئق›› في الهامش) = + ه رلا : هام.
[1290] وإحدى ثلاثون ثانية] هام (مع رمز ‹‹صح››).
[1291] ٦٣ب: ص.

[1292] وثانيتان] هام (مع رمز ‹‹صح›› و يوجد ال‹‹ى ند ب›› في الهامش أيضاً).
[1293] درجة] + وتسع وخمسون دقيقة: شاص.
[1294] دقيقة وتسع] –غ.
[1295] وأربع وخمسون دقيقة وتسع ثواني] هام (مع رمز ‹‹صح›› ويوجد ال‹‹مح ند ط›› في الهامش أيضاً).
[1296] الأرض] غ (ال‹‹رض›› في الهامش).
[1297] وأربعون ثانية] فام = + ا سد نه مب: هام.
[1298] واثنان] واسان: م.
[1299] وستّ وثلاثون ثانية] هام (مع رمز ‹‹صح›› ويوجد ال‹‹لج لب لو›› في الهامش أيضاً).
[1300] ثمان] ثماني: م.
[1301] درجة] + وتسع وخمسون دقيقة: شاص.
[1302] وأربع وخمسون دقيقة وتسع ثواني] هام (مع رمز ‹‹صح›› ويوجد ال‹‹مح ند ط›› في الهامش أيضاً).
[1303] وفي] في: غ.
[1304] ٤٣آ: غ = ٦٨آ: م.
[1305] أربعون] واربعون: ك.
[1306] لأنّه] لان: ك.
[1307] ٦٤آ: ص.
[1308] ٤٢ب: ك.
[1309] بُعدها] بعده: ك.
[1310] والظلّ] والضل: ك.
[1311] ٦٨ب: م.
[1312] فليكن] فلكن: ص = فلكن: م.
[1313] د] ى: ص، ك، م.
[1314] ه ز ح] ر ه ح : ك.
[1315] بُعده] بعدها: غ.
[1316] الفصل] الفضل: غ.
[1317] ٦٤ب: ص.
[1318] الفصل] الفضلَ: غ.

[1319] د س] ى س: ص، ك، م.
[1320] ٤٣ب: غ.
[1321] بنقط] بنقطه: غ.
[1322] المارّة] المار: ص، ك، م.
[1323] تماسّ] بماس: ك، م.
[1324] متوازية] مواربه: م.
[1325] ٦٩آ: م.
[1326] درجة] + وثلاث وعشرون دقيقه: شام.
[1327] وخمس عشرة دقيقة واثنتان وأربعون ثانية] هام (مع رمز ‹‹صح››).
[1328] ٤٣آ: ك.
[1329] في مثلّث] مثلث: غ.
[1330] ٦٥آ: ص.
[1331] زاويتان] غ (ال‹‹ن›› في الهامش).
[1332] الدور] الذور: ك.
[1333] فيصير] فصر: ص، ك.
[1334] درجة] + ںلث وعشرون دقںقه: شام.
[1335] وخمس عشرة دقيقة واثنتان وأربعون ثانية] هام (مع رمز ‹‹صح››).
[1336] فيكون] فكون: ص.
[1337] ٦٩ب: م.
[1338] عشر] عشره: ص.
[1339] دقيقة] + واںنتا: شام.
[1340] ٤٤آ: غ.
[1341] وأربعون] + وست واربعوں ىاںه مه م (مع رمز‹‹صح›› ويوجد ال‹‹وست واربعوں ىاںه›› شطوباً).
[1342] ٦٥ب: ص.
[1343] الأرض] الارفق: غ.
[1344] الأرض] غ (ال‹‹رض›› في الهامش).
[1345] وهو] –غ.
[1346] إذا] غ (توجد الكلمة غير المقروئة بعد ال‹‹إذا››).

[1347] ٧٠آ: م.
[1348] واحد] + وىلت دقايق واىنتاى [؟] وعسرون: شام (توجد في الهامش مع رمز ‹‹صح›› ولكن غير مقروئة).
[1349] ٤٣ب: ك.
[1350] ثانية] + عشرين: شام.
[1351] قدر] ثانيه قدر: م.
[1352] وتكون] وىكون: ص = ويكون: غ، ك، م.
[1353] كان] كا: غ.
[1354] ستًا] سبعا ستا: غ.
[1355] ابعد] فام.
[1356] ثلاث دقائق واربع عشرة] هاغ (مع رمز ‹‹صح››).
[1357] ٦٦آ: ص.
[1358] واثنتان وأربعون ثانية] هام (مع رمز ‹‹صح››).
[1359] يكون] ىكون: ص.
[1360] واحد] ك (توجد ال‹‹و›› المشطوب بعد هذه الكلمة).
[1361] ٧٠ب: م.
[1362] ألفاً] + اربعمايه و[؟] وحمسين: شام (توجد الكلمة غير مقروءاً).
[1363] ومائة واثنين] هام.
[1364] وتسعين] طام.
[1365] ٤٤ب: غ.
[1366] وتسعة وعشرين دقيقة وأربع ثوان] –م.
[1367] رأس] الراس: ص، ك، م.
[1368] لتشابه] التشابه: غ.
[1369] دقيقة] + واثنتا عشرة: ك، شام.
[1370] وأربعين] هام (مع رمز ‹‹صح››).
[1371] عشر] عشره: ص، ك، م = واربع عشره: هام (يوجد شطوباً، مع رمز ‹‹صح››).
[1372] دقيقة] + ثماني: شام.
[1373] عشرة] وعشرة: غ = عشرون: شام.
[1374] واثنتان وأربعون ثانية] هام (مع رمز ‹‹صح››).

[1375] فجيبة] فحسبه: ص = فحسه: ك.

[1376] ٤٤آ: ك.

[1377] الظلّ] + ماه وسبعه وتسعين ملا: شام.

[1378] ٦٦ب: ص.

[1379] الأرض] + وخمس وسدس مل اضا: شاص.

[1380] مأتين وأربعة أمثال لنصف قطر الأرض وأربعا وأربعين دقيقة] هام (مع رمز ‹‹صح››).

[1381] وعن مركز الأرض] –غ.

[1382] مثلاً] + وبلابه لدباع مل: شاص.

[1383] المناظر] المناظرات: غ.

[1384] تكون] تكون: ص، غ = يكون: ك، م.

[1385] ٤٥آ: غ.

[1386] عشر] عشره: ص.

[1387] دقيقة] فاص.

[1388] وهو أربع] واربع: غ.

[1389] ٦٧آ: ص.

[1390] وهو خمسة] وحمسه: غ.

[1391] وتسعة] واربع: هاص (مع رمز ‹‹صح››).

[1392] وأربعون] هاص (مع رمز ‹‹صح››) = ىلب: شاص.

[1393] ٤٤ب: ك.

[1394] قطر] قطرا: ص.

[1395] ٤٥ب: غ.

[1396] المطلوب] المط: غ.

[1397] ٦٧ب: ص.

[1398] واحد إلى مقدار بعدها الاوسط بهذا المقياس] –ك.

[1399] حصل] جصل: ك.

[1400] وظاهر] وظ: غ.

[1401] ٦٨آ: ص.

[1402] ٤٦آ: غ.

1403 المطلوب] المط: غ.
1404 ٤٥آ: ك.
1405 أ مد ب] + دقيقة: ك.
1406 المطلوب] المط: غ.
1407 ب نو نا] جـ ما مد دقيقة: ك.
1408 البعد] بعد: ك.
1409 مقدار] فاص، غ (الـ‹‹ر›› في الهامش).
1410 ٦٨ب: ص.
1411 المطلوب] المط: غ.
1412 الأرض] غ (الـ‹‹رض›› في الهامش).
1413 نه هـ] ا ط جـ دقايق: ك.
1414 أبعاد] —غ.
1415 في معرفة أبعاد العلويّة والثوابت] هاص (مع رمز ‹‹صح››).
1416 ٤٦ب: غ.
1417 يد جـ] يد هـ: غ.
1418 ٤٥ب: ك.
1419 المطلوب] المط: غ.
1420 ٦٩آ: ص.
1421 ب لد نه ل] ب لد ند ل: غ.
1422 المطلوب] المط: غ.
1423 المطلوب] المط: غ.
1424 ومائتان] غ (الـ‹‹ئتان›› في الهامش).
1425 أيْ خمسة عشر ألفاً ومائتان وستة وخمسون مثلاً وخمس دقائق] اعى سعه عسر الفا ومابه واربعه وعسرىں مىلا للمماس وىماىه وىلاىں دفىفه: هاص (مع رمز ‹‹صح››).
1426 ٤٧آ: غ.
1427 ٤٦آ: ك.

1428 ٦٩ب: ص.

1429 المطلوب] المط: غ.

1430 مسطّح] –غ.

1431 المطلوب] المط: غ.

1432 وهو] + معادر: شاغ.

1433 فلك الثوابت] ذلك الثوابت: غ (ال‹‹بت›› في الهامش).

1434 بما به نصف قطر الأرض واحد] + ودلك سبع وعشرون الفا واسان وىمانون مثلا للمماس واسان وىلىون دمىمه اعنى كـ لا ر مثلا للمقاس ولـ دمىمه: ص (ال ‹‹ ولـ دمىمه›› في الهامش مع رمز ‹‹صح››) = + وذلك: شاغ.

1435 المطلوب] المط: غ.

1436 جزء] حرو: ص.

1437 ه مط] مط: غ.

1438 ٧٠آ: ص.

1439 المطلوب] المط: غ.

1440 ببُعد] –ك.

1441 هذا] فاص.

1442 ٤٧ب: غ.

1443 الأرض] غ (ال‹‹ض›› في الهامش).

1444 ٤٦ب: ك.

1445 لجرم] لحزم: غ.

FIGURE APPARATUS

المقالة الأولى، الباب الأوّل في بيان عدد الأفلاك الكليّة وكيفيّة نضدها

شكل ١: صورة الأفلاك

فلك الأفلاك] ص، ك، م = اطلس: غ. فلك البروج] ص، ك، م = ثوابت: غ (مطموس). فلك زحل] ص، ك، م = زحل: غ (مطموس). فلك المشتري] ص، ك، م = مشتري: غ (مطموس). فلك المرّيخ] ص، ك، م = مريخ: غ (مطموس). فلك الشمس] ص، ك، م = سمس: غ. فلك الزهرة] ص، ك، م = زهرة: غ (مطموس). فلك عطارد] ص، ك، م. عطارد: غ. فلك القمر] ص، ك، م = قمر: غ. كرة النار] ص، ك، م = نار: غ. كرة الهواء] ص، ك، م = هوى: غ. كرة الماء] ص، ك، م = ما: غ (غير مقروء). كرة الأرض] ص، ك (ال‹‹كرة›› مطموس)، م = ارض: غ. (توجد نقطة في مركز الشكل في ص، غ، ك). (توجد دائرة زائدة تحت ‹‹ارض›› في غ). (ال‹‹مركز عالم›› وال‹‹مركز ارض›› زائدان في غ).

المقالة الأولى، الباب الرابع في هيئة أفلاك الكواكب السيّارة

شكل ٢: صورة فلك الشمس

صورة فلك الشمس] ص، غ، م = + وهئيه افلاك كل: ك. الأوج] ص، ك، م = اوج: غ (مكتوب بشكل معكوس فوق محدّب الفلك الممثّل). الشمس] ص، ك، م = شمس: غ (مكتوب بشكل معكوس). (دائرة الشمس في يسار الصورة في ص، غ). المتمم المحوي] ص، غ (مكتوب بشكل معكوس)، ك، م. الفلك الممثّل] ص، ك، م = ممثل: غ (مكتوب بشكل معكوس). الفلك الخارج المركز] ص، ك، م = حارج المركز: غ (مكتوب بين ال‹‹اوج›› و‹‹المتمم المحوي›› بشكل معكوس). مركز الخارج] م = —ص، —ك، —غ. مركز العالم] غ ، م = —ص، —ك. (توجد نقطتان لل‹‹مركز العالم›› وال‹‹مركز الخارج›› في ص، غ، م) الحضيض: ص، ك، م = حضض: غ (مكتوب بشكل معكوس). المتمم الحاوي] ص، غ، م = المم المحوائ: ك. (الشكل مدوّر مائة وأربعين درجة تقريباً على خلاف توالي الساعة في غ).

الشكل ٣: هئية أفلاك العلويّة والزهرة

هئية أفلاك العلويّة والزهرة] ص، ك، م = غ (العبارة ليست فوق الصورة، بل في المتن). الأوج] ص، ك، م = اوج: غ. الفلك الممثّل] ص، ك، م = ممثل: غ. الكوكب] ص، ك، م =كوكب: غ (مكتوب في داخل دائرة التدوير). فلك التدوير] ص، ك، م = فلك تدوير: غ. (دائرة ال‹‹فلك التدوير›› ناقصة في ك). (دائرة ال‹‹الكوكب›› في هابط نصف دائرة التدوير في ص). الفلك الحامل] ص، ك، م = فلك الخارج المركز: غ (مكتوب بين ال‹‹اوج›› وال‹‹المتمم المحوى››). الحضيض] حضيض: غ. (نقطتان وال‹‹مركز خارج المركز›› وال‹‹مركز عالم›› زائدون في غ).

شكل ٤: صورة أفلاك القمر

الأوج] ص، ك، م = —غ. المتمّم المحوي] ص، ك، م = —غ. الفلك المائل] ص، ك، م = مايل: غ. الكوكب] ص، ك، م = قمر: غ. التدوير] ص، ك، م =تدوير: غ (مكتوب في داخل دائرة ‹‹التدوير››). (دائرة ال‹‹التدوير›› ناقصة في ك). الفلك الحامل] ص، ك، م = فلك حارج المركز: غ (مكتوب تحت مقعّر الفلك الحامل رأسياً). الحضيض] ص، ك، م = —غ. فلك الجوزهر] ص، ك، م = جوزهر: غ. المتمّم الحاوي] ص، ك، م = —غ. (الدائرتان للفلك المائل في اللون المختلف في غ). (نقطتان وال‹‹مركز حارج المركز›› وال‹‹مركز عالم›› زائدون في غ).

الشكل ٥: [صورة أفلاك عطارد]

(الشكل ناقص في غ). (ال‹‹الفلك الحامل›› موقعان في ص، ك، م). (الدائرة للكوكب ناقصة في ك).

المقالة الأولى، الباب السادس، الفصل الأوّل فيما يعرض للكواكب في الطول

الشكل ٦: [صورة تعديل الشمس]

(ال‹‹الأوج›› فوق محدّب الدائرة في غ). مركز الخارج] ص، ك، م = مركز حارج: غ. (مكتوب ‹‹الخط الخارج من نقطه المر›› زائداً رأسياً على يمين ال‹‹مركز حارج›› في غ). (مكتوب ‹‹الحط من بعطه›› زائداً رأسياً على يمين

ال‹‹مركز حارج›› في غ). مركز العالم] ص، ك، م = مركز عالم: غ (مكتوب رأسياً). مركز الشمس] ص، ك، م = مركز شمس :غ (مكتوب زائداً في مركز الدائرة الصغيرة في اليمين). (مكتوب ال‹‹الخط التقويمى›› (موقعان) على نقطة تقاطع الخطّان التقويميان مع الدائرة الخارجة رأسياً). (الدائرة الصغيرة من اليمين تحت نصف النهار والدائرة من اليسار فوق نصف النهار في غ). (الدائتان الصغيرتان فوق نصف النهار في ك). الحضيض] ض، ك، م = حضيض: غ (مكتوب تحت الدائرة للخارج). (ال‹‹حمل›› زائد في غ). (الشكل مدوّر قليلاً على توالي الساعة).

الشكل ٧:

(الشكل من اليمين): (الشكل مدوّر تسعين درجة تقريباً على خلاف توالي الساعة في غ). الذروة المرئية (موقعان)] ص، ك، غ، م. القمر (موقعان)] ص، ك، م (مكتوب بخط مختلف في موقع واحد) = القمر نازل (في موقع)؛ القمر الصاعد من الحضيض (في موقع آخر) : غ. الأوج] ص، ك (مكتوب فوق مقعّر الدائرة الكبيرة)، م = —غ. مركز التدوير (موقعان)] ص، ك (مكتوب فوق محدّب الدائرة الصغيرة)، م = —غ. زاوية التعديل المفرد] ص، ك، م = —غ. (مكتوب ال‹‹حط مركز المعدل›› زائداً في داخل الدائرة الكبيرة في غ) زاوية التعديل المعدل] ص، ك، غ، م (بخط مختلف). (يوجد ال‹‹زاويه التعديل المعدل›› والخط يخرج من مركز العالم إلى طرف على نصف الصاعد للدائرة الصغيرة من اليسار شطوباً في م). مركز العالم] ص، ك، م = مركز عالم: غ. (مكتوب ال‹‹حمل›› زائداً على يمين محدب الدائرة الكبيرة في غ). (مكتوب ال‹‹مغرب›› وال‹‹مشرق›› عند محدّب الدائرة كبيرة في الجهتين في غ). (مكتوب ال‹‹حضيض›› زائداً تحت محدّب الدائرة الكبيرة في غ).

(الشكل من اليسار): (الشكل مدوّر تسعين درجة تقريباً على خلاف توالي الساعة في غ). الذروة المرئيّة (موقعان)] ص (مكتوب معكوساً)، ك (موقع واحد)، غ، م (موقع واحد). الكوكب من المتحيرة (موقعان)] ص، ك (مكتوب ال‹‹الكوكب›› موقع واحد)، م (في موقع واحد؛ يوجد أيضاً شطوباً في موقع مختلف) = محىره نازله (في الموقع المتماثل في الدائرة الصغيرة العليا) ؛ محىرة صاعدة (في الموقع المتماثل في الدائرة الصغيرة السفلية): غ . (يكون الخط يخرج من مركز العالم إلى الكوكب على الدائرة الصغيرة متماثلاً (موقعان) في غ). (يوجد الخط يخرج من مركز العالم إلى نقطة فوق الدائرة الصغيرة السفلية في ك). الأوج] ص، ك، م = —غ. زاوية التعديل المفرد] ص، ك، م = —غ. زاوية التعديل المعدل]

ص، ك، غ، م (بخط مختلف؛ يوجد نفس العبارة شطوباً متماثلاً أيضاً). (مكتوب ال‹‹مغرب›› وال‹‹مشرق›› عند محدّب الدائرة كبيرة في الجهتين في غ).

الشكل ٨:

(الشكل نقصان في غ). (الشكل في الهامش في ص). (شكل دائرة التدوير تحت شكل دائرة الخارج في ص). الذروة المرئية] ص، م = الدروة المرىى: ك. (مكتوب ال‹‹البعد الأوسط بحسب المسافة›› عند يمين شكل التدوير معكوساً في ك، م). (مكتوب ال‹‹البعد الأوسط بحسب المسافة›› عند يسار شكل التدوير رأسياً في ك).

المقالة الأولى، الباب السادس، الفصل الثالث فيما يعرض للكواكب في الطول والعرض معاً

الشكل ٩: [صورة اختلاف المنظر]

(مكتوب ال‹‹سمت الرأس›› معكوساً في غ). (الخطوط يخرجون من ال‹‹موضع المناظر›› وال‹‹مركز العالم›› والنقطة تظهر ال‹‹كوكب›› مدوّرون تسعين درجة على خلاف توالي الساعة في غ). مركز الكوكب (موقعان)] ص، ك، م = كوكب: غ (موقع واحد). موضع الناظر] ص، ك، م = ناصره: غ. الأفق الحسي] ص، ك ، م = خط الافق الحسى: غ (مكتوب فوق تلك الخط). مركز العالم] ص، ك، م = مركز عالم: غ. (الخط يخرج من طرف الدائرة الكبرى إلى طرف الآخر نقصان في ص، ك). (ال‹‹حط الافق الحقيقى›› زائد تحت الخط يخرج من طرف الدائرة الكبيرة إلى الآخر في غ). (ال‹‹كره الارض›› وال‹‹فلك الكوكب›› زائدان في داخل الدائرة الكبيرة في غ). (مكتوب ال‹‹موضع حقيقى بالاتفاق›› وال‹‹موضع مرئى عند المتقدمين›› وال‹‹موضع مرئى عند المتاخرين (مع رمز ‹‹م››)›› وال‹‹دائرة الارتفاع على سطح كرة العالم›› عند محدّب الدائرة الكبيرة). (يوجد ال‹‹ جانب المغرب مثلا›› في يمين الشكل وال‹‹جانب المشرق مثلا›› في يسار الشكل في غ).

الشكل ١٠:

(الشكل مدوّر تسعين درجة على خلاف توالي الساعة في غ). (لا تظهر الأجزاء القمر السوداء في ص). الشمس] ك، م = شمس: غ = —ص. المحاق] ك، م = محاق: غ = —ص. الهلال] ك، م = هلال: غ (فوق مقعّر الدائرة الكبيرة) = —ص. التربيع الأول] ك، م = تربيع اول: غ (فوق مقعّر الدائرة الكبيرة) = —ص. التثليث الأول] ك، م = تثليث اول: غ = —ص. البدر] ك، م = بدر: غ (مكتوب معكوساً) = —ص. التثليث الثاني] ك، م = تثليث ثانى: غ (فوق مقعّر الدائرة الكبيرة) = —ص. التربيع الثاني] ك، م = تربيع ثانى: غ (فوق مقعّر الدائرة الكبيرة) = —ص. آخر الشهر] غ (فوق مقعّر الدائرة الكبيرة) ، ك، م = —ص.

الشكل ١١:

(الشكل مدوّر تسعين درجة على خلاف توالي الساعة في غ). (دائراتا القمر صغيرتان جدّاً في غ). (لا يظهر الأقسام في الظل في ك، غ). (لا يظهر قسم القمر الأعلى في الظل في ص). موضع الناظر] موضع النظر: غ (مكتوب تحت دائرة الأرض).

المقالة الثانية، الباب السادس

في الأيّام بلياليها وأجزائها من الليل والنهار والساعة المستويّة والمعوّجة والصبح والشفق

الشكل ١٢:

(الشكل مدوّر خمسة وأربعين درجة على خلاف توالي الساعة في الهامش في غ). (الشكل مدوّر مائتان وخمس وعشرين درجة على خلاف توالي الساعة في ك، م). رأس مخروط ظلّ الأرض] راس محروط الطل الارض] ك.

العمود] عمود: غ. الأفق الحسّي] غ (مكتوب معكوساً). (لا يوجد قطر الأرض مرسوماً في ص، ك، م). (يوجد ال‹‹وتر مثلث›› مكتوباً معكوساً فوق قطر الأرض في غ). الشمس] مركز الشمس: غ (مكتوباً في وسط الشكل).

المقالة الثانية، الباب العاشر في استخراج خطّ نصف النهار ومعرفة أوقات الصلوة وسمت القبلة

الشكل ١٣:

(الشكل مرسوم في الهامش في غ). (كلّ الأسماء فوق الشكل ناقص في ص). المسطرة] –ص، –غ. (طرف حيط الشاقول يماسّ قاعدة المثلّث في ك).

المقالة الثالثة، المقدّمة في معرفة مقادير الأبعاد والأجرام

الشكل ١٤:

(كلّ الأسماء فوق الشكل ناقص في ص). (المثلّثان متبادلان في ص) (المثلّث الثاني مدوّر مائة وخمسة وثلاثين درجة على توالي الساعة في غ). (المثلّث الأوّل مدوّر خمسة وأربعين درجة على توالي الساعة في ك، م. الضلع المعلوم] –غ (العبارة الأولى في المثلّث الأوّل). العمود] العمود الداخل فى المثلث: غ (في المثلّث الثاني). العمود] العمود خارج: غ (في المثلّث الثاني). الزاوية المعلومة] الراويه المعارفه: ك (في المثلّث الثاني).

المقالة الثالثة، الباب الثاني في معرفة أبعاد القمر عن مركز العالم بما به نصف قطر الأرض واحد ومعرفة نسبة قطره وقطر الظلّ وقدرهما من أجزاء الدور

الشكل ١٥:

(الشكل مدوّر مائة وخمسة وثلاثين درجة على خلاف توالي الساعة في غ). دائرة الارتفاع] –غ = داره الاربفاع فى فلك البروج: ص. أرض] –ص. (مكتوب ال‹‹حقيقى›› في طرف الخط يخرج من نقطة ‹‹ب›› زائداً في غ). (يوجد الخط الزائد يخرج من نقطة ‹‹ب›› وهو موازي للخط يخرج من نقطة ‹‹أ›› في غ). (مكتوب ال‹‹مرئى›› في طرف الخط زائداً في غ).

المقالة الثالثة، الباب الثالث في معرفة مقدار قطري القمر والظلّ وبُعد الشمس الأوسط وبُعد رأس مخروط الظلّ عن مركز الأرض بما به نصف قطرها واحد

الشكل ١٦:

(الشكل مدوّر تسعين درجة على خلاف توالي الساعة في غ). (الشكل مدوّر مائة وثمانين درجة على خلاف توالي الساعة في م). (يُكتب ال‹‹أ›› وال‹‹ ج›› متبادلاً في ك).

CHAPTER 6

ENGLISH TRANSLATION OF *AL-RISĀLA AL-FATḤIYYA*

[*Al-Risāla al-Fatḥiyya by ʿAlī al-Qūshjī*]

[Preface]

In the Name of God, the *Beneficent*, the Merciful

[1] Praise be to God Who created the heavens so that people possessed of minds reflect on the wonders of the heavens, and Who ordained mansions in the [heavens] so that they learn the number of years and [their] calculation. And may His blessings be upon His messenger, the pole of the orb of guidance, and upon his family, stars in the sky of succession and sovereignty. Now then, among the most honorable blessings and most excellent favor God the Exalted has bestowed upon me is that He made me fortunate to join the service of his Highness, the great Sultan, the possessor of the necks of nations, God's shadow on the two earths, the steward of water and clay, the Sultan of the conquests and warriors, suppressor of the enemies and the disobedient, the most just of rulers in the worlds, the helper of the servants of God, the protector of the countries of God, reviver of the principles of justice and equity, destroyer of the tenets of oppression and tyranny. The sea is a drop among the drops of his beneficence; the Sun is a light among the lights of his munificence. His gifts are a zenith beyond measure, lying outside any degree of comprehension. Pearls and twinkling stars are so frightened of his generosity that they project themselves in the sea and in the orbs. He is supported from the sky, victorious over the enemies, guardian of the kingdoms of the world, revealer of the Highest Word of God, Sultan of the two continents, ruler (*khāqān*) of the two seas: The Father of the Conquest, Sultan Muḥammad Khān, May God make him happy in the two abodes and spread the place of his dynasty beyond the gap between the Two-Calf stars (*farqadān*). He is the one who raised the flags of science after their degeneration and rebuilt the regions of eminence after they were obliterated. For the gardens of the

sciences have returned to their pleasing appearance with the greening of its areas, and its gardens have reverted to their splendor, with the flowering of their verges and surroundings. Since I have been in his service, I have seen philosophy (al-*ḥikma*) as the aspiration most prioritized by him, and as the one that deserves most to be presented to him. And so, I chose, among those [sciences], the science of *hayʾa,* which is lauded in the revelation [revealed] to human beings by [God] Most Exalted saying: "Who remember God standing, sitting, and lying upon their sides, and reflect upon the creation of the heavens and the earth, 'Our Lord, Thou hast not created this in vain.' " (*The Qur'an,* Āli ʿImrān 3: 191).[1] And I composed[i] in [the science of *hayʾa*] an epitome intended for [the Sultan], named after him, small in words, large in meaning, diminutive in volume, great in signification. Since its completion coincides with the glorious conquest[ii] of most of the kingdoms in the inhabited quarter, I named it *The Treatise of Conquest*, May God the Exalted let it be joined[iii] with the conquest of the other lands and may He make eternal the sovereignty of the Conqueror until the Day of Calling. For He fulfills every wish and request.

[2] I arranged it according to an introduction and three parts.[iv]

[i] composed] γ = made: α, β.
[ii] with the glorious conquest] γ: for the glorious conquest: α, β.
[iii] let it be joined] "it" is referred to by the masculine pronoun (–*hu*): β, γ = "it" is referred to by the feminine pronoun (–*hā*): α.
[iv] I arranged it according to an introduction and three parts] γ = –α, –β.

Introduction

Concerning That Which is Needed by Way of Introduction before Undertaking [Our] Objectives

[1] A point has a position and is not divisible. A line is that which has length only and ends in a point if it terminates positionally. A surface is that which has length and width only and ends in a line and a point as well if it terminates positionally. A solid is that which has length, width, and depth and ends in a surface; it can also terminate in a line or a point. A straight line is the shortest line joining two points. A circular [line] is that in which there is a point in its concavity from which lines extending from it to the [circular line] are equal to one another. That point is its center[v], and those lines are its radii[vi]. Except for these two types, [other lines] are called curved. A plane surface is such that when any two points on it are connected with a straight line, that line does not depart from this surface. A circular [surface] is such that when it is cut by a plane surface, there results [in the plane] a circle; a circular surface may be characterized by having a point in its concavity such that all the lines extending from that [point] to the [surface] are equal to one another; this point is the center of the [surface][vii]. All surfaces except for the plane and the circular are called curved.

[2] A plane angle, also called simple, is a shape that occurs at a point on a surface in such a way that [the surface] has two boundaries that meet at that point. A solid angle is the meeting of one or more surfaces that bound a body at one point on the [body]. The point at which two lines meet or intersect is their common section; likewise, a line for

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[v] its center] "its" is referred to by the masculine pronoun (–*hu*): β, γ = "its" is referred to by the feminine pronoun (–*hā*): α.
[vi] its radii] "its" is referred to by the masculine pronoun (–*hu*): β, γ = "its" is referred to by the feminine pronoun (–*hā*): α.
[vii] center of the [surface]] "surface" is referred to by the masculine pronoun (–*hu*): β, γ = it is referred to by the feminine pronoun (–*hā*): α.

surfaces, and a surface for bodies. An angle is right if its two sides, after their extension, encompass four equal angles. Otherwise, the smaller [angle] is acute and the larger is obtuse.[viii] A line is perpendicular to another line if it intersects it at right angles, and to a surface if it bounds equal angles[ix] with any given straight line on [the surface] that meets it. Otherwise, [the angle] is inclined. Two surfaces intersect at right angles if a perpendicular to their common section from one of them along with another line from the other surface bounds a right angle, or we may say [they are at right angles] if a perpendicular to one of the surfaces extending from a point on their common section does not depart from the other surface.[x]

[3] Parallel lines are those that are straight occurring on one surface in such a way that they do not meet, even if they are extended on both sides unendingly. [Parallel] surfaces are those planar ones that do not meet, even if they are extended similarly on all sides.[xi] It might be said that non-straight [lines] and non-planar [surfaces] are parallel if the distances between them do not change whatsoever. [Examples] are spherical surfaces that are drawn from the same center, and circles drawn from the [same center], or about the same two poles.

[4] A figure is that which is enclosed by one or more boundaries. A surface [figure] is enclosed by one or more lines. A solid [figure] is enclosed by one or more surfaces. A circle is a [plane] surface figure enclosed by a circular line, which is its circumference; its centre is the centre of the [circle] and its radii are the [circle's] radii. A

[viii] otherwise, the smaller [angle] is acute and the larger is obtuse] γ = −α, −β.
[ix] equal angles] γ = right angle: α, β.
[x] if a perpendicular to their common section from one of them along with another line from the other surface bounds a right angle, or we may say [they are at right angles] if a perpendicular to one of the surfaces extending from a point on their common section does not depart from the other surface] β, γ = if each of the perpendiculars extending along them from any point assumed on their common section is right: α.
[xi] all sides] β, γ = both sides: α.

straight line extending in both directions from [the center][xii] to the circumference is a diameter [of the circle], which bisects it. Every line that cuts the circle is one of its chords; what is separated off on the circumference is an arc. A circle's segment is a [plane] surface figure enclosed by a chord and some part of the circumference, be it half[xiii] or more than or less than a half. The chord is called the base of the segment. The straight sine [sinus rectus] is a perpendicular extending from one endpoint of the arc to the diameter that passes through its other endpoint. What is between the point of the perpendicularity and the other endpoint of the arc along the diameter[xiv] is its versed sine, which is also known as a sagitta. A sinus rectus does not exceed the radius, which is sometimes called the greatest sine. The complete sine is the opposite of the versed sine, so it may exceed [the radius].

[5] Figures with straight sides are those that are enclosed[xv] by straight lines; it is called a triangle if it is [enclosed] by three lines[xvi]; a quadrilateral if there are four [lines]; a pentagon if there are five [lines]; and so on analogously. A triangle is either equilateral, isosceles, or scalene. Also, it might be either right-angled, obtuse-angled or acute-angled. A perpendicular in a triangle is a straight line extending from one of the angles that stands upright on its subtended side; that side is called the base.

[6] A sphere is a solid figure enclosed by a circular surface, which is its circumference. Inside [the figure] is a point from which lines extending to the [circumference] are equal. That point is its center, and those lines are the radii of the

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[xii] from [the center]] "the center" is referred to by the masculine pronoun (–*hu*): γ = it is referred to by the feminine pronoun (–*hā*): α, β.
[xiii] be it half] "be it" is referred to by the verb in feminine form (*kānat*): β, γ = it is referred to by the verb in masculine form (*kāna*): α.
[xiv] the other endpoint of the arc along the diameter] γ = the endpoint of the arc: α, β.
[xv] that are enclosed] "that" is referred to by the feminine pronoun (*bihā*): β, γ = it is referred to by the masculine pronoun (*bihi*): α.
[xvi] it is [enclosed] by three lines] γ = it is three lines: α, β.

[sphere]. Every line extending[xvii] from the [point] to the circumference in both directions is the diameter of the [sphere]. If [that line] is the one around which the sphere moves, then it is its axis and its endpoints are the poles of the sphere. A complete segment of the sphere is a part of a sphere enclosed only by a section from its surface and by a circle that occurs by imagining the cutting of a sphere by a plane into two segments, one of which is the aforementioned segment. And this circle is the common section between the two segments.

[7] A circular cone[xviii] is a solid enclosed by a circle, which is its base, and by a pine cone-shaped surface that rises from [the base], narrowing to a point that is the cone's vertex, in such a way that when a straight line[xix] connecting its vertex and the base's circumference revolves, it will be contiguous with the surface.[xx] The line connecting its vertex and the center of its base is the axis of the cone and its sagitta. If the [axis] is perpendicular to its base, then the cone is right; otherwise it is oblique. A truncated cone is that which is left from a cone after it is cut with a plane surface parallel with the base of the cone, the part above the cut being cast off.[xxi] [xxii]

[xvii] every line extending] γ = extending: α, β.
[xviii] a circular cone] β, γ = a cone: α.
[xix] a straight line] it is referred to by the word *mustaqīm*: α, γ = it is referred to by the phrase *khaṭṭ mustaqīm*: β.
[xx] it will be contiguous with the surface] α, γ = that line will be contiguous with this surface: β.
[xxi] cast off] α, γ = + from it (*minhu*): β.
[xxii] the part above the cut being cast off] γ = + or we say it is that which is left from a cone after a cone similar [to the orginal one] being cast off: α, β.

The First Part

On an Explanation of the Circumstances of the Celestial Bodies

Comprising Six Chapters[xxiii]

Chapter 1 [of Part 1]

On Explaining the Total Number of Orbs and the Manner of Their Arrangement

[1] The World is one sphere whose center is the center of the Earth. The orbs are nine, enclosed by one another in such a way that the concavity of the enclosing [orb] is tangent to the convexity of the enclosed [orb]; yet they are united positionally. The orb enclosing the other orbs is called the greatest orb, the *aṭlas* orb and the orb of orbs. In its cavity is the orb of the fixed stars; all the fixed stars are embedded in it in such a way that the diameter of the [star], which is no smaller than [any] of the fixed stars, is equal to the thickness of this orb. In the cavity of [the orb of the fixed stars] are the orbs of Saturn, Jupiter, Mars, the Sun, Venus, Mercury and the Moon [respectively] with which the world of the celestial bodies terminates. In the cavity of [the orb of Moon] is the world of the elements. The first of these is the sphere of fire, [followed respectively by] the spheres of air, water and earth.

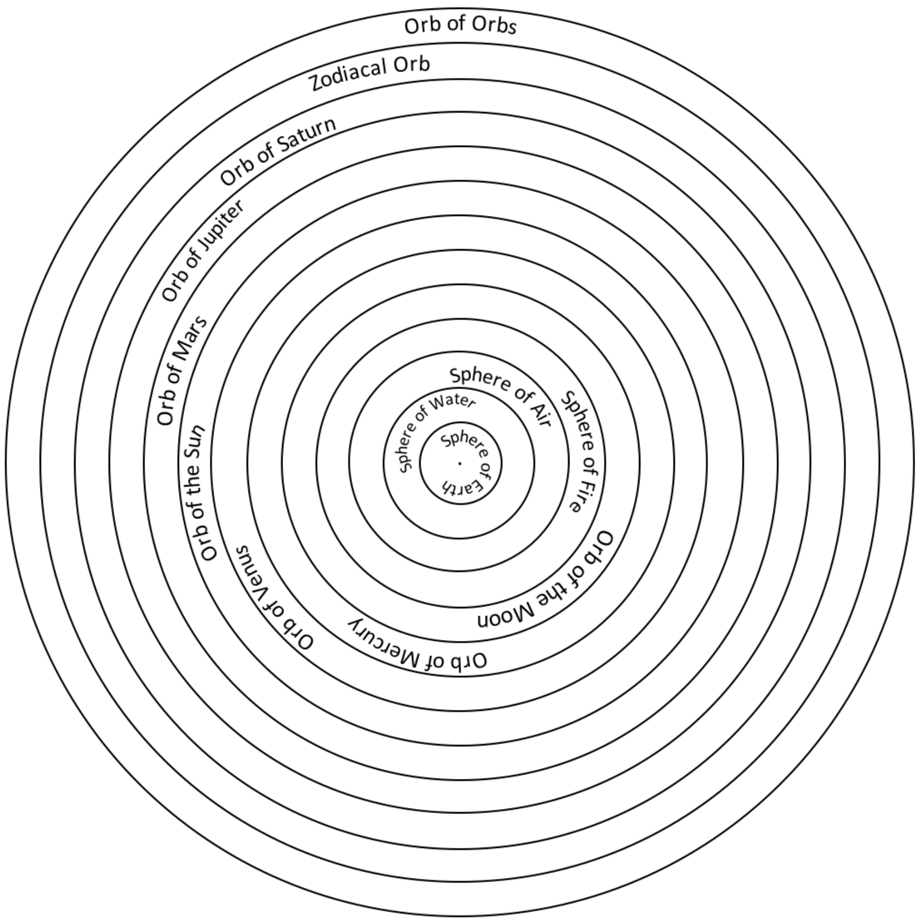
[2] These spheres enclose one another [as] the orbs enclose [one another]. I mean that the convexity of the enclosed [sphere's] two surfaces and the concavity of the enclosing [sphere's] two surfaces are united positionally. However, Divine Providence requires that some [parts] of the Earth's surface are uncovered above the water so that it will become a habitat for breathing beings. This [habitat] is nearly a fourth [of the

[xxiii] the first part on an explanation of the circumstances of the celestial bodies comprising six chapters] β, γ = – α.

surface of the Earth]. The undulations on the surface of the Earth, such as mountains, hills, and valleys, do not make [the sphere of the Earth] deviate from perceptible sphericity, for [those undulations] do not have a sensible value compared to [the Earth].[xxiv]

[3] Here is the illustration of the orbs and elements. Each circle is a surface, and what is between two circles is either an orb or an element, as it is the basis for the illustration of the bodies on surfaces.

Illustration of the Orbs



[Figure 1]

xxiv to [the Earth]] "the Earth" is referred to by the feminine pronoun (–*hā*): γ = it is referred to by the masculine pronoun (–*hu*): α, β.

Chapter 2[xxv] [of Part 1]

On the Well-Known Great and Small Circles, and the Well-Known Arcs

[1] [Mathematicians] divided the circumference of each circle into 360 parts, and the diameter of each circle into 120 parts. They named each part a degree. Then they divided each degree into 60 parts and named each part[xxvi] a minute. They then divided each minute into 60 seconds, each second into 60 thirds, and so forth up to what they wanted. Then, a one-quarter revolution is 90 [degrees], and the complement of each arc less than [90] is what remains [after subtracting that arc from] 90. If you have learned this, we can then say:

[2] Among the well-known great [circles] are: the equator of the greatest orb[xxvii] which is called the equinoctial, and its poles are the poles of the World. One of [these poles] being northern is close to the Big Dipper. The other [pole] is southern. The equator of the orb of the fixed stars[xxviii] is also called the zodiacal equator and zodiacal orb[xxix]; its poles are the poles of the zodiac. [This equator] intersects the equinoctial[xxx] at two facing points named the two equinox points.[xxxi] The circle passing through the four poles is a great [circle] passing through the poles of the two [aforementioned] equators.[xxxii] A latitude circle is a great [circle] passing through the poles of the zodiacal

xxv Chapter 2] β, γ = Chapter 3: α.
xxvi degree. Then they divided each degree into 60 parts and named each part] β, γ = –α.
xxvii the greatest orb] γ = the first motion, the greatest orb: β = the first motion: α.
xxviii the orb of the fixed stars] γ = the second motion, the orb of the fixed stars: β = the second motion: α.
xxix also called the zodiacal equator and zodiacal orb] β, γ = is called the zodiacal equator: –α.
xxx the equinoctial] β, γ = + in all of the orbs which are moved by the two motions: α.
xxxi at two facing points named the two equinox points] β, γ = + so, when the Sun crosses them, it becomes northern to the equinoctial, and it is vernal equinox and the first of Aries. And the other is autumnal [equinox] and the first of Libra. The maximum distance between the two equators is equal to the distance between their poles on its side, and is called the total obliquity: α.
xxxii of the two [aforementioned] equators] α, γ = + the shortest arc occuring along this circle between the two equators or between their poles is called the total obliquity: β.

orb, and through an [arbitrary] part of the [zodiacal orb], or through the center of a [given] star. The arc occurring on this circle between that part and the equinoctial on the nearer side is called the second declination of that part. The [arc] occurring on [the circle] between the center of the star and the zodiacal equator on the nearer side is called the latitude of that star.

[3] The declination circle is a great [circle] passing through the poles of the World and, through a part of the zodiacal orb, or through the center of a [given] star. The arc occurring on this circle between that part and the equinoctial on the nearer side is called the first declination of that part. The [arc] occurring on the [declination circle] between the center of the star and the equinoctial on the nearer side is called the distance of that star. The horizon circle is a great [circle], one of its poles being the zenith, the other one the nadir. We mean by the zenith a point on the [greatest] orb at which a line ends that extends from the center of the World and passes straight through the erect body of a person. The opposite [point] is the nadir. By [the horizon circle], one learns the rising and setting of the stars. It bisects the equinoctial at two points, one of them called the east point and the eastern equinox, and the other the west point and the western equinox. The line connecting those two points is called the east-west line. The arc occurring on that circle between the east point and a part on the zodiacal orb, or between the center of a [given] star on the nearer side is called the ortive amplitude of that star or part. It bisects the zodiacal equator at two points, one of which is called the ascendant, and the other descendant as well as the seventh.

[4] The meridian circle is a great [circle] passing through the poles of the World, zenith and the nadir. It bisects the horizon at two points. The closest [of them] to the northern pole is called the northern. [The point closest] to the southern pole is called the

southern. The line connecting between the two [points] is called the meridian line. It bisects the zodiacal equator at two points. One of them is above the Earth, called the tenth and the cardine of the sky; and the other one is below the Earth called the fourth and the cardine of the Earth. The arc occurring on that circle between the pole of the horizon and the equinoctial, or between the pole of the equinoctial and horizon is called the latitude of a [given] locality. The east-west circle, also called the circle of the initial azimuth, is a great [circle] that passes through the zenith and nadir, as well as through the east and west points.

[5] The ecliptic meridian circle is a great [circle] that passes through the poles of the zodiacal orb and through the zenith and nadir. It bisects the visible and invisible halves of the zodiacal orb. Its poles are the ascendant and descendant points. The arc occurring on that circle between the pole of the horizon and the zodiacal equator, or between the horizon and the zodiacal pole on the nearer side is called the local ecliptic latitude. The altitude circle is a great [circle] passing through the zenith and nadir, as well as through any assumed point on the zodiacal orb.[xxxiii] It intersects the horizon at two points[xxxiv] called the two azimuth points. For this reason, this circle is also called the azimuthal [circle]. The line extending between those points is called the azimuthal line.[xxxv] The arc occurring on that circle between this [azimuthal] point and the horizon is called the altitude of that point, if the point is above the Earth,[xxxvi] and its depression, if

[xxxiii] the zodiacal orb] γ = the orb: α, β.
[xxxiv] at two points] α, γ = + facing each other as [the altitude circle and horizon] are great [circles]: β.
[xxxv] the azimuthal line] α, γ = the line of the equal direction: β.
[xxxvi] the Earth] α, γ = the horizon: β.

[the point] is below the [Earth]. The arc occurring on the horizon between that circle and the circle of the initial azimuth[xxxvii] is called the arc of the azimuth for that point.

[6] Among the well-known small circles are: Circuits of declinations, which are also called day-circles. Parallel to the equinoctial, they are small [circles] that are described by the points assumed on [the great orb] due to the prime motion. Each of [those circles] is called the circuit of the point by whose motion [the corresponding circle] is described. What occurs above the horizon of the circuit of a [given] star is the arc of daylight for that star; what occurs below the horizon is the arc of night. The difference between half the arc of daylight or night, and one-quarter revolution, is the equation of daylight of that star. What occurs on the arc of daylight of a [given] star between its center and the horizon is called the arc of elapsed daylight, if [considering] the eastern horizon; and the arc of remaining daylight,[xxxviii] if [considering] is the western horizon. What occurs on the arc of night between the center of the [given star] and the horizon is called the arc of elapsed night, if [considering] the western horizon; and the arc of remaining night, if [considering] the eastern horizon.

[7] Parallels of latitude are small [circles] parallel to the zodiacal equator. They are described by the motion of the assumed points[xxxix] [on the great orb] due to the motion of the eighth orb. Almucantars are small [circles] parallel to the horizon. Those above the horizon are called the almucantars of altitude, and those being below [the horizon] are called the almucantars of depression. Among the almucantars, the one tangent to the surface of the Earth at one point is called the perceptible horizon. The horizon that has been mentioned earlier is called the true horizon.

[xxxvii] azimuth] the word is in plural form (*al-sumūt*): β, γ = it is in singular form (*al-samt*): α.
[xxxviii] the arc of remaining daylight] “from it (*minhu*)” is included in the term: β, γ = it is not included in the term: α.
[xxxix] the assumed points] α, γ = + that move (*al-mutaḥarrika*): β.

[8] Among the well-known arcs are: The longitude of a locality, [which] is an arc along the equinoctial between its two overhead[xl] intersections: [one] with the meridian of the beginning of the inhabited region in the west, and [the other] with the meridian of the locality. The beginning of the [arc] is the intersection of the beginning of the inhabited region,[xli] [measured] in the sequence of the inhabited region.[xlii] [Another of the well-known arcs] is the co-ascension of the zodiacal arc, being that which rises along the equinoctial with that arc. [Another of the well-known arcs] is the co-ascension of a [discrete] part along the zodiacal orb, or of the center of a [given] star.[xliii] It is an arc along the equinoctial between the first of Aries and a [discrete] part along the equinoctial. [That discrete part along the equinoctial rises] with the [discrete] part along the zodiacal orb, or with the center of this star,[xliv] on the eastern horizon sequentially.

[xl] overhead] β, γ = – α.
[xli] the beginning of the [arc] is the intersection of the beginning of the inhabited region] γ = –α, – β.
[xlii] region] α, γ = + the beginning of the [arc] is the intersection of the beginning of the inhabited region: β.
[xliii] or of the center of a [given] star] β, γ = – α.
[xliv] or with the center of this star] β, γ= – α.

Chapter 3[xlv] [of Part 1]

On Explaining the Configuration of the Ninth and Eighth Orbs, Their Motions, and the Manner of the Division of the Eighth Orb into Zodiacal Signs and an Account of a Few Situations Regarding the Fixed Stars

[1] Each of these two orbs[xlvi] is enclosed by two parallel surfaces whose centers are the center of the world. The ninth orb completes its rotation approximately in a nychthemeron. The eighth orb traverses 1 degree in every 70 solar years, completing its rotation in 25200 years. Its motion is from west to east. As mentioned before[xlvii], the equator of the ninth orb intersects the equator of the eighth orb[xlviii] at two points.[xlix] One of them, which is such that the Sun, when crossing it,[l] comes to be north of the equinoctial, is called the vernal equinox; the other is called the autumnal equinox. The maximum distance between those two circles [i.e. the equators of the ninth and eighth orbs] is called the total obliquity. Different [values for the total obliquity] were found by [various] observations; according to our observation, it is 23;30;17. Two points on the zodiacal orb, when they are at the maximum declination, are called the solstice points. One of them, being toward the northern side, is called the summer solstice point; and the other is called the winter solstice point.

[2] The zodiacal equator is divided, by these four points, into four equal parts. The duration of the Sun's staying in each of the parts [corresponds to] each of the well-

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[xlv] chapter 3] β, γ = chapter 2: α.
[xlvi] each of these two orbs] the pronoun referred to this phrase is in the masculine form (–*hi*): γ = the pronoun is in the feminine form (–*hā*): α, β.
[xlvii] as mentioned before] β, γ = and it is called the equinoctial: α.
[xlviii] the equator of the eighth orb] β, γ = + and it is also called the zodiacal equator and zodiacal orb: α.
[xlix] at two points] β, γ = + they are called the two equinox points: α.
[l] crossing it] "it" is referred to by the feminine pronoun (–*hā*): γ = it is referred to by the masculine pronoun (-*hu*): α, β.

known seasons of the year. [Astronomers] imagined two points for each adjoining quarter of these quarters. By [those points], this quarter is divided into three equal parts. [Astronomers also] imagined five circles of latitude, one of which passes through the equinox points, and the remaining four [circles] pass through those four points. Inevitably, the zodiacal orb is divided into 12 parts, like slices of a watermelon, by those five circles and by the circle passing through the four poles. [Those parts] are called the zodiacal signs. Each of them is 30 degrees in longitude along the zodiacal equator, and 180 degrees in latitude from pole to pole. Three of the zodiacal signs are vernal: Aries, Taurus and Gemini. Three [of them] are estival: Cancer, Leo and Virgo. Three [of them] are autumnal: Libra, Scorpio and Sagittarius. Three [of them] are hibernal: Capricorn, Aquarius and Pisces. When a star moves from Aries through Taurus to Gemini, it is said that [the star] moves in the sequence of the zodiacal signs. When it moves opposite that order, it is said that [the star] moves in the counter-sequence of the zodiacal signs. Since the beginning of the zodiacal signs is from the west, all of the westward motions will be in the sequence of the zodiacal signs, and all of the eastward motions are in the counter-sequence of it.

[3] The fixed stars are so numerous that it is not possible to enumerate them. Yet, scholars of this discipline have observed 1022 stars and determined their positions on the zodiacal orb. In order to determine the positions [of those stars], they imagined 48 constellations, some of those stars falling on the constellations themselves, namely, on the same lines themselves, on which or between which those constellations are imagined. Some of [those stars] fall outside of those lines. When [astronomers] want to point to a star among the stars in the constellation itself, they say, for instance, "the star

which is on the right hand of the constellation[li] of Leo," or "[the star which is on] the left foot of [the constellation]."[lii] When they want to point to a star among the stars outside of the constellation, they say, for instance, "the star which is close to the right foot in the constellation of Leo," or "[the star] which is close to the left hand of the [constellation]" and so forth on this pattern. Twenty-one of those 48 constellations are located to the north of the zodiacal equator, 12 of them are on the [zodiacal] equator itself, and 15 of them are to the south of the [zodiacal equator].

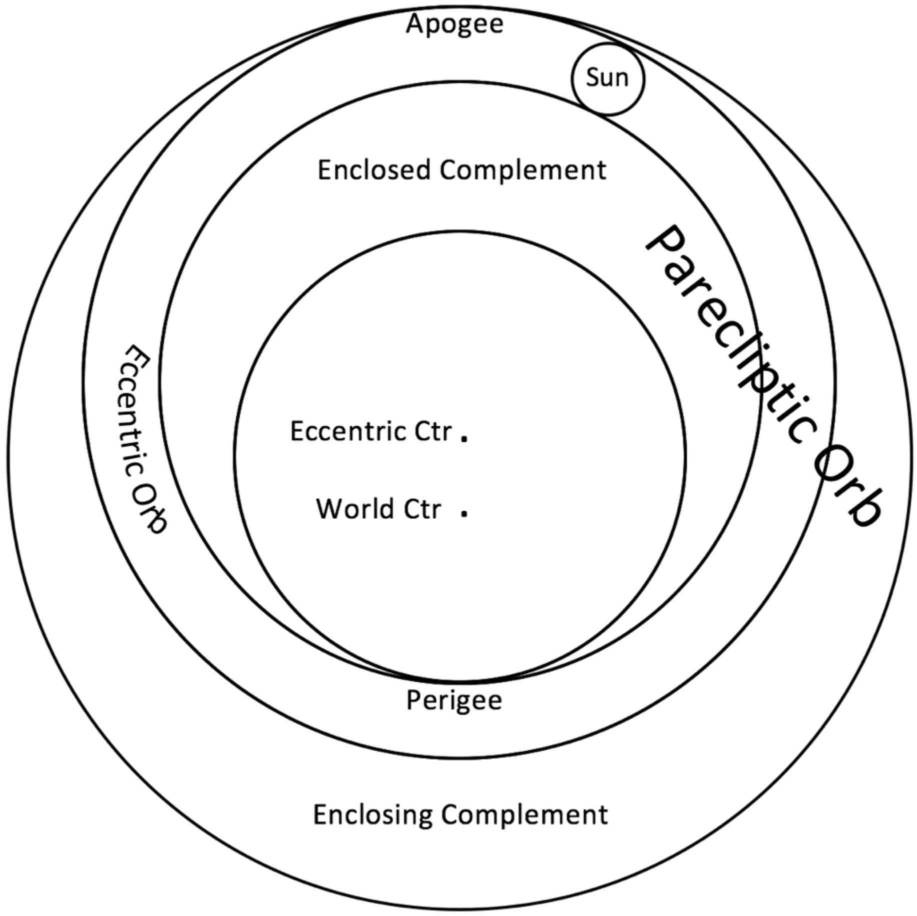
[li] constellation] γ = – α, –β.
[lii] of [the constellation]] this phrase is referred to by the feminine pronoun (-*hā*): γ = it is referred to by the masculine pronoun (-*hā*): α, β.

Chapter 4 [of Part 1]

On the Configuration of the Orbs of the Wandering Planets

[1] The Sun has two orbs [enclosed by] two parallel surfaces. The center of [one of those orbs] is the center of the World, and [that orb] is called the parecliptic. Another orb is separate from the [parecliptic orb]; its center is removed from the center of the World. For this reason, [this orb] is called the eccentric. The convexity of [the eccentric orb's] surfaces is tangent to the convexity of the first orb's surfaces at one common point between them, called the apogee. The concavity of the surfaces [of the eccentric orb] is tangent to the concavity of the first orb's surfaces at another common point between them, called the perigee. The Sun is a solid, spherical body embedded within the body of its eccentric orb, in such a way that [the Sun's] surface is tangent to the surfaces of [the eccentric orb] at two common points.

Illustration of the Sun's Orb



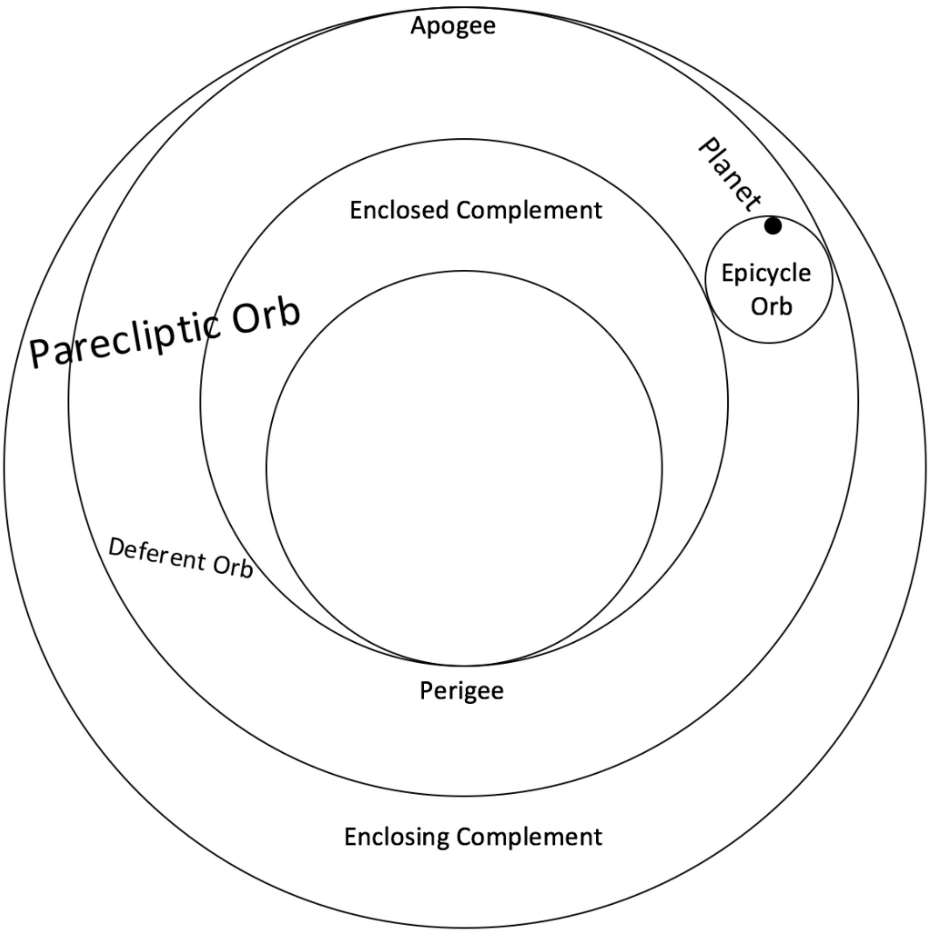
[Figure 2]

[2] The configuration of each of the superior planets and Venus is exactly the same as the configuration of the orb of the Sun; there is no difference between them, except that for each of these four [planets], there is another orb called the epicycle. It is a solid, spherical body embedded within the body of the eccentric orb,[liii] in such a way that the diameter of [the epicycle] is equal to the thickness of the [eccentric]. The planet is

[liii] orb] β, γ = its orb: α.

embedded in [the epicycle], in such a way that it is tangent to the surfaces of the [both orbs] at one common point.[liv]

The Configuration of the Orbs of the Superior Planets and Venus

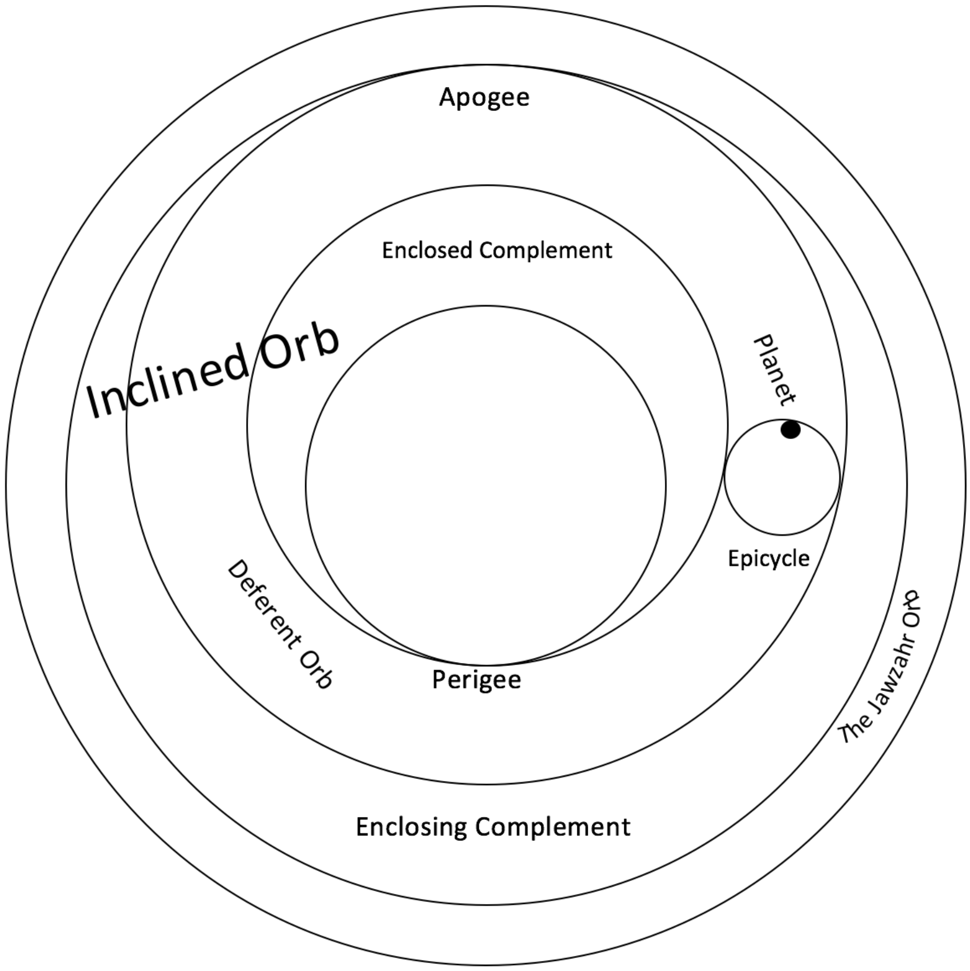


[Figure 3]

[3] The configuration of the Moon's orbs is the same as the configuration of any of these four [planets]. There is no difference between them, except that the Moon has one more orb that encloses its other orbs. Its center is the center of the World, and it is called the *jawzahr*. In the [case] of the Moon, the orb that encloses the eccentric is called the inclined [orb].

[liv] one common point] β, γ = two common points: α.

The Illustration of the Moon's Orbs



[Figure 4]

[4] The configuration of the orbs of Mercury is the same as the configuration of any of those four [planets, i.e. Superior planets and Venus]. There is no difference between them, except that the center of the orb, from which the eccentric orb is separated off is not the center of the World; rather, [that orb] is likewise separated off from another orb whose center is the center of the World and is called the parecliptic.[lv]

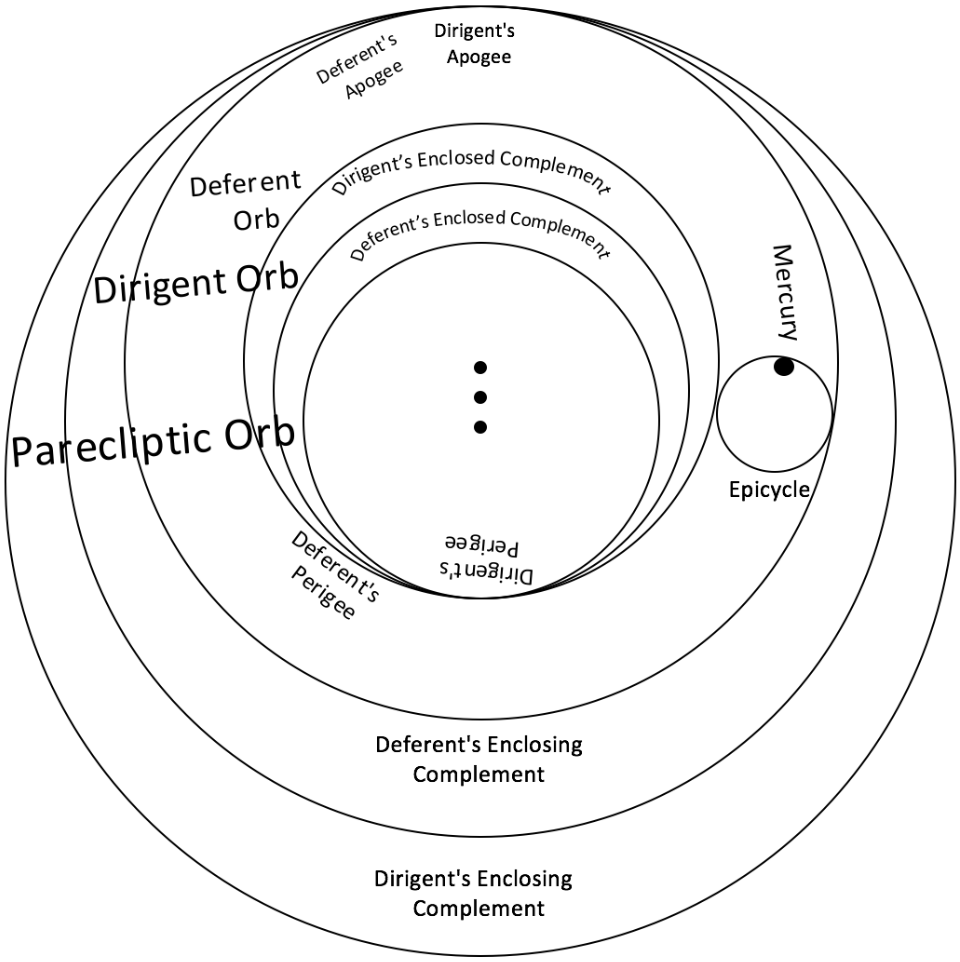
[lv] parecliptic] β, γ = + and the center: α.

The convexity of this separated orb's[lvi] surfaces is tangent to the convexity of the pareclipic orb's surfaces at a common point called the apogee. The concavity of the [same] orb's surfaces is also tangent to the concavity of the parecliptic orb's surfaces at a common point called the perigee. [This orb] is called[lvii] the dirigent.

[5] Mercury has two apogees: One of them is a common point between the convexities of the parecliptic and dirigent [orbs]. And the other [apogee] is a common [point] between the convexities of the eccentric and dirigent [orbs]. Likewise, [Mercury] has two perigees. One of them is a common [point] between the concavities of the parecliptic and dirigent [orbs]. The other [perigee] is a common [point] between the concavities of the eccentric and dirigent [orbs]. The point between the parecliptic and dirigent [orbs] is called the apogee of the dirigent or its perigee. And the common point between the dirigent and deferent [orbs] is called the apogee of the deferent or its perigee. The eccentric orbs within whose thicknesses are the epicycle orbs are called the deferent orbs.

[lvi] this separated orb's] β, γ = + eccentric to the center of the World: α.
[lvii] ... is called] β, γ = and this orb, I mean the orb that diverges from the parecliptic, is called: α.

[Illustration of Mercury's Orbs]



[Figure 5]

Chapter 5 [of Part 1]

On the Motions of the Orbs of the Wandering Planets

[1] The motions of these orbs, in their multiplicity, have two divisions: One of them is [the motion] from west to east, and the other [motion] is the opposite. Among the [motions in] the first division are: the motions of the parecliptic orbs, which are equivalent to the motion of the fixed stars. By this motion, all the apogees move, except for the Moon's apogee and Mercury's deferent apogee; the motion of the Sun's eccentric, which is in a nychthemeron 0; 59, 8; and the motions of the deferent orbs, which per day are:

for Venus equivalent to the motion of the Sun's eccentric orb [namely, 0;59,8]

for Mercury double that [i.e. motion of Venus' deferent orb, namely 1;58,16]

for Saturn 0;2

for Jupiter 0; 4,59

for Mars 0;31,27

for the Moon 24;22,53.

[2] Among [the motions in] the second division are: the motion of Mercury's dirigent, which is equivalent to the motion of the Sun's eccentric [orb, namely 0;59,8]; the motion of the Moon's *jawzahr* [nodes], which is 0;3,11 daily; and the motion of the Moon's inclined, which is 11; 9, 7 daily.

[3] As for the epicycle orbs, since they do not enclose the Earth, if the motion in their upper parts[lviii] is in sequence, namely from west to east, then the motion in their lower parts is obviously in counter-sequence, as is [the case] for the epicycles of the vacillating [planets]. If the motion in their upper parts is in counter-sequence, then the motion in their lower parts is in sequence, as is [the case] for the Moon's epicycle. Therefore, the motions of [the epicycles] are not included in these divisions [of the motions]. It is more appropriate to take into account the motions of the upper parts of [the epicycles], and [so] the motion of the Moon's epicycle is deemed to be among the eastward motions. And the motions of the epicycles of the other [planets] will be among the westward motions. The motion of the epicycle is called the proper motion. And each day it is:

for the Moon's epicycle 13;3,54

for each of the superior planets, it is in the amount of the excess of the motion of the Sun's eccentric over the motion of [each superior planet's] deferent

for Venus 0;36,53

for Mercury 3;6,4.

[lviii] their upper parts] the phrase is written as "*aʿlāhā*": γ = it is written as "*aʿlayhā*": α, β.

Chapter 6 [of Part 1]

On What Occurs to the Planets, in 4 Sections

Section 1 [of Chapter 6]

On What Occurs to the Planets in Longitude

[1] The longitude of a planet, also called the true position, is an arc along the zodiacal equator [measured] sequentially between the first of Aries and the location of a [given] planet in longitude. By the location of a planet in longitude, I mean the endpoint of a line extending from the center of the World that ends in the highest orb after passing through the center of the planet, provided that the planet has no latitude. Otherwise, [if the planet has latitude, its location in longitude] is the point at which the latitude circle passing through the endpoint of that [extended] line intersects the zodiacal equator; and [by that location], I mean the closest of the two intersections [of the latitude circle] with the endpoint of the aforementioned line. This line is called the line of the true position [*al-khaṭṭ al-taqwīmī*]. The motion by which the planet traverses this[lix] arc is called the motion of longitude, and also the motion of the true position.

[2] Since each of the wandering planets has various orbs, not all of their motions are uniform about the center of the World, and therefore their motions of true positions differ. In order to derive the true position of each [planet] for anytime they wanted, [astronomers] needed to record precisely the mean positions and equations [of those planets]. For example, the Sun has two orbs. One of them is the parecliptic whose motion is uniform about its center, which is also the center of the World. The other [orb of the

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[lix] this] it is referred to by the feminine demonstrative pronoun (*hādhihi*): β, γ = it is referred to by the masculine demonstrative pronoun (*hādha*): α.

Sun] is the eccentric [one] whose motion is uniform about its center, which is not the center of the World. Thus, [the Sun's] true motion about the center of the World varies.

[3] The Moon has four orbs; the motion of two of [these orbs], namely the *jawzahr* and the inclined [orbs], is uniform about their center, which is the center of the World. Likewise, the motion of the deferent orb is uniform about the center of the World, even if an analogy [with the previous examples] would require its motion to be uniform about its center, which is eccentric to center of the World. However, [astronomers] learned by observation and calculation that the motion of the [Moon's deferent orb] [lx] is uniform about the center of the World, which is among the difficulties in this discipline. However, the motion of the [Moon's] epicycle orb, being uniform about its center[lxi], is not uniform about the center of the World. Consequently, the motion of its true position varies.

[4] Each of the superior planets and Venus has three orbs. One of them is the parecliptic, and its motion is uniform about the center of the World. The second of [those orbs] is the deferent orb, and its motion is not uniform about the center of the World nor about its own center, even if an analogy [with the previous examples would require] it to be uniform about its own center. However, observation and calculation necessitate that the motion of [the deferent orb] be uniform about a point whose distance from the center of the deferent on the side of the apogee is equal to the distance of the deferent orb's center from the center of the World in the same alignment; I mean [this point is] on the line passing through the two centers. This also is among the difficulties in this

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[lx] the motion of the [Moon's deferent orb]] "[Moon's deferent orb]" is referred to by the masculine pronoun (-*hu*): β, γ = it is referred to by the feminine pronoun (-*hā*): α.
[lxi] being uniform about its center] "being" is referred to by the feminine pronoun (-*li-kawnihā*): β, γ = it is referred to by the masculine pronoun (-*li-kawnihi*): α.

discipline.[lxii] The third of [those orbs] is the epicycle; its motion is uniform about its center. Consequently, the motion of their true position varies on account of these two reasons.

[5] Mercury has four orbs. One of them is the parecliptic, and its motion is uniform about the center of the World. The second of them is the dirigent, and its motion is uniform about its own center, which is eccentric to the center of the World. The third of them is the deferent, and its motion is not uniform about its own center, nor about the center of the World, nor about the center of the dirigent, but rather about a point that is at the midpoint of the line that passes through the centers of the dirigent and the World. The distance of [that point] from each of the two [centers] is equal to the distance of the center of the deferent from the center of the dirigent. This point about which the motion of the deferent is uniform in the vacillating planets is called the center of the equant orb, and this also is among the difficulties in this discipline.[lxiii] The fourth [of Mercury's orbs] is the epicycle, and its motion is uniform about its own center, which is not the center of the World. For these reasons, the motion of [Mercury's] true position varies.

[6] It has thus been established that the motions of true position for the wandering [planets] vary. Therefore, in order to derive each planet's true position for anytime they wanted, the scholars of this science were compelled to determine precisely the mean [positions] and equations. The mean [position] for the [planets] other than the Moon is an arc [measured] sequentially along the parecliptic orb between the first of Aries and the endpoint of the line of mean position. For the Moon, [the mean position] is an arc [measured] sequentially along the inclined between the point aligned with the first of Aries and the endpoint of the line of mean position. What is meant by the line of

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[lxii] and this also is among the difficulties in this discipline] β, γ = – α.
[lxiii] and this also is among the difficulties in this discipline] β, γ = – α.

mean position[lxiv] is a line that extends from the center of the World and passes through the center of the epicycle center, if the motion of [the epicycle center] is uniform about its own center, as is [the case] in the Moon. Otherwise, it is a line that extends from the center of the World parallel with the line extending from the point about which the motion of the epicycle center or the planet is uniform that passes through [the epicycle center or the planet], as is the case for the other wandering planets.[lxv]

[7] The motion traversed by the line of the mean position is an arc of the line of the mean position, called as the mean motion. The amount of [this motion] for the Sun and the vacillating [planets], except for Mercury, is the sum of the motions of the parecliptic and eccentric [orbs]. For the Moon, the amount is the excess of the sequential motion of the deferent over the sum of the counter-sequential motions of the *jawzahr* and inclined. For Mercury, the amount is the excess of the sum of the sequential motions of the parecliptic and deferent over the counter-sequential motion of the dirigent.

[8] As for the equations, the Sun has one equation, and it is an arc along the parecliptic between the endpoints of the mean line and true line. As long as the Sun is in the descending half, namely moving from apogee to perigee, the equation is subtractive from the the mean in order to obtain the true [position]. As long as it is in the ascending

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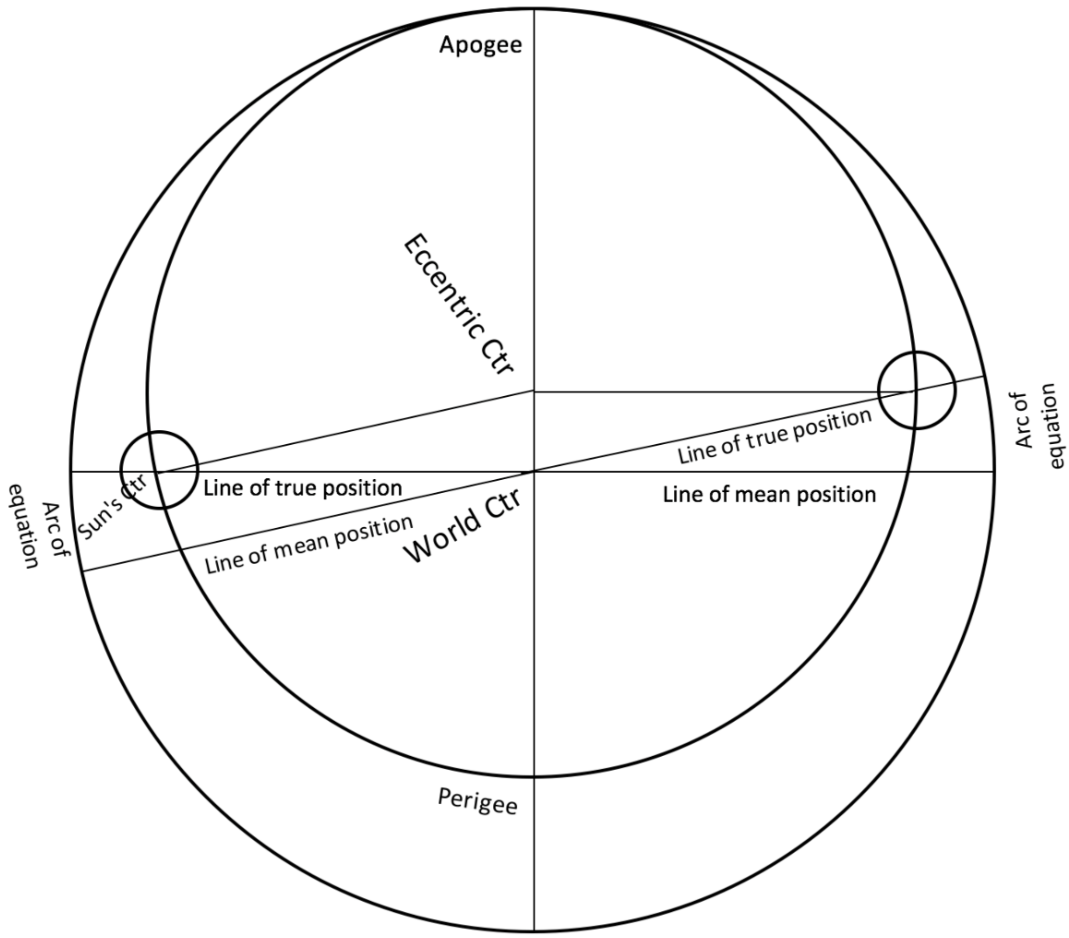
[lxiv] by the line of mean position] β, γ = + in the Moon: α.
[lxv] if the motion of [the epicycle center] is uniform about its own center, as is [the case] in the Moon. Otherwise, it is a line that extends from the center of the World parallel with the line extending from the point about which the motion of the epicycle center or the planet is uniform that passes through [the epicycle center or the planet], as is the case for the other wandering planets] γ = if the motion of [the epicycle center] is uniform about its own center, as is [the case] in the Moon. Otherwise, it is a line that extends from the center of the World parallel with the line extending from the point about which the motion of center of the Sun or the epicyclic center is uniform that passes through [the epicycle center or the planet], as is the case for the other wandering planets: β = and ending at the equator of the inclined orb. And in the Sun, [the line of the mean position] is a line extending from the center of the World parallel with a line extending from the center of the eccentric orb to the center of the Sun. In the vacillating [orbs], it is a line extending from the center of the World parallel with a line extending from the equant center to the epicyclic center: α.

half, the equation is added to the mean [position] in order to obtain the true [position]. By this figure, it is easy to conceive what we have said:

[Illustration of the Sun's Equation]



[Figure 6]

[9] [An equation] comparable to this one is also needed for the vacillating [planets], because the motions of their deferent [orbs] are not uniform about the center of the World. The arc bounded on the parecliptic between the line of the mean position and the line of the adjusting center, which is a line extending from the center of the World passing through the center of the epicycle, is called the third equation. And the

practitioners [of this discipline] have named it[lxvi] the first equation. It is subtractive from the mean [position] in order to obtain the adjusting center, as long as the epicycle center is in the descending half. [By that], I mean [the epicycle center] is in motion from apogee to perigee. As long as [the epicycle center] is in the ascending half, namely it being in motion from perigee to apogee, [the equation] is added to the mean [position] in order to obtain the adjusting center. I mean[lxvii] by the adjusting center an arc [measured] sequentially[lxviii] along the parecliptic between the first of Aries and the endpoint of the line of the adjusting center.

[10] [In the calculation of the third equation], the dirigent's apogee and perigee are considered for Mercury; this equation is not needed for the Moon, because the motion of its deferent is uniform about the center of the World. However, for the Moon and vacillating planets, another equation that originates from the epicycle is needed. The explanation of this is that the position of the line of adjusting center along the parecliptic is known for the Moon simply by knowing its mean [position]. For the vacillating planets, it is known by means of the third equation, as mentioned before. If this line passes through the center of the planet, then we will not need to do work to calculate the true positions of the planets, because this line is the line of the true position on the basis of this assumption. However, this line only passes through the planet's center when the planet is at apparent apex and apparent perigee. What are meant by the apparent apex and apparent perigee are the two intersection points of the aforementioned line with the epicycle's circumference. The farthest of them is the apparent apex and the closest one is the apparent perigee.

[lxvi] named it] "it" is referred to by the feminine pronoun: γ = "it" is referred to by the feminine pronoun: α, β.
[lxvii] I mean] β, γ = the intention: α.
[lxviii] sequentially] β, γ = −α.

[11] As the planet departs from the apparent apex and apparent perigee, the line of the true position separates from the line of the adjusting center, and [therefore those lines start to] enclose an angle at the center of the World. That angle varies in size according to the difference in the distance of the epicycle center from the center of the World. Thus, [astronomers] assumed the epicycle center at the apogee, and derived the amounts of those angles with respect to the center of the planet [moving] little by little along the epicycle equator. [This amount] is called the first equation, and also the independent equation. Then they derived the additions [on the amounts of those angles] with respect to the epicycle center [moving] little by little along the deferent. These additions are called the second equation. They called the sum of [these] two equations the adjusting equation.

[12] When the Moon is in the descending half on [its] epicycle, namely it moves from apex to perigee, the adjusting equation is subtracted from the mean [position]. In the other half, [the adjusting equation] is added to the mean [position] to obtain the true [position]. This is because the upper segment of its epicycle moves counter-sequentially, and the lower segment of its epicycle moves sequentially. When the vacillating planets are in the descending half, the adjusting equation is added to the adjusting center[lxix] to obtain the true [position]. In the other half, it is subtracted from [the adjusting center][lxx] to obtain the true position. This is because the upper segment of the epicycles [of the vacillating planets] moves sequentially, and its lower segment of their [epicycles] moves counter-sequentially. With these two figures, it is easy to conceive what we have said[lxxi]:

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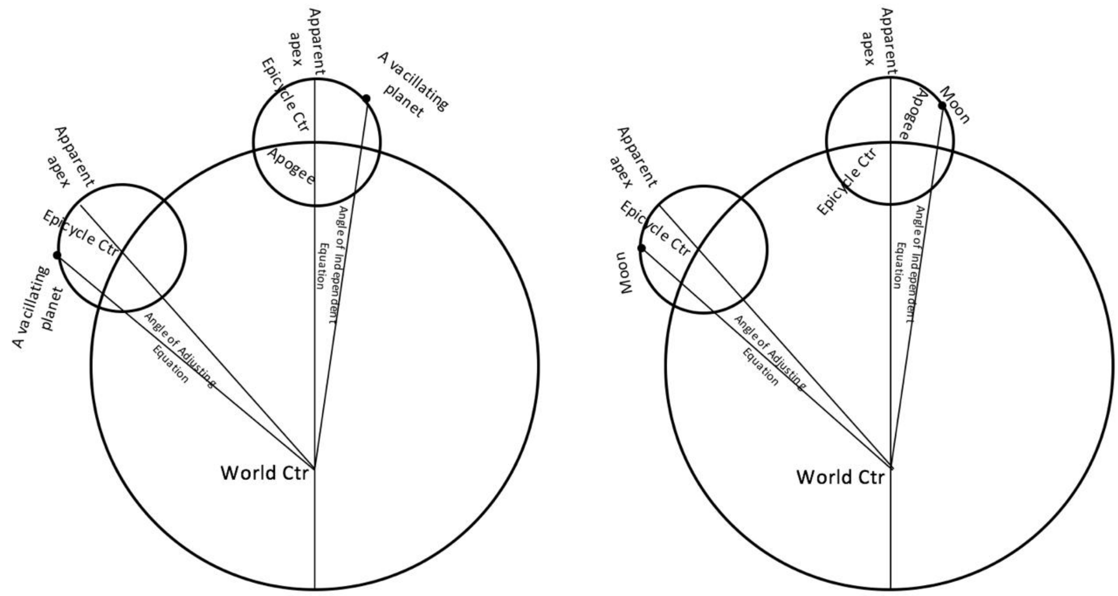
lxix the adjusting center] γ = the mean [position]: α, β.
lxx from [the adjusting center]] γ = from the mean [position]: α, β.
lxxi said] γ = mentioned: α, β.



[Figure 7]

[13] Some [astronomers] deem the vacillating [planets'] epicycle centers to be at the mean distance with respect to [its] distance along the deferent. You will learn the meaning of the mean distance [later]. They derive the size of the angle enclosed by the line of the adjusting center and the line of the true position with respect to [the planet moving] little by little along the epicycle equator in that situation; I mean the epicycle center being at the mean distance. They call this angle the first equation or also the independent equation. Then, they derive the subtractive amount of this angle with respect to the epicycle center being on the side of apogee from the mean distance. [They] also [compute] the added amount with respect to [the epicycle center] being on the side of perigee. They call both the subtraction and addition the second equation. And both the result after addition and the remainder after subtraction are called the adjusting equation. Then, [astronomers] derive by means of the adjusting equation, as we have mentioned earlier, the true [positions] of the vacillating [planets], and this method is the

best known one. However, we preferred the first method in the *Zīj al-Jadīd*, because it is easy to work with.

[14] One should know that when the center of a sphere moves with simple motion along the circumference of a circle, its motion about the center[lxxii] of this circle must be uniform. The distance of [the sphere's center] from [the circle's center] must also be equal. One of the [sphere's] diameters is also aligned with this center, I mean, this circle's center. These three matters must be preserved with respect to the same point. However, observations showed that these three matters diverge for the Moon, such that its epicycle center along its deferent's circumference moves with simple motion [with respect to] three [different] points: the distances [of the epicycle center] with respect to the deferent's center are equal; [its motion] is uniform with respect to the center of the World; and a diameter [of the epicycle] is aligned to the point of alignment, which is a point on the line that passes through the centers of the World and deferent. The distance of [that point] from the center of the World is equal to the distance of the center of the World from the center of the deferent.

[15] In the vacillating [planets], the divergence occurs at two points: the equality of distances [from the epicycle center] with respect to the deferent's center, whereas the motion is uniform and the diameter is aligned with respect to the center of the equant orb. This is also among the difficulties in this discipline. The two endpoints of the [epicycle's] diameter that are aligned, in the vacillating [planets], with the center of the equant orb, and that are aligned, in the Moon, with the point of alignment, are called the mean apex for the farthest of them from the center of the World and the mean perigee for the closest of them from the center of the World. From what we have said, it follows

[lxxii] the center] γ = −α, −β.

that the two apices, and likewise the two perigees, coincide when the epicycle center is at the apogee or perigee. And they are separated [from each other] when they leave [the apogee and perigee].

[16] For this reason, one needs another equation called the third equation in order to find the apparent proper anomaly; I mean [by that anomaly] an arc, along the epicycle equator, bounded between the apparent apex and the center of the planet in the sequence of the motion of epicycle, the motion as a result of which one comes to know the first and second equations. The explanation of this is that the mean proper anomaly, which is an arc along the epicycle equator between the mean apex and the center of the planet in the sequence of the motion of epicycle, is known any time we want; for the motions of the epicycles are known, as mentioned earlier. When we add what is between the two apices to the mean proper anomaly, if the epicycle center is descending, and subtract it from [the mean proper anomaly], if the center of epicycle is ascending, the result after addition or the remainder after subtraction is the amount of the apparent proper anomaly. What is between the two apices is called the third equation. Since what is between the two apices in the vacillating [planets] is the amount between the line of the mean [position] and the line of the adjusting center, there are no additional equations for the vacillating planets over and above the three, as is the case for the Moon.

[17] What occurs to the five vacillating planets in longitude are retrogradation, direct motion, and station. The explanation of this is that when a planet is in the upper [half] of the epicycle, its sequential motion is seen to be faster, since it is seen to be moving sequentially in the total [amount] of two motions, since, as you have learned, the motion of the vacillating planets' deferents are sequential. As you have also learned, the

upper [half] of the vacillating planets' epicycles moves sequentially, and therefore, the planet is seen to be in direct [motion]. When the [planet] moves to the lower [half] of the epicycle – and it has been mentioned that the lower halves of the vacillating planets' epicycles move counter-sequentially – its sequential motion becomes slower. For its [motion] is observed at that time in the amount of the excess of the sequential motion of the deferent over the counter-sequential motion of the epicycle.

[18] As [the epicycle] approaches the perigee, its counter-sequential motion becomes faster, and, therefore, the aforementioned excess decreases and its slowness intensifies. However, as long as the sequential[lxxiii] motion of the deferent is more than the counter-sequential motion of the epicycle, the compound motion is seen in the amount of the aforementioned sequential excess, and the planet remains in direct motion until the counter-sequential motion of the epicycle matches the sequential motion of the deferent. The planet, then, is seen to be stationary until the counter-sequential motion of the epicycle exceeds the sequential motion of the deferent, as a result of which the planet is seen to retrograde. As [the planet] approaches the perigee, [the planet] will be faster in retrogradation until it reaches the perigee, at which it is in the highest speed in retrogradation.

[19] After [the planet] passes through the perigee, it becomes slower in the retrogradation. As it moves away from the perigee, its slowness increases in retrogradation until it becomes stationary for the second time. Then it undergoes a direct motion and becomes faster in [its] direct motion [as it approaches the apex, until it reaches it, at which point it has the highest speed in direct motion; [the planet then] returns to its original situation. What we have mentioned reveals that the planet at its

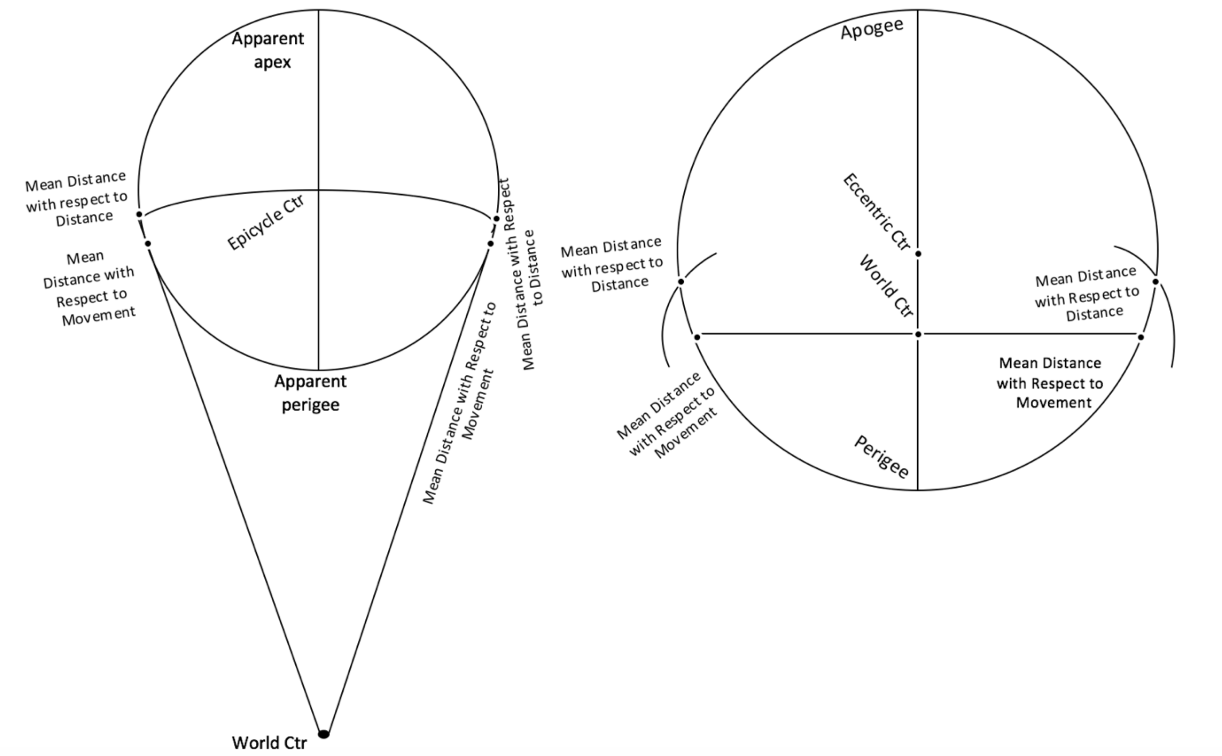
[lxxiii] sequential] γ = −α, −β.

apex on the epicycle will be stationary two times. The first one [occurs] after direct motion and before retrogradation, which is the first station. The other one [occurs] after retrogradation and before direct motion, which is the second station.

[20] What occurs to the seven wandering planets is variation in their situations in ascending, descending, elevation, and depression. The explanation of this is that scholars of this discipline divided each of the deferent and epicycle orbs into four parts called the planetary sectors, two of them being upper and equal, and the [other] two lower and equal. The apogee in the deferent and apex in the epicycle have been agreed upon to be the initial [points] of the first part [sector]. Likewise, their perigees have been agreed upon to be the initial points of the third part [sector].

[21] However, [the scholars' opinions] differ with regard to the initial [points] of the other two [sectors]. Some of them consider distance and determined the initial [points] of the two parts [sectors] such that the distances [of those points] are at the mean between the distant and close distances. And those [points] on the deferent are two intersecting [points] of the [deferent's] equator, with a circle drawn about the center of the World with a distance [equal to] the deferent orb's radius. In the [case] of the epicycle, the two intersecting [points] on the [epicycle equator] are with the deferent's equator. Some of them considered movement and determined the initial [points] of the other two aforementioned sectors where the movement is at the mean between the slow and fast. Those [points] on the deferent are two endpoints of the line extending from the center of the World, being perpendicular to the line passing through the two centers [i.e. centers of the World and deferent orb], and ending in the two directions on the deferent's equator. In the [case] of epicycle, they are two points of tangency of the [epicycle] equator with a line extending from the center of the World.

The planet is descending in the first and second sectors, and ascending in the other sectors. It is elevated in the first and fourth sectors, and depressed in the other sectors. By these two figures, it is easy to conceive what we have stated:



[Figure 8]

[22] We will finish this chapter by stating the amounts of the epicycles' diameters and of the [distances] between the centers. We say that the distance of the eccentric center of the Sun from the center of the World is 2;1,20[lxxiv], given the radius of the eccentric being 60.[lxxv] The distance of the center of the Moon's deferent from the center of the World, given the radius of the inclined being 60, is 10;23. On the basis of those

[lxxiv] 2;1,20] "1" is referred to by the phrase "one minute (*daqīqa wāhida*)": γ = it is referred to by the phrase "a minute (*daqīqa*)": α, β.
[lxxv] given the radius of the eccentric being 60] γ = –α, –β.

parts, the radius of the Moon's epicycle[lxxvi] is 5;12. The distance of the deferent's center from the center of the World is:

for Saturn	3;29
for Jupiter	2;47
for Mars	6;14
for Venus	0;52

[23] As for the distance of the center of Mercury's deferent from the center of the World, it varies, increasing and decreasing from nine to three parts. The explanation of this is that the distance of its deferent from the center of the dirigent is three parts. Likewise, the distance of the dirigent center from the equant center, and the distance of the equant center from the center of the World, each of them, is three parts. However, the dirigent rotates the deferent center around its own center, on a circuit called the circuit of the deferent center. Then, it follows that the deferent center coincides with the equant center once in a rotation,[lxxvii] whereupon its distance from the center of the World will be three parts. [The deferent center] aligns with [the equant center] once more, whereupon its distance from the center of the World will be nine parts. In other remaining situations, it is between three and nine parts. All of these are based upon the radius of that planet's deferent being 60, and on the basis of these parts, the epicycle radius is:

for Saturn	6;51
for Jupiter	11;47

[lxxvi] the radius of the Moon's epicycle] γ = half the Moon's epicycle: α, β.
[lxxvii] in a rotation] β, γ =in a rotation twice (*dawra marratayn*): α.

for Venus	43;10[lxxviii]
for Mars	39;43
for Mercury	22;30.

All of these amounts are based on our observations, some of which concur with previous observations, and some of which are at variance with them.

[lxxviii] 43;10] γ = 43;12: α, β.

Section 2 [of Chapter 6]

On What Occurs to the Planets in Latitude

[1] The Sun has no latitude, since both its parecliptic and eccentric equators are in the plane of the zodiacal equator.

[2] The remaining planets are sometimes north of the zodiacal equator, at other [times] south of it, or on the [the zodiacal equator] itself. For the equators of the deferent orbs intersect the zodiacal orb at two points called the two *jawzahr*s. The one that is the crossing point of the planet toward the north is called the head, and the other the tail; this is [the case] for the Moon and the superior planets. As for the two inferior planets, Venus' head[lxxix] is its crossing point toward the apogee, and Mercury's head is its crossing point toward the perigee. [Their] tails face [their heads].

[3] The circles that occur on the surface of the greatest orb by conceiving the deferent equator intersecting the orbs are called inclined orbs. The maximum value for this inclination is:

for the Moon	5;0 degrees
for Saturn	2 ½ degrees
for Jupiter	1 $^{1}/_{3}$ degrees
for Mars	1;0 degree
for Venus	$^{1}/_{6}$ of a degree
for Mercury	¾ of a degree.

[lxxix] Venus' head] β, γ = + and it is: α.

[4] This inclination is fixed for the Moon and superior planets. As for the inferior planets, it is not fixed. Rather, the inclined orb's plane coincides with the plane of the zodiacal equator when the centers of their epicycles reach the *jawzahr*s. After departing from [the *jawzahr*s], half the inclined orb on which the epicycle center is located is inclined toward the north for Venus, and toward the south for Mercury. This inclination increases until the epicycle center reaches midway between the two nodes, at which the inclination is at its maximum. Then, it decreases until the epicycle center reaches the other node. So, the equator of the inclined coincides with the zodiacal equator for a second time. Then, the half [of the inclined orb] which the epicycle center reaches is inclined toward the north for Venus, and toward the south for Mercury. The [inclination] increases until [the inclination] reaches its maximum at midway between the two nodes. Then, it decreases until the two equators coincide with each other when the epicycle center reaches the first node, and it returns to the initial situation. From what we have stated, it follows that Venus' epicycle center is always north of the zodiacal equator, and Mercury's epicycle center is always south of [the zodiacal equator].

[5] For the Moon, there is no other latitude than this, because the equators of the inclined, deferent and epicycle [orbs] are on the same surface. For the vacillating planets, there is another latitude called the inclination of the apex and perigee. [This inclination] is from the [epicycle] diameter passing through the apex and perigee not being in the plane of the inclined. As for the superior planets, [being in the inclined plane] only occurs when the epicycle center is at either the point of the head or the tail.[lxxx] Then when the epicycle center traverses the head, the apex begins inclining from the plane of the inclined toward the south, and the perigee toward the north. The

[lxxx] the head or the tail] "or" is referred to by the "and (*wa*)": γ = it is referred to by the "or (*aw*)": α, β.

inclination[lxxxi] continues to increase until the epicycle center reaches midway between the two nodes, at which the inclination is at its maximum. Then, the inclination begins to decrease until it vanishes when the epicycle center reaches the tail. There, the diameter passing through the apex and perigee enters into the plane of the inclined. Then, when the epicycle center traverses the tail, the apex begins inclining to the north from the plane of the inclined, and the perigee to the south from it. [The inclination] continues to increase until it attains its maximum, when the epicycle center reaches midway between the two nodes. Then, it continues to decrease until it vanishes when [the epicycle center] reaches the head, and it returns to the initial situation. From what we have stated, it follows that the apex is always away from the inclined, being toward the zodiacal equator; and the perigee is the opposite to this.

[6] As for the inferior planets, [there is an inclination] except when the epicycle center is midway between the nodes, which is the location of the apogee and perigee; and so, at the apogee, the epicycle apex begins inclining toward the north for Venus, and toward the south for Mercury. At the perigee, it is the opposite for them. The inclination attains its maximum at the two nodes. Its increase, decrease, and coincidence occurs according to the [aforementioned] description. And the maximum [value] for this inclination is:

for Saturn	6;0
for Jupiter	2;46
for Mars	2;07
for Venus	2 ½

[lxxxi] the inclination] β, γ = – α.

for Mercury 6 ¼.

[7] The superior planets do not have any other latitude than what has been mentioned. However, the inferior planets particularly have another latitude called the latitude of the slope [*wirāb*], the slant [*inḥirāf*], the twist [*iltiwāʾ*], and the winding [*iltifāf*]. It is that the diameter passing through the two mean distances — I mean the diameter that intersects, at right angles, the diameter passing through the apex and perigee — is not in the plane of the zodiacal equator nor in the inclined orb, except when the epicycle center reaches either the point of the head or tail, and when the inclined coincides with the zodiacal equator. If [that] point is the head, then the evening endpoint of that diameter begins to incline toward the north, and the morning endpoint toward the south. The inclination continues to increase until it attains its maximum midway between the two points [nodes], which is the apogee for Venus and the perigee for Mercury. Then, it decreases until it vanishes when the epicycle center reaches the tail, whereupon the diameter passing through the two mean distances coincides with the plane of the inclined. Then, when the epicycle center traverses the tail, the evening endpoint of that diameter begins to incline toward the south, and the morning [endpoint] toward the north, until it attains its maximum midway between the two points [nodes]. Then, it decreases until it vanishes when the epicycle center reaches the head for a second time, and it returns to the initial situation. The maximum [value] for this inclination is 3 ½ for Venus, and 7;0 for Mercury.

[8] Let us complete this section by stating the positions of the apogees and *jawzahr*s that are moved by the motion [of the orb] of the fixed stars. We say that in the beginning of Muḥarram, 841 years after the migration of the Prophet (peace and prayers be upon him), the date on which we composed *al-Zīj al-Jadīd*, [the apogee were at]:

for the Sun	Cancer 2;26
for Saturn	Sagittarius 16;56
for Jupiter	Virgo 29;32
for Mars	Leo 21;57
for Venus	Gemini 22;25
for Mercury	Scorpio 4;28.

[9] As for the [positions] of the *jawzahr*s, Saturn's head is 3 degrees beyond its apogee; Jupiter's head is 82 degrees in advance of its apogee; Mars' head is 49 degrees in advance of its apogee; Venus' head is 90 degrees in advance of its apogee; Mercury's head is 90 degrees beyond its apogee. All of these are on the basis of our observations.

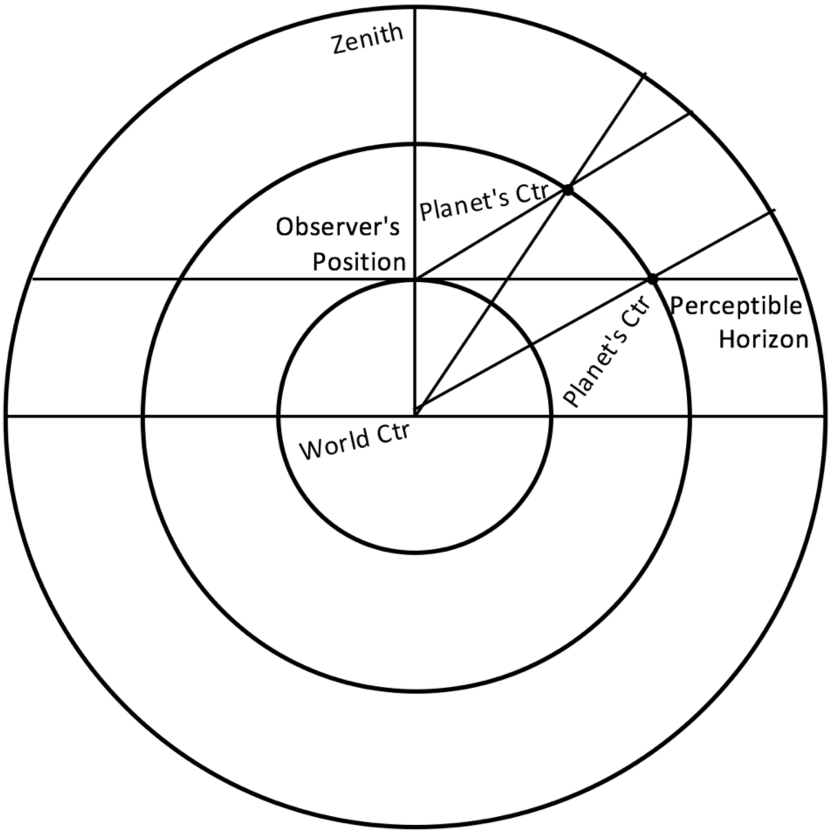
Section 3 [of Chapter 6]

On What Occurs to the Planets in Longitude and Latitude Together

[1] There may occur to the planets near the Earth, especially for the Moon, a difference between their true and apparent positions.[lxxxii] What is meant by the true position is the endpoint of a line extending from the center of the World, passing through the center of the planet, and terminating on the surface of the greatest orb. What is meant by the apparent position is the endpoint of a line extending from the center of the World, being parallel with the line extending from the perspective of sight to the center of the planet[lxxxiii], and terminating on the greatest orb. If the planet is at the zenith, the aforementioned lines coincide. When it leaves the zenith, the two aforementioned lines diverge, and there occurs an angle between them, called the angle of parallax. The arc bounded between them along the altitude circle is called the arc of parallax. And this is its illustration:

[lxxxii] their true and apparent positions] γ = its true and apparent position: α, β.
[lxxxiii] to the center of the planet] β, γ = – α.

[Illustration of Parallax]



[Figure 9]

[2] As the planet gets closer to the perceptible horizon, the parallax increases. The [parallax] value [attains] its maximum when [the planet] is on the perceptible horizon. The arc bounded on the altitude circle between the true horizon and [the planet's] true position is its true altitude. The [arc] bounded between the [true horizon] and its apparent position is its apparent altitude, and the apparent altitude will always be less than the true altitude. When two circles of latitude pass through the true and apparent positions of the planet, and if those circles coincide, this only being the case when the planet is on the ecliptic meridian circle, [in this case], there is no divergence in

longitude for the planet, and the parallax is precisely the divergence of latitude. The planet is sometimes on the zodiacal equator itself when [the planet] passes through the zenith at which time, its parallax will be exactly the divergence of longitude, and there will be no latitude and divergence of it for that planet.

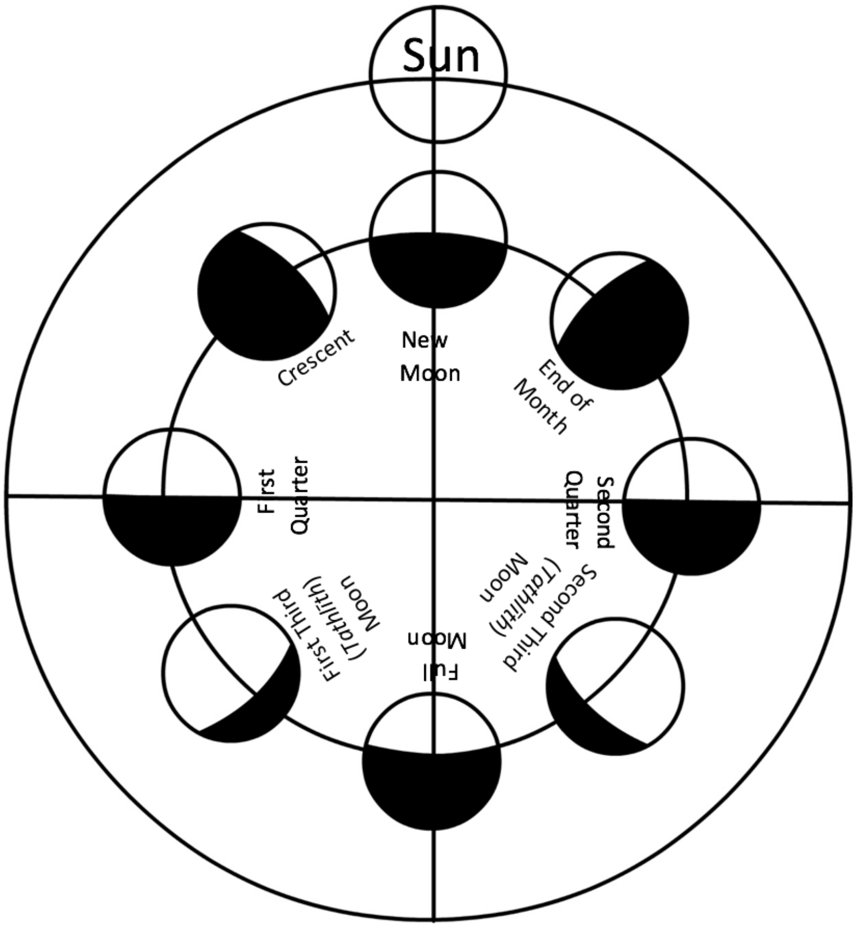
[3] Other than these two situations, two circles of latitude, passing through the true and apparent positions, will intersect at the two zodiacal poles. They intersect the zodiacal equator at two other points and what is bounded between [those points] on the zodiacal equator will be the divergence of longitude. However, their true and apparent latitudes might be the same; so, in this situation, there will be no divergence of latitude for the [planet].

Section 4 [of Chapter 6]

On What Occurs to the Planets in their Relative Positions to One Another[lxxxiv]

[1] The explanation of the variation in the Moon's illumination, being full or partial, is [as such]: The Moon is a smooth body that receives light from the Sun, and since it is spherical and smaller than the Sun, a little more than half of it[lxxxv] will be illuminated. Thus, approximately[lxxxvi] half of it facing toward the Sun will always be illuminated, and the other half always dark. At conjunction, its half facing toward us will be dark, and that [situation] is the new Moon. Then, when it moves away from [the Sun] by nearly 12 degrees, its luminous half will incline toward us, and, therefore, we see an edge of it, which is the crescent. And as its distance from the [Sun] increases, the inclination of the luminous half toward us increases. Then, its light increases until when it is in opposition, we come to be between the [Sun and Moon], and that which faces the [Sun] faces us, which is the full Moon. When it departs from being in opposition, some of its dark half inclines toward us. Then, the darkness begins to increase and [the light] decreases until it is effaced for a second time. This [repeats itself] continuously. If there is anything[lxxxvii] obscure to you, then resort to this figure:

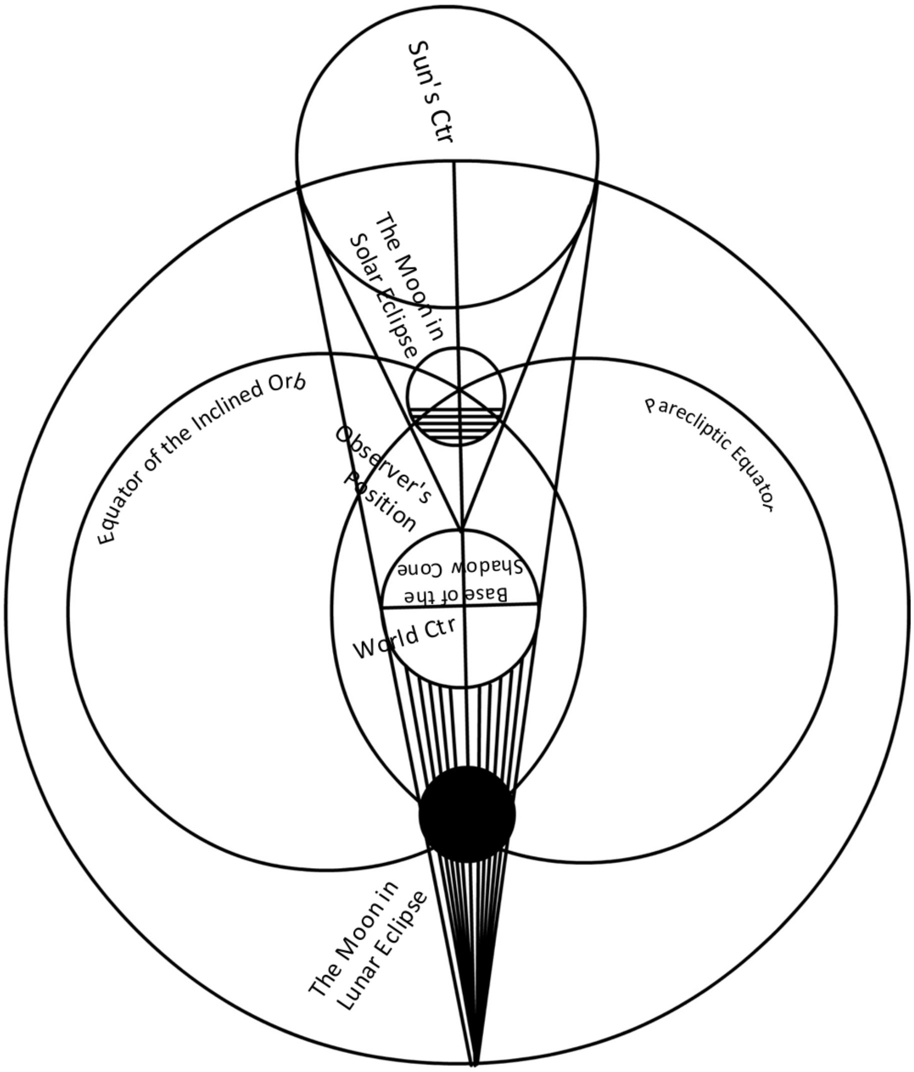
[lxxxiv] their relative positions to one another] "their" is referred to by the pronoun (-*hā*): γ = it is referred to by the dual pronoun (-*humā*): α, β.
[lxxxv] a little more than half of it] β, γ = its half, even a little more than its half: α.
[lxxxvi] approximately] β, γ = –α.
[lxxxvii] anything] β, γ = –α.



[Figure 10]

[2] Consequently, when the Moon is in conjunction or around it on the Sun's path —and that [occurs] at the head or tail or around them— the Moon interposes between the [Sun] and us, concealing its light from us fully or partially, which is a solar eclipse. The blackness that appears in the [Sun] is the color of the Moon. And for this reason, the Sun's blackness and likewise its reappearance begin from the western side. When the [Moon] is in opposition on the path of the Sun, the Earth interposes between the two, and the Sun's light does not reach the [Moon]. Therefore, the Moon remains in its

original darkness, which is a lunar eclipse. Its eclipse[lxxxviii] and reappearance begin from the eastern side, because the [Moon] catches up with the Earth's shadow from the western side. Thus, [the Moon's] eastern edge arrives first into the shadow. Likewise, the eastern edge passes through the shadow first. Then the reappearance begins from [the eastern edge].



[Figure 11]

lxxxviii its eclipse] γ = a lunar eclipse: α, β.

[3] Among what occurs to the Moon with respect to the Sun is that [the Sun] is in the middle between the [Moon's] apogee and epicycle center. The explanation of this is that after the Sun, the Moon's apogee and epicycle center are in conjunction at a part of the zodiacal orb — for instance, let it happen in the first of Aries— the epicycle center will move every day due to the motion of the deferent 24;22, and the inclined, together with the *jawzahr*, move the apogee counter-sequentially every day 11;12 [and therefore] they return the epicycle center back by this amount. So, the distance of the epicycle center from the Sun remains 13;10. Then since the Sun moves by [the amount of] 0;59, the distance of [the Sun][lxxxix] from each of the Moon's apogee and epicycle center will be 12;11.[xc] For this reason, the motion of the deferent is called the double elongation, namely twice the distance of the epicycle center from the Sun.[xci] From what we have stated, it follows that the epicycle center will always be at the apogee, when [there occurs] conjunction or opposition, and at the perigee, when [there occurs] quadrature. [From what we have explained, it also follows] that the epicycle center reaches the apogee and perigee twice every month.

[4] Similar to this middle positioning [*tawassuṭ*] is what occurs to the apogee of Mercury's dirigent with its epicycle center and deferent's apogee. This is so because after its epicycle center is in conjunction with the apogee of [its deferent] at a part of the zodiacal orb — for instance, let it be the first of Aries— the epicycle center will then move sequentially by the motion of [Mercury's] deferent by an amount of twice the motion of the Sun's center, and the dirigent moves counter-sequentially the deferent's apogee by an amount of the motion of the center of the Sun; [therefore] the epicycle center also turns back by this amount. Then the distance of the dirigent's apogee from

[lxxxix] the distance of [the Sun]] γ = "the Sun" is explicitly written: α, β.
[xc] 12;11] the word "minute" is included after the value: γ = it is not included: α, β.
[xci] the Sun] β, γ = the apogee: α.

each of its deferent's apogee and epicycle center will be by the amount of the center of the Sun. From what we have stated, it follows that Mercury's epicycle center reaches each of the deferent's apogee and perigee twice between the time of its departure from the dirigent's apogee until returning to it.

[5] Among what occurs to the vacillating planets with respect to the Sun: As for the superior planets, [the case] is that the distance of their centers from the apices of their epicycles is equal to the distance of their epicycle centers from the center of the Sun. The combusts for the superior planets will always occur at the apex, when they are midway through the direct motion, whereas their oppositions at the [epicyclic] perigee will occur midway through the retrograde motion. For this reason, Mars in the combust is more distant from the Sun than it is in the opposition, because, as demonstrated in studies of distances and bodies, the diameter of Mars' epicycle is much bigger than the diameter of the Sun's parecliptic with the [addition] of the thickness of the complementary body of Mars.

[6] [Among what occurs to the vacillating planets with respect to the Sun]: As for the two inferior planets, [the case] is that the two centers of their epicycles will be always aligned with the center of the Sun. They distance[xcii] themselves from [the center of the Sun] only by the amount of what is required by the epicycle radius. This is well known among practitioners [in this discipline], and it is an obvious statement. The verification is that their mean [motions] are consistent and will never waver from that consistency.

[xcii] distance] the verb is in singular form: γ = it is in dual form: α, β.

The Second Part

On an Explanation of the Configuration of the Earth and Its Division[xciii] *into Climes; An Explanation of [the Consequences] Accruing to it*[xciv] *Due to the Positions of the Celestial Bodies*

Ten Chapters

Chapter 1 [of Part 2]

An Explanation of the Configuration of the Earth[xcv] and Its Division into Climes

[1] The Earth is spherical in form, and its sphericity is established on a strange case, which is [as follows]: If it were possible to travel around the entire Earth and three individuals were assumed to split apart from a single location, such that one of them travelled towards the west, the other towards the east, and the third stayed in place until the westward traveler returned to him from the east and the eastward traveler returned to him from the west, both at the same time, then the [number] of days counted by the westward [traveler] during the period of the circuit would be one fewer than the [number] of days [counted] by the stationary person. The [number] of days [counted by the eastward [traveler] would be more than [the number of days counted by the stationary person], also by one day. [Other] strange matters would result from it, as, for instance, it may be asked: Is it[xcvi] possible that the same day is Friday for one individual, Thursday for another, and Saturday for the third person, and so forth along these lines? It is answered positively and [so] is found to be strange.

[xciii] its division] "its" is referred to by the feminine pronoun: β, γ = "its" is referred to by the masculine pronoun: α.
[xciv] accruing to it] "its" is referred to by the feminine pronoun: β, γ = "its" is referred to by the masculine pronoun: α.
[xcv] the configuration of the Earth] γ = + and its latitude and longitude: α, β.
[xcvi] is it] β, γ = −α.

[2] Three circles are assumed[xcvii] on the [Earth]. One of them is in the plane of the equinoctial, and it is the equator. The second [circle] is in the plane of the equator's horizon; and the third is in the plane of the meridian circle. Both of [the last two circles] are in the middle of the inhabited land through the equator. The first [circle] divides the Earth into southern and northern halves. The second [circle] bisects each of[xcviii] the two aforementioned halves, so the Earth becomes quartered through [these two circles], two southern quarters and two northern quarters. The inhabited of them is one of the northern quarters, and it is well-known as the populated quarter. However, not all of that quarter is inhabited, but the latitude of the inhabited part is $66^1/_2$ degrees[xcix] and its longitude is 180 degrees; the beginning [of its longitude] is from the Maghrib, according to the Greeks. However, some of [the Greeks] take it to be from the coast of the Western Ocean and some of them from islands called the Eternal Islands and Fortunate Islands, whose distance from the coast is 10 degrees. [The islands] were inhabited in the past, but now are submerged. The third [circle] cuts the inhabited land into western and eastern halves, and the intersection point between the first and third circles is called cupola of the Earth.

[3] [The people of this discipline] divided most of the inhabited land[c] in the populated quarter. [This divided part] is beyond 10 degrees in latitude up to the boundary of 50 [degrees]. Some of them divided all the inhabited region into seven tambourine-like, longitudinal sections parallel to the equator and called climes. Each clime is enclosed by the two halves of parallel circuits and by two arcs of the horizon of the cupola [of the Earth]. The amount of [the two arcs] is small, and it should be the

[xcvii] three circles are assumed] γ = we assume three circles: α, β.
[xcviii] each of] β, γ = both: α.
[xcix] degrees] β, γ = – α.
[c] the inhabited land] the word is in the feminine form (*al-maʿmura*): γ = it is in the masculine form (*al-maʿmur*): α, β.

amount of the difference of half an hour in length[s] of longest daylight. The initial and midpoints of the climes and [their] longest periods of daylight are as follows: As for the first [clime], according to the majority, its beginning is where its longest day is (12 + ½ + ¼) hours and its latitude is $12^{2}/_{3}$ degrees; according to some, [it starts] from the equator. Its midpoint, by consensus, is where the day is 13 hours[ci] and the latitude is (16+ ½ + $^{1}/_{8}$). The beginning of the second [clime] is where the day is 13¼ hours and the latitude is (20+ ¼ + $^{1}/_{5}$) degrees.[cii] The beginning of the third [clime] is where the day is (13+ ½+ ¼) hours and the latitude is 27½. The beginning of the fourth [clime] is where the day is 14¼ hours and the latitude is (33 + ½ + $^{1}/_{8}$). The beginning of the fifth [clime] is where the day is (14 + ½ + ¼) hours and the latitude is 39 minus $^{1}/_{10}$. The beginning of the sixth [clime] is where the day is 15¼ hours and the latitude is (43 + ¼ + $^{1}/_{8}$). The beginning of the seventh [clime] is where the day is (15 + ½ + ¼), and the latitude is $47^{1}/_{5}$ and its midpoint, by consensus, is where the day is 16 hours. The latitude is (48 + ½ + ¼ + $^{1}/_{8}$), and its endpoint is, according to the majority, where the day is 16¼ hours and the latitude is $50^{1}/_{3}$. According to some, the designation of the furthest limit for the inhabited region has already been settled. The end of each clime, except for [the seventh one], is the beginning of the one that comes after it. It is obvious that once the latitudes of the initial points, midpoints and endpoints of the climes are known, it is easy to [know], from that locality's latitude, the clime in which that locality is [located]. And if one were to include information about [the locality's] longitude, [it is easy] to determine its position [in the clime]. Once this principle is [accepted], there is no need to list the localities in each clime, as has been done conventionally.

[ci] hours] γ = degrees: α, β.
[cii] degrees] γ = −α, −β.

Chapter 2 [of Part 2]

On the Characteristics of the Equator

[1] The equinoctial passes through the zenith of each locality on the equator, and its poles are on the horizon of [those localities]. The equatorial horizons separate all the day-circuits into visible and invisible halves, and, therefore, days and nights are equal for [those horizons]. All the stars rise and set at [the equatorial horizons], and the zodiacal equator passes through their zeniths twice in a nychthemeron: once, when the first of Aries reaches the zenith, and another, when the first of Libra reaches it. In [these] two situations, the zodiacal poles are on the horizon. **During the passage of the northern half of the** [zodiacal] **equator across the meridian, the southern of the two** zodiacal **poles is visible; during the passage of the southern half, the northern is visible. The altitude [of each pole] does not exceed the magnitude of the obliquity**.[2] The seasons of a year are eight: two summers whose beginnings are when the Sun reaches the two equinoxes; two winters whose beginnings are when [the Sun] reaches the two solstices; two springs whose beginnings are when [the Sun] reaches the middles of Leo and Aquarius; and two falls whose beginnings are when [the Sun] reaches the middles of Taurus and Scorpio. The turning of the orb is wheel-like there, and therefore their horizons are called the horizons of the right orb.

[2] The grand master Abū ʿAlī Ibn Sīnā judged [the localities on the equator] to be the most temperate ones. The most erudite Imām Fakhr al-Dīn al-Rāzī—may God be pleased with him—judged the most temperate localities to be the [ones] in the fourth clime. In this [matter], the judicious sage Naṣīr al-Dīn al-Ṭūsī—may his innermost being be sanctified—said that the truth in this [matter] is that if **one means by temperate a uniformity in the conditions, then there is no doubt that it is so at the equator** […]

But if one means by it a balancing of the two [extreme] weather conditions, I mean moderation between hot and cold, **then there is no doubt that the equator is not this way**, for it is **indicated by the extreme blackness in color of its inhabitants** and by **the extreme frizziness of their hair, and other things that are brought about by the heat of the air**.[3] The abundance of reproduction and propagation and the abundance of habitations in the fourth clime, as well as its inhabitants being the most excellent of people in creation and [in their] disposition indicate that the [fourth clime's] climate is the most temperate one.

Chapter 3 [of Part 2]

On the Characteristics of the Oblique Horizons in a General Manner

[1] **For every location that is neither beneath the equinoctial nor beneath one of its poles**,[4] **the turning of the orb there is slanted**.[5] Its horizon is called the oblique horizon and it has five divisions: first, the [horizon] whose latitude is less than the total obliquity; second, the one whose latitude is equal to the total obliquity; third, the one whose latitude is more than the total obliquity and less than its complement; fourth, the one whose latitude is equal to the complement [of the total obliquity]; and fifth, the one whose latitude is more than the complement of the [total] obliquity and less than 90. One of the equinoctial poles is above these horizons in the amount of the local latitude; the other [equinoctial point] is below them in the same amount. [These horizons] bisect the equinoctial; therefore, when the Sun reaches one of the equinoxes, day and night is equal in all of these horizons. They divide the day-circuits into two unequal parts: the largest of them is the visible part that is on the side of the visible pole; the invisible [part] is on the side of the invisible pole. However, [for the day-circuits] whose distance[s] from [the equinoctial] are no less than the complement of the local latitude, [these horizons][ciii] do not cut divide them; rather the ones on the side of the visible pole are always visible, and the ones on the side of the invisible pole are invisible. The horizon is tangent to [those day-circuits] whose distance [from the equinoctial] is equal to the complement of the local latitude from above if [they] are in the direction of the visible pole; and from below if [they] are in the direction of the invisible pole.

[ciii] [these horizons]] the phrase is referred to by the feminine pronoun: γ = it is referred to by the masculine pronoun: α, β.

[2] [Regarding] any two day-circuits with equidistant from either side of the equinoctial, the visible part of one of them is equal to the invisible part of the other. [As for] any two day-circuits on the same side of the equinoctial, when [those day-circuits] are on the side of the visible pole, the visible [part] of the one closer to [the equinoctial] is smaller, i.e. has fewer degrees than the visible [part] of the one more distant to it. When they are on the side of the invisible pole, [the situation] is reversed. For this reason, for the horizon that intersects the two solstice circuits, the longest day is the solstice day that is on the side of the visible pole. Each circuit whose distance is more than the local latitude on the side of either the invisible or visible pole does not intersect the prime vertical above the horizon. [The circuit] whose distance on the side of the visible pole is equal to the local latitude is tangent to the prime vertical at the zenith and does not intersect it. [The circuit] whose distance on the [same] side is less than the local latitude intersects [the prime vertical] at the eastern and western points at which the star has zero azimuth.

Chapter 4 [of Part 2]

On the Characteristics of Each of the Five Divisions for the Oblique Horizons

[1] As for the first division, each circuit whose distance from the equinoctial in the direction of the visible pole is equal to the local latitude divides the zodiacal equator into two unequal parts at two points equidistant from the equinoctial. When the Sun reaches [these points], there is no shadow for the people at noon on that day, and, in this situation, the zodiacal poles are on the horizon. As long as the Sun is on the arc between the two points on the side of the visible pole, which is the shortest of the two parts, the Sun passes beyond the zenith on the side of the visible pole and the noon shadow falls toward the side of the invisible pole. As long as [the Sun is on] the other arc, which is the longest of the two parts, [the Sun] passes on the side of the invisible pole[civ] from the zenith and the shadow falls toward the side of the visible pole. The zodiacal poles have a rising and a setting; then as long as the first arc transits the meridian, the zodiacal pole that is on the side of the visible pole will be below the Earth, and the other pole above it. As long as the other arc transits through it, the zodiacal pole that is on the side of the visible pole will be above the Earth, and the other pole below it. The minimum altitude of the Sun has two limits: one of them is on the side of the visible pole, which is larger; the other is on the side of the invisible pole, which is smaller.

[2] As for the second division, the solstice circuit which is in the direction of the visible pole passes over the zenith, and the other solstice circuit passes through the nadir. The minimum altitude of the Sun has one limit; it is the amount of twice the total obliquity. The maximum [altitude] reaches ninety. The [noon] shadow is always on the side of the visible pole, except for the time when the Sun reaches the visible solstice, as

[civ] pole] $\gamma = -\alpha, -\beta$.

there is no shadow of a person at noon on that day. The zodiacal pole that is on the side of the visible pole is permanently visible, and the other pole is permanently invisible. They touch the horizon; the visible one does not set, and the invisible one does not rise.

[3] As for the third division, the Sun[cv] has two altitudes: a highest one, and it is the amount of the total of the complement of the local latitude and the total obliquity; and a lowest one, and it is the amount of the excess of the complement of the local altitude over the total obliquity. The visible zodiacal poles have two altitudes: a highest one [occurring] when the invisible solstice reaches the meridian; and a lowest one [occurring] when the visible solstice reaches the meridian.

[4] As for the fourth division, the visible solstice circuit is the largest permanently visible circuit, and the invisible solstice circuit is the largest of the permanently invisible circuits. Once in a revolution, the two solstices reach the horizon, the visible zodiacal pole [reaches] the zenith, the invisible [zodiacal pole reaches] the nadir, and the zodiacal equator coincides with the horizon. **Then when the pole departs from the zenith** […], **the eastern half of the** [zodiacal] **equator rises in one stroke from the horizon**." I mean **the half that the vernal equinox is in the middle of if the visible pole is northerly, or the autumnal if it is southerly**.[6] And the other half of the [zodiacal] equator drops in one stroke from the horizon. Then the half that has risen sets point by point[cvi] in all parts of the western half of the horizon, and the half that has dropped rises point by point in all parts of the eastern half of the horizon during the period of a nychthemeron **until the position of the orb returns to** the initial condition. **[The maximum for] each of the ortive amplitude and the equation of daylight will there be a quarter revolution. Daylight will increase until the measure of the**

[cv] the Sun] the conjunction "*fa-*" is attached to the word: γ = the conjuction is missing: α, β.
[cvi] point by point] β, γ = −α.

nychthemeron becomes entirely daylight; night will thereafter occur, increasing until the measure of the nychthemeron becomes entirely night.[7] This is according to a gross reflection (*naẓar*). Through a [more] subtle reflection, [one can conclude that] daylight may reach the measure of two revolutions of the equinoctial; likewise, it is possible that night reaches that measure. The maximum [value] for the Sun's altitude is the amount of twice the total obliquity on the side of the invisible pole. The inhabited part [of the Earth] ends on northern side with these horizons.

[5] As for the fifth division, in it the largest of the permanently[cvii] visible circuits intersects the zodiacal equator at two points, whose declinations on the side of the visible pole are equal to the complement of the local latitude. Likewise, the largest of the permanently invisible circuits intersects the zodiacal equator at two points, whose declinations are equal. The zodiacal equator is divided into four arcs by these four points. One of them is permanently visible at whose midpoint is the visible solstice; when the Sun is at [this point], daylight is the longest. Another [point] is permanently invisible at whose midpoint is the invisible solstice; when the Sun is at [this point], night is the longest. The endpoints of the first arc touch the horizon but do not set, and the endpoints of the other arc touch the horizon and do not rise. As for[cviii] the remaining two arcs, the one that has the first of Aries at its midpoint rises in reverse order and sets in regular order when the northern pole is visible. When the southern pole is visible, it rises in regular order and sets in reverse order. The one that has the first of Libra at its midpoint is the opposite in rising and setting. The visible solstice in these horizons has two altitudes: a highest one and it is the amount of the sum of the total obliquity and the complement of the local latitude in the direction of the invisible pole from the zenith;

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cvii permanently] β, γ = –α.

cviii as for] the conjunction "*wa*-" is attached to the conjunction "*ammā*": β, γ = the conjunction "*wa*-" is missing: α.

and a lowest one and it is the amount of the excess of the total obliquity over the complement of the local latitude in the direction of the visible pole from the zenith. The visible zodiacal pole and visible solstice will be on the meridian simultaneously, but in opposite directions from the zenith and **their altitudes are at opposite [extremes]**.[8]

Chapter 5 [of Part 2]

On the Characteristics of Locations Whose Latitude is One-Quarter Revolution

[1] "This does not occur on the Earth except at two points at which one of the poles of the equinoctial is [...] at the zenith," and other is at the nadir. "The equinoctial circle becomes coincident with the horizon," and there the orb turns in a spinning manner. "Thus the half of the orb that is in the direction of the visible pole from the equinoctial is permanently visible, and the other half is permanently invisible."

[2] **As long as the Sun is in the visible half of the** zodiacal orb, **it will be daytime; and as long as it is in the invisible half of it, it will be night. Thus its [the Sun's] entire year will be a nychthemeron [lit. a day with its night]**, and the amount of one over the other **due to the variability in speed [lit., the slowness and fastness] of the [Sun's] motion. Beneath the northern pole at this time**, the period of daytime is longer than [that of] night by nine of our nychthemerons. This is [the case] because the apogee of the Sun is at the beginning part of Cancer and its perigee is at the beginning part of Capricorn. The period for dawn and dusk will be 50 of our days. **The maximum altitude of the Sun and its maximum depression is in the amount of the maximum declination [i.e. the obliquity].**[9] The rising of the Sun and planets, and likewise their setting, which are due to the secondary motion, do not occur from and at the same places on[cix] the horizon.

[3] **The periods of visibility and invisibility** for the fixed stars **will vary depending on how far or how near** their day-circuit of latitude[cx] is from the zodiacal orb. The planet whose latitude is equal to the total obliquity **touches the horizon once**

[cix] the same places on] β, γ = the same place in: α.
[cx] how far or how near their day-circuit of latitude] In "near" the "day-circuit" is referred to by the masculine pronoun: γ = it is referred to by the feminine pronoun: α, β.

during one revolution of the second motion. Neither it nor the one **whose latitude exceeds the obliquity will have a rising or a setting, but instead they will be either permanently visible or invisible**.[10]

Chapter 6 [of Part 2]

On the Nychthemerons, Their Daytime and Nighttime Parts, Equal and Unequal Hours, and Dawn and Dusk

[1] When the Sun is above the Earth, [the Earth's] face that is on our side[cxi] is illuminated, and its shadow occurs opposite of our direction[cxii]; this is daytime. When [the Sun] is below the Earth, this side becomes dark since its shadow occurs[cxiii] above [the Earth]; this is night. According to the convention of the jurists, daytime begins with the rising of the true dawn; according to the convention of the practitioners of the stars [*al-munajjimīn*], as well as the Persians and Byzantines [*Rūm*], [it begins] with the rising of the Sun. Night starts, according to the convention of all of them, with the setting of the Sun. However, the people of the Divine Law (*sharīʿa*) say that this is [the case] **if its setting is visible, like in deserts. But if it is not visible, like in the middle of mountains or populated areas, [it can be determined] by the fact that no ray stays at the top of walls or mountain peaks, and the darkness** [...] **proceed**s **from the eastern side**.[11]

[2] Since the Sun is bigger than the Earth, more than [the latter's] half is illuminated, and [its] illuminated and dark [parts] are separated by a small circle on the surface of the Earth. The [Earth's] shadow will be in the shape of a circular cone, whose base is that small separating [circle], narrowing gradually until it ends at the orbs of Venus. **When the Sun approaches the eastern horizon, the [Earth's] shadow cone inclines toward the west. Then of the rays surrounding it, what is visible first is that which is the nearest the eye**.[12] What is nearest [to the eye] is the spot to which

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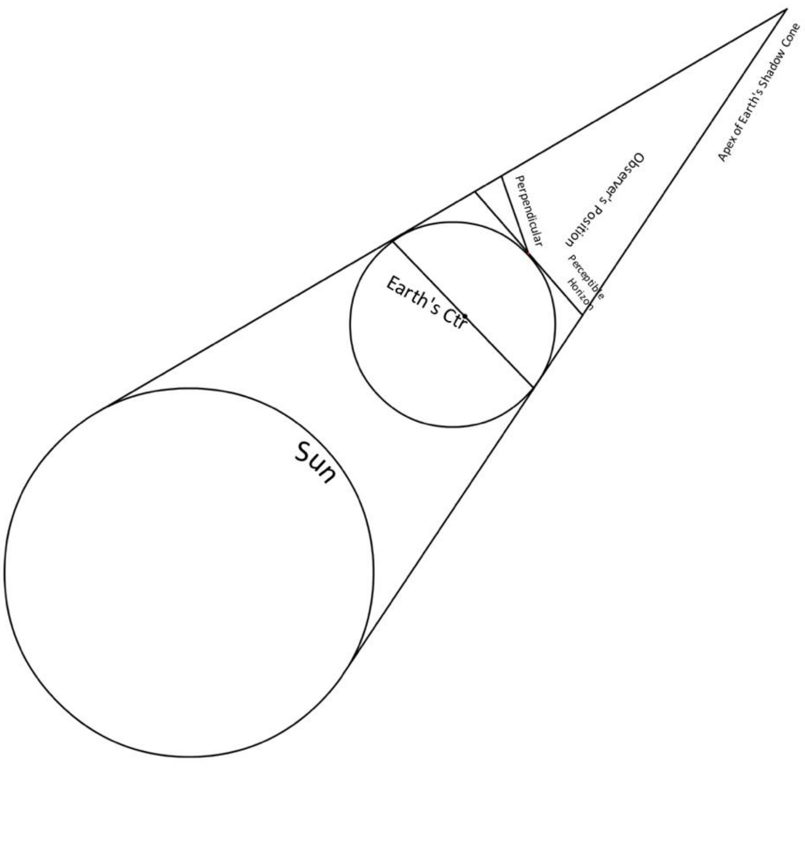
[cxi] that is on our side] β, γ = that faces the Sun: α.
[cxii] our direction] β, γ = the Sun's direction: α.
[cxiii] since its shadow occurs] β, γ = its shadow occurs: α.

the perpendicular extends from the eye, not the place of its intersection with the horizon, since **the latter is longer than the perpendicular due to its being the subtense of a right [angle] and the perpendicular being the subtense of an acute [angle].**[13] For when we imagine a plane passing through the centers of the Sun and Earth, as well as through the cone's sagitta, a triangle occurs. The angle of [the triangle] that is between the horizon and its side toward the Sun is acute. **Therefore the first observed light of the Sun is seen above the** horizon **as a straight line that falls on the above side, but what is near the horizon is still dark. For this reason, that light is called** the false dawn. **For it to be believed that it is truly the light of the Sun, then [one would expect that] what is illuminated should be toward the Sun**,[14] I mean around the horizon, rather than what is above [the horizon]. This is an illustration of the triangle, the horizon, the perpendicular, and the Sun:



[Figure 12]

[3] **Then when the Sun comes quite near** the horizon, **the light will spread; the horizon will then become lighted and the dawn will be true. Dusk will be the reverse of dawn. It has become known by trial and error that the depression of the Sun below the horizon at the first rising of dawn and the final setting of dusk is 18** degrees.[15]

[4] A nychthemeron, according to the practitioners of the stars, is equivalent to the period from the Sun's departure from a half of the meridian, bounded by the poles of the World, to its return to the [same half]. [This period] is longer than the revolution of the equinoctial by the co-ascension of [the path] the Sun traverses in the period from departure to return. Since the Sun's speed varies [due to its being on an eccentric] and on the assumption of equal [speed] its co-ascension varies, **the lengths of the nychthemerons will [also] be variable** [...] **However, the variation [in the nychthemerons] is imperceptible in one or two days due to the smallness of the difference; one perceives it over many days.**[16] **The calculators, being obliged to use nychthemerons of equal size in order to find the mean** [motion of the Sun] and to compile [astronomical] tables, **have taken the above increase to be in the amount of the mean motion of the Sun** [...] **They named those days that were taken to be equal the mean days**.[17] The days taken in the first manner are the true days, and the difference between the true and mean days is called the equation of days [i.e. the equation of time].

[5] [A nychthemeron], according to the Arabs and most of the practitioners of the Divine Law, is from [the first] setting of the Sun to another, since their months start with the crescent, [namely] its visibility after setting. According to some, [a nychthemeron] is from [the first] rising of the Sun to another. Furthermore, the practitioners of the stars

divided both the true and mean days into 24 equal parts, and called them the equal or average hours. [They also] divided both the night and daytime into 12 equal parts and called them the unequal [lit. distorted] or seasonal [lit. temporal] hours.

Chapter 7 [of Part 2]

On the Months, Years, and Epochs

[1] **Since the most known of the celestial bodies are the two luminaries, most of the nations considered** their **revolution [...] in their convention of months and years.**[18] Thus, they rendered the period [between] the departure of the Sun from a certain point, for instance from the first of Aries, and its return to [the same point], one year; [they also rendered] the period [between] the departure of the Moon from a certain position that occurs [with respect to] the Sun, for instance the crescent, and its return to the [same position], one month. Since the period of 12 revolutions of the Moon is close to the period of one solar revolution, some rendered 12 months as one year; they called this [period] the lunar year, and [the former one] the solar year. Also, since the period of the Moon's single revolution is close to the period of the Sun's motion in one zodiacal sign, some rendered the Sun's motion in one zodiac as one month, and named this [period] a solar month, and [the former one] a lunar month. So, both the year and month are solar and lunar. Each of [these divisions] is either the true [division] in which the true motions of the two luminous planets are considered, or the conventional [division] in which the number of days and months is considered, and therefore the divisions will be eight. Each division has been adopted by [a certain] group.

[2] As for the epoch [*taʾrīkh*], it is an expression for the designation of a [certain] day during which a famous event occurred, such as [the emergence] of a nation or a dynasty, or an exceptional [event] like a storm or earthquake, and their like. [This designation is made] in order to know [the time that has passed] between [that day] and the occurrence of [later] events, and what is required to determine one's time [with

respect to] the beginning of a time-period [i.e. epoch]. Among the well-known epochs in our time are:

[3] The Byzantine [*Rūm*] epoch: Its years are conventional solar, being 365 days and a quarter day. Likewise, their months are conventional solar. **The details of the names of their months and the number of their days are as follows**[19]: Tishrīn al-Awwal, 31 [days]; Tishrīn al-Ākhir, 30; Kānūn al-Awwal, 31; Kānūn al-Ākhir, 31; Shubāṭ, 28; Ādhār, 31; Nīsān, 30; Ayyār, 31; Ḥazīrān, 30; Tammūz, 31; Āb, 31; and Aylūl, 30. Then, [the people using this epoch] extract one extra day in four years by accumulating the quarter days, and add [that day] to the days to Shubāṭ, and so they render its days 29. They call this [year] a leap year. The beginning of this epoch is a Monday, 12 solar years after the death of Alexander son of Philip [Fīlqūs] of the *Rūm* [*al-Rūmī*], who took over the seven climes.

[4] The Hijra epoch: [Used] among the Arabs and those unskilled in the calculation of the motions of the two luminaries, its years are true lunar. Likewise, its months are [true lunar]. Since the beginnings [of its months] are from the visibility [of the crescent], and the period of a month is [the time that passes] between two [consecutive] crescents, a month does not exceed 30 days; the maximum [number of such] consecutive [months] will be four. It will not be less than 29 days, and the maximum [number of such] consecutive [months] will be three. The practitioners of the stars (*al-munajjimun*) consider Muḥarram 30 [days], and Ṣafar 29 [days], and likewise they consider one month 30 [days] and the [next] 29 [days] until the end of the year. In every thirty years, they take Dhū al-Ḥijja to be 30 [days] 11 times, which are [as follows]: the second, fifth, seventh, tenth, thirteenth, fifteenth, eighteenth, twenty-first, twenty-fourth, twenty-sixth, and twenty-ninth years; [these numbers] are designated by a

[combination of the alphanumericals]: (*bahaz yajhaḥ aduwṭ*). According to consideration of the practitioners of the stars, its years, and likewise its months, are conventional lunar. The names of its months are 12. As they are of extremely well-known, there is no need of mentioning [them]. The first [day] of this epoch is **a Thursday, based on the average [synodic period]**,[20] a Friday based on the visibility [of the crescent]. [The epoch] began with the Muḥarram of the year in which our Prophet—blessings and peace be upon him—emigrated from Mecca to Medina.

[5] The Persian epoch: Its years are conventional solar, and they are 365 days. Their 12 months are likewise: Farvardīn, Urdībihisht, Khurdādh, Tīr, Murdād, Shahrīvar, Mihr, Ābān, Ādhar, Day, Bahman, Isfandārmadh.[cxiv] Since [each of these months] is 30 [days], the additional 5 [days] are called the stolen five or supplementary five [days]. Some [who use this epoch] consider [these five days] to be at the end of the month Ābān. The practitioners of the stars consider them to be at the end of the month Isfandārmadh, in order to prevent variation in the number of days in the pages of calendars. **Because the years and months of this** epoch **are free from fractions**,[21] the practitioners of the stars used it more than others. Most of the *zīj*es that have come down to us are based on [this epoch], indeed all of them except for the Z*īj al-Muʿtabar.* The beginning of this calendar is Tuesday, and it is the first day of the year in which Yazdajird son of Shahryār, the last of the emperors of Persia, started to rule.

[cxiv] Isfandārmadh] γ = + and likewise its months: α, β.

Chapter 8 [of Part 2]

On Co-ascensions of the Arcs along the Zodiacal Orb

[1] At the equator's horizon, [the co-ascension] is enclosed between two declination circles, one of which is their [own] horizon. At oblique horizons, [the co-ascension] is [enclosed] between the horizon circle, and the great circle that passes through the first of the arc in question and that is tangent to the greatest permanently visible [day-circle]. At the equator, each quarter along the zodiacal orb that is bounded by two of the four equinox or solstice points rises with a quarter along the equinoctial. Thus, co-ascension and ascendant are not equivalent, except for the [case already] mentioned. In oblique horizons, each half along the ecliptic that is bounded by the two equinox points rises with a half of the equinoctial. However, in the [localities] with latitudes less than the total obliquity, it sometimes occurs that the local latitude and the local ecliptic latitude will be equivalent with alternative directions in latitude, and thus, the co-ascension and rising arc will be equivalent, each of them being less than the half.

Chapter 9 [of Part 2]

On the Degrees of Transit of the Stars on the Meridian and on Their Degrees of Rising and Setting

[1] When a line extends from the center of the World to the center of the star and terminates on the surface of the greatest orb, if it happens to terminate on the zodiacal equator itself, then its endpoint is the star's degree and and its location. Otherwise, the closest of the two intersections of the latitudinal [circle] that passes through the endpoint [of that line] is the star's degree. The part along the zodiacal orb that [transits] with the endpoint of the aforementioned line in the half of the declination circle bounded by the two poles[cxv] of the World that passes through [that endpoint] is the degree of transit of the star. It will be same as the star's degree, if the star has no latitude, or it has latitude [but] is at one of the solstice points. [In this case, the degree of transit of the star] will not be located between the zodiacal and World poles; for if it were located between them, the degree of transit of the star would be facing [the star's] degree. [If the case is] other than what we have mentioned, the degree of transit of the star will be another point, not [the star's] degree. What is between them [i.e. the degree of transit of the star and the star's degree] along the zodiacal equator is called the transit difference. The arc along the equinoctial that is between half the aforementioned declination [circle] and half the latitudinal circle and bounded by the zodiacal poles that passes through the endpoint of the aforementioned line[cxvi] is called the equation of the

[cxv] by the two poles] β, γ = between the two poles: α.
[cxvi] The arc along the equinoctial that is between half the aforementioned declination [circle] and half the latitudinal circle and bounded by the zodiacal poles that passes through the endpoint of the aforementioned line] β, γ = what is between the circles of the star's declination and of its latitude: α.

degree of transit. The sequential [arc] along the equinoctial between the first of Aries and this half of the declination circle is called the co-ascension of transit of the star.[cxvii]

[2] If the star's degree is from somewhere between the winter solstice to the summer solstice, and if its latitude is in the direction of the visible pole of the two poles of the World[cxviii], [the star] transits the meridian before its degree. It transits [the meridian] after its degree if [its latitude] is in the direction of the other pole. If its degree is on the other half of the zodiacal orb, namely being from somewhere between the winter solstice to the summer solstice, and if its latitude[cxix] is in the direction of the visible pole of the two poles of the World, it transits the meridian after its degree. [It transits the meridian] before its degree if its latitude is in the direction of the invisible pole.

[3] As for the degree of rising and setting of a star, it is the part of the zodiacal equator that rises and sets with [the star]. At the [horizons] of the equator, **the rising and setting of the stars are [...] similar to their transit across the meridian for the rest of the horizons**[22]; I mean[cxx], when the star's degree is one of the solstitial points[cxxi] and the star is not between the poles[cxxii], then the star rises and sets with its degree.[cxxiii] When[cxxiv] the star's degree is from the winter to the summer solstitial points[cxxv], and if its

[cxvii] The sequential [arc] along the equinoctial between the first of Aries and this half of the [declination] circle is called the co-ascension of transit of the star] β, γ = –α.
[cxviii] of the two poles of the World] β, γ = –α.
[cxix] its latitude] γ = –β = its degree: α.
[cxx] the rising and setting of the stars are [...] similar to their transit across the meridian for the rest of the horizons; I mean] γ = –α, –β.
[cxxi] the solstitial points] β, γ = + in a locality whose latitude is less than the total obliquity, when the star's degree is one of the points that pass through the locality's zenith, the zodiacal equator is divided by them into two arcs, one big and the other small; and in [a locality] whose latitude is equal to the total obliquity when the star's degree is the summer solstitial point: α.
[cxxii] and the star is not between the poles] γ = –α, –β.
[cxxiii] with its degree] β, γ = + and at the equator: α.
[cxxiv] When] the conjunction "-*wa*" is attached to the word: β, γ = the conjunction "-*wa*" is missing: α.

latitude is in the direction of the visible pole of the two poles of the World, then the star rises and sets before its degree[cxxvi]. It rises and sets after its degree[cxxvii], if[cxxviii] [its latitude] is in the direction of the invisible pole.[cxxix] When[cxxx] the [star's degree] is in the other half of the zodiacal equator, namely its degree being from the summer to the winter solstitial points[cxxxi], the star rises and sets after its degree[cxxxii] if the star's latitude[cxxxiii] is on the side of the visible of the poles of the World. It rises and sets before its degree[cxxxiv] if [its latitude] is on the side of the invisible pole. In a locality with a latitude[cxxxv] more than the total obliquity, and if [its latitude] is on the side of the visible of the poles of the World, then the star rises before its degree and sets after it. [The case] is the opposite if [the latitude] is on the other side, namely [the star] rises after its degree and sets before it.

[4] In [a locality] whose latitude is equal to the total obliquity, when the star's degree is the autumnal equinox, the star rises with its degree, no matter on which side its latitude is. It sets after [its latitude] if [the star] is on the side of the visible pole, and before it if it is on the other side. If its degree is the vernal equinox, then the star sets with its degree, no matter on which side its latitude is; it rises before [its degree] if [the

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cxxv to the summer solstitial points]: β, γ = + and in a [locality] whose latitude is less than [the total obliquity] when the star is on the greater arc; and in a [locality] whose latitude is equal to the total obliquity when the star is not at the summer solstitial point; and in [a locality] whose latitude is more than the total obliquity, absolutely: α.

cxxvi sets before its degree] γ = before its degree and sets after it: α, β.

cxxvii sets after its degree] γ = after its degree and sets before it: α, β.

cxxviii if] the conditional "*idhā*" is used: β, γ = the conditional "*in*" is used: α.

cxxix the invisible pole] β, γ = + and at the equator: α.

cxxx When] the conjunction "-*wa*" is attached to the word: γ = the conjunction "-*wa*" is missing: α, β.

cxxxi the winter solstitial points] β, γ = + and in [a locality] whose latitude is less than the total obliquity, when the star is on the smaller arc: α.

cxxxii sets after its degree] γ = after its degree and sets before it: β = before its degree and sets before it: α.

cxxxiii the star's latitude] γ = the star: α, β.

cxxxiv sets before its degree] γ = before its degree and sets after it: α, β.

cxxxv in a locality with a latitude] γ = in [a locality] whose latitude: β = –α.

star] is on the side of the visible pole, and after it if the [star] is on the other side. If the star's degree is a part of the zodiacal equator other than what we have mentioned, then the rule [for the localities whose latitude is equal to the total obliquity] is what we have stated for those [localities] whose latitude is more than the total obliquity.

[5] At a locality whose latitude is less than the total obliquity, when the star's degree is one of the two endpoints[cxxxvi] of the arc which is equal to the shortest of the two parts along the zodiacal equator —[those] parts that are obtained from the two points passing through the zenith—and whose midpoint is the vernal equinox[cxxxvii], the star sets with its degree and rises before it. If the star's degree is one of the two [points] facing these two endpoints[cxxxviii], the star rises with its degree and sets after it. If the star's degree is a part of this arc, then the star rises and sets before its degree. If the star's degree is one facing a part of this arc, then the star rises and sets after its degree. If the star's degree is another part of the zodiacal equator, not one we have already mentioned, the star rises before its degree and sets after it. All of these are [as stated] if the star's latitude is on the side of the visible of the poles of the World. If [the star's] latitude is on the side of the invisible of [the poles of the World] and the star's degree is one of the two endpoints[cxxxix] of the aforementioned arc, then the star sets with its degree and rises after it. If the star's degree is one of the [points] facing these two endpoints[cxl], then the star rises with its degree and sets before it. If the star's degree is one of the parts of this arc, then the star rises and sets after its degree. If the star's degree is one facing one of the parts of this arc, then the star rises and sets before its

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[cxxxvi] one of the two endpoints] γ = the beginning: β = –α.
[cxxxvii] the vernal equinox] γ = + I mean its anterior endpoint is rising: β = –α.
[cxxxviii] one of the two [points] facing these two endpoints] γ = the [part] facing the end of this arc: β = –α.
[cxxxix] one of the two endpoints] γ = the beginning: β = –α.
[cxl] one of the [points] facing these two endpoints] γ = the [part] facing the end of this arc: β = –α.

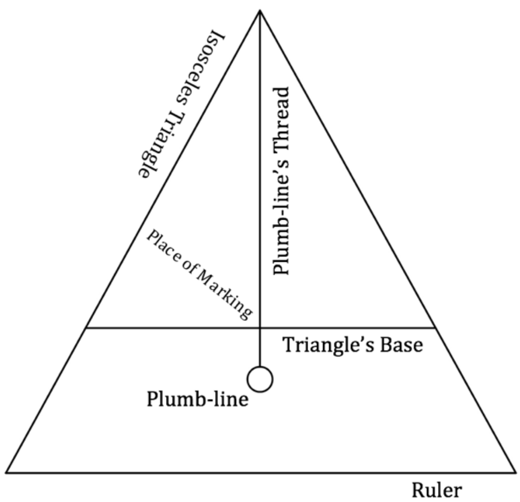
degree. If the star's degree is another part of the zodiacal equator, not one we have already mentioned, then the star rises after its degree and sets before it. In such a locality, it sometimes occurs to the stars close to the pole, i.e. those whose latitudes are more than the complement of the second declination of its degree, that they will rise along with the part facing their degree where [before] we stated that they would set with their degree and they will set along with the part facing their degree where [before] we stated that they would rise with their degree, being the opposite of what we stated [previously]. This is a very subtle and precious [matter].[cxli]

[cxli] more than the total obliquity, and if [its latitude] is on the side of the visible of the poles of the World, then the star rises before its degree and sets after it (…) In such a locality, it sometimes occurs to the stars close to the pole, i.e. those whose latitudes are more than the complement of the second declination of its degree, that they will rise along with the part facing their degree where [before] we stated that they would set with their degree and they will set along with the part facing their degree where [before] we stated that they would rise with their degree, being the opposite of what we stated [previously]. This is a very subtle and precious [matter]] β, γ = – α.

Chapter 10 [of Part 2]

On Obtaining the Meridian Line and Finding the Prayer[cxlii] Times and the *Qibla* Bearing

[1] [In doing these], we need a level surface. In order to obtain it, we take a leveled ruler with utmost correctness. We mount on it an isosceles triangle whose base is parallel with this ruler. We put a mark on the midpoint of its base. Then we hang, from the head corner of the triangle, a plumb-line whose thread is in contact with this mark. If the ruler is rotated on the surface, touching it throughout the rotation with no light is seen between [the ruler and surface] and the plumb-line's thread does not depart from this mark, then [it means that] the surface is level and coincident with the horizon. Then we inscribe on [the surface] a circle that is smaller than [the surface's] margin to indicate the shadow's entrance into and departure from [the surface], and take a cone whose height is such that its shadow falls short of the circumference [of the circle] at noon, and exceeds it on both sides [of noon].



[Figure 13]

[cxlii] prayer] β, γ = prayers: α.

[2] Then, we draw on the circle's center [another] circle that is as big as the base of the gnomon or a bit larger than it, in such a way that if [the base] were placed on [that circle], then [the circle] would coincide with it or encompass [the base] in parallel with it. Then we bisect the width of the shadow upon its entering and departing [the aforementioned larger circle], and then [bisect] the arc between these two midpoints or [the arc's] chord.[cxliii] Then, we connect the center and the middle of the arc or the chord[cxliv] with a straight line; this then is the meridian line. The line passing through the center of the circle that is perpendicular to the meridian line is the east-west line and the equinox line. These two lines divide the circle into fourths. We then divide each fourth into 90 [equal parts]; this circle is known as the Indian. You should know that the most appropriate time to take the shadow [measurement] is [when] the Sun is in [one of] the solstice [points] or close to it — the summer [solstice][cxlv] is better— and when [the Sun's] altitude is in the measure of two spears.

[3] As for determining the prayer times, you should know that everybody agrees that the *ẓuhr* prayer is after noon even if it is one minute. It is determined through the inclination of the shadow towards the east from the meridian line, if [the meridian line] has been derived. Otherwise, [it is known] with the occurrence of [a shadow] if there is no [shadow] at noon; or if there is a continuing [shadow at noon], [it is known through] an increase in [the shadow] over what was [at noon] even if by a little bit. This continuing [shadow] is named the noon shadow (*fayʾ*). The beginning of the *ʿaṣr* prayer, according to al-Shāfiʿī and the community of Ḥijāz, is when [shadow] occurs or increases over the noon shadow by the length of the gnomon, or, according to Abū Ḥanīfa and the community of ʿIrāq, by two times [its length]. The beginning of the *maghrib* prayer is

[cxliii] or [the arc's] chord] β, γ = –α.
[cxliv] or the chord] β, γ = –α.
[cxlv] the summer [solstice]] β, γ = and the summer [solstice]: α.

determined through the setting of the [Sun], if [the setting] is seen, or through the darkness drawing near from the East, if [the setting] is not seen. The beginning of the *ʿishāʾ* prayer is [determined] through the setting of dusk, which is the redness according to al-Shāfiʿī, and whiteness according to Abū Ḥanīfa, may God be pleased with them. The beginning of the *ṣubḥ* prayer time is [determined] through the rising of true dawn.

[4] As for the *qibla* bearing, it is the intersection point of a locality's horizon and the azimuthal [circle] passing through the zeniths of Mecca and the locality. [The line] connecting [the intersection point] and the center of the horizon is the line of the *qibla* bearing. As for the [*qibla*] bearing from the locality named as the arc of the slant, it is an arc along the horizon between its intersection [point] with the aforementioned azimuthal [circle] and one of the four points, namely north, south, east, and west. In order to determine the two [*qibla*] bearings, one must know the longitude and latitude of the locality and Mecca's longitude, which is 77 degrees[cxlvi] and 10 minutes from the the [Eternal] Islands, and [Mecca's] latitude, which is 21 degrees and 40 minutes.

[5] Then we say: The easiest location with respect to the *qibla* [bearing] is the one that aligns with Mecca, as the *qibla* bearing is not assigned there, but rather "Wheresoever you turn, there is the Face of God."[23] The most difficult location is the one whose latitude is 90, since determining east, west, south, and north is not possible there. One can determine the [*qibla*] bearing there by observing celestial events such as eclipses. For locations other than these two, we say: A locality coincides with Mecca in longitude or not. If it is the first [case], then the *qibla* bearing is the south point if the [locality's] latitude[cxlvii] is more northerly than [the latitude of Mecca]; otherwise, [the

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[cxlvi] 77 degrees] β, γ = 67 degrees: α.
[cxlvii] [locality's] latitude] the "latitude" is referred to by the masculine pronoun "-*hu*": β, γ = it is referred to by the feminine pronoun "-*hā*": α.

qibla bearing] is the north point. If it is the second [case], when the longitude difference between [Mecca and the locality] is 180 degrees, the *qibla* bearing is the south[cxlviii] point if [the locality's] latitude is more southerly; otherwise, [the *qibla* bearing] is to the north[cxlix] point.

[6] In other locations than what has been mentioned, we measure [two points] along the [circumference] of the Indian circle, being east to each of the south and north points [of the Indian circle] by the amount of the difference between the two longitudes, if Mecca's longitude is more [than that of the locality]; it is west of [the south and north points] if [Mecca's longitude is] less. Then we connect [these] endpoints. If the difference [between Mecca's and the locality's longitudes] is 90 [degrees], we extend a line parallel to the meridian line from the east point for the first case [i.e. Mecca's latitude is more], and from the west point for the second case. If [the longitude difference] is more than 90, then we take the supplement to 180 of the difference between the longitudes instead of the difference between the longitudes. [We measure two points along the circumference of the Indian circle] from the east and west points in the amount of the difference between the two latitudes[cl], to the south if the latitude of Mecca is less, to the north if it is more. Then we connect [these] two endpoints. If there is no difference in latitude, then we take the east-west line in place of the connected line.[cli] Of course, these two extended lines intersect, and the line connecting from the center [of the Indian

[cxlviii] south] β, γ = north: α.
[cxlix] north] β, γ = south: α.
[cl] in the amount of the difference between the two latitudes] γ = –α, –β.
[cli] If there is no difference in latitude, then we take the east-west line in place of the connected line] γ = –α, –β.

circle] and their intersection point is the *qibla* bearing line. This method [for the *qibla*-bearing] is approximate; we presented it[clii] on account of its being well-known.

[7] Another method [for the *qibla* bearing] is as follows: we convert the difference between the longitudes into hours and their fractions such that we calculate each 15 degrees of the difference between the longitudes to be one hour, and each degree [of longitude] to be four minutes of the minutes of hours. And each [such] minute [of longitude] will be four seconds of the seconds of the hours, and so forth. We observe on the day the Sun arrives at a part of the zodiacal equator whose declination is equal to the latitude of Mecca, May God the Exalted honor it, which is the eighth [degree] of Gemini or 23rd [degree] of Cancer.[cliii] Then, on that day, the direction of the shadow is taken using a gnomon at a time that is after[cliv] noon of that day by the amount of those hours and their fractions that have been converted from the difference between the longitudes if the longitude of Mecca is less than that of the locality. [The shadow is taken] before[clv] noon by the aforementioned amount if the longitude of Mecca is more. Then, a line is extended in that direction [of the shadow] until it cuts the Indian circle. The intersection point is the point of [the *qibla* bearing]; I mean, the intersection point that is in the opposite direction of the shadow.

[8] It is clear that this method is not useful in a case when the converted hours are more than the hours [until] noon of that day, since the Sun is below the horizon at that time, and it will be not possible to record the direction of the shadow at this time. [In such a case] the method is that one observes the arrival of the Sun at the part [of the ecliptic] opposite the part passing through the zenith of Mecca, which is the 8th of

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[clii] we presented it] β, γ = we presented: α.
[cliii] which is the eighth [degree] of Gemini or 23rd [degree] of Cancer] γ = –α, – β.
[cliv] after] γ = before: α, β.
[clv] before] γ = after: α, β.

Sagittarius or the 23rd of Capricorn. Then the direction of shadow is recorded on that day by the amount of the aforementioned hours before midnight, for what we said above was before noon, and after midnight, for what we said above was after noon. [Then], the *qibla* bearing is the intersection point that is in the direction of the shadow.[clvi]

[clvi] I mean, the intersection point that is in the opposite direction of the shadow (...) [Then], the *qibla* bearing is the intersection point that is in the direction of the shadow] $\gamma = -\alpha, -\beta$.

The Third Part

On Finding the Measurements of the Distances and the Bodies

Comprising an Introduction and Six Chapters

Introduction

Concerning That Which is Needed by Way of Introduction before Undertaking [Our] Objectives

[1] They are 10 preliminary propositions: First: The circumference of every circle is $3^1/_7$ times its diameter. Thus, when the result of the multiplication of the diameter by 22 is divided into seven, its circumference is obtained. When the result of the multiplication of its circumference by seven is divided by 22, its diameter is obtained.

[2] Second: The area (*taksīr*) of every circle is equal to a surface that is enclosed by its radius times its half circumference.

[3] Third: The surface [area] of every sphere is equal to what is enclosed by its diameter times the [circumference] of the largest circle occurring on [the surface]. Thus, it is said that [that surface] is four times the [area of the] largest circle occurring on it.

[4] Fourth: The magnitude [i.e. volume, *ʿuzm*] of every sphere is equal to a body obtained by multiplying its radius by one-third of its surface area.

[5] Fifth: Every portion [lune] of a sphere's surface enclosed by the halves of two great circles is equal to a surface enclosed by the diameter times the maximum inclination between [the circles].

[6] Sixth: The surface area of a complete segment of a sphere, be it half [the total surface], less or more, is equal to a circle whose radius is equal to a line extending from the pole of the base to its circumference.[clvii]

[7] Seventh: If four quantities are proportional and three of them are known, then it is possible to extrapolate the fourth unknown one; its method is [as such]: We divide the area [i.e. the multiplication] of the two extremes by one of the means if the unknown is a mean. Or [we divide] the area of the two means over one of the extremes if the unknown is an extreme. The result of the division is the quantity of the unknown.

[8] Eighth: It is among the subdivisions of the seventh [propositions], called the conversion of quantities (*radd al-maqādir*) from one unit to another. It is [as such]: If we know the ratio of one unit to another—[as] they are on the basis of the ratio between [whatever their] numbers are, and let us name the number of every unit as its magnitude[clviii]— and if [we also] know the quantity of one of the units or its parts, and we want to know exactly the number of this quantity in terms of another unit or its parts, then we multiply the number of the known quantities or parts by the magnitude[clix] of the first unit and then divide the result by the number of the second unit. As a result, the number of the units or parts sought-after is obtained. Another type of conversion is [as such]: In the case where a unit or part of it measures two quantities and another [unit] or a part of it measures only one of them, —and let us name it the first [known quantity]—it will necessarily measure the second [quantity]. As for how much it calculates it, it can be known through the seventh [proposition above], since the ratio of what is in the first quantity in terms of the number of units to the second quantity in

[clvii] its circumference] γ = the circumference of the base: α, β.
[clviii] and let us name the number of every unit as its magnitude] γ = –α, –β.
[clix] magnitude] γ = number: α, β.

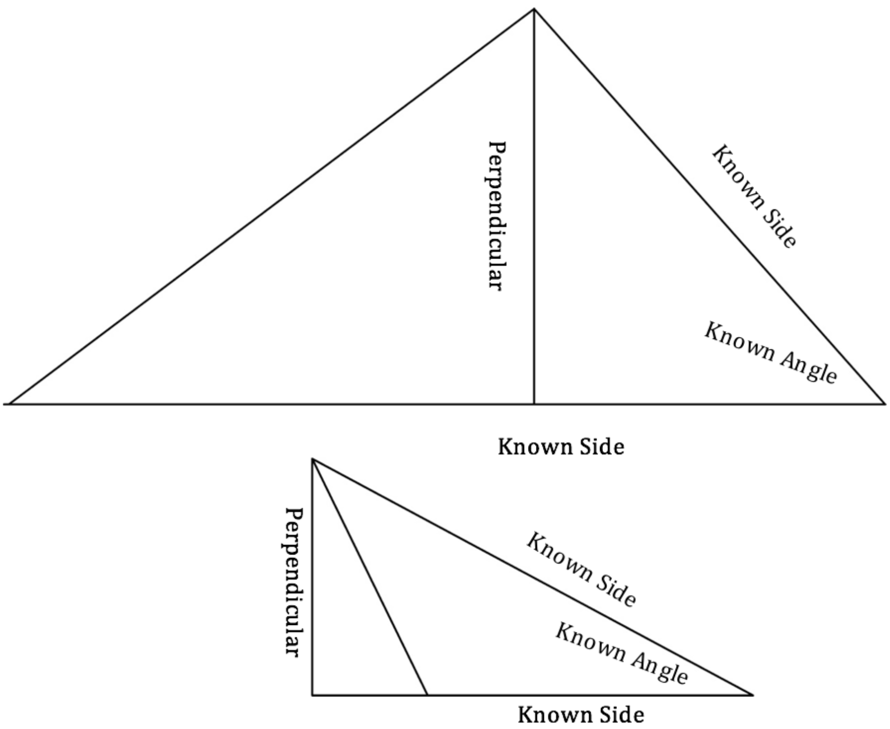
terms of the number [of units] is as the ratio of what is in the first in terms of the number of [other units] to what is in the second in terms of its number, which is the fourth unknown. Then If we multiply the second [quantity] in terms of the number of units in what is in the first in terms of the other number [of units] and then the result is divided by the first quantity in terms of the number of other units, the second quantity in the other unit is found.[clx]

[9] Ninth: If one marks on one of the legs of an isosceles triangle two points that, along with the base [of the triangle] form two equal lines [by dividing the leg], and two lines parallel to the base are extended from those points, then the total [amount of the lengths] of the base and upper line is equal to twice the [length] of the middle line.

[10] Tenth: For seeking to find the unknown [quantity] of a triangle's sides or angles, you should know that the quantity of the angle [formed by] two straight lines is the quantity of the arc that is subtended when the angle is formed at the center of a circle. The sides that subtend the angles are proportional to the ratio of the sine [values] of those angles. I mean that the ratio of each side to another is as the ratio of the sine of the angle subtended by the first side to the sine of the angle subtended by the other side. If one side and two angles or one angle and two sides are known in a triangle, then the remaining sides and angles are calculated through the 4-number proportion method. However, if two sides and the angle between them are known, the 4-number proportion method does not work there, since the known angle is not subtended by one of the two known sides. In such a case, we say: If the known angle is right, then we take the root of the sum of the squares of the two sides, and so that the side that subtends the known angle becomes known. If [the known angle] is not right, then we extend from one of the

[clx] Another type of conversion is [as such] (…) and then the result is divided by the first quantity in terms of the number of other units, the second quantity in the other unit is found] γ = –α, –β.

remaining angles a perpendicular to the side that subtends [the known angle] so that there occur two triangles with right angles. One of [those triangles], one of whose angles is the known angle, will be of the first kind, namely [the case] in which triangle's two angles and one side are known. The second of the [two triangles] will be of the third kind, namely [the case] in which two sides and the right angle between them are known. [In these cases], the 4-number proportion method will work and the desired [result] will be obtained.



{Figure 14]

Chapter 1 [of Part 3]

On the Measure [*misāḥa*] of the Earth and What Pertains to It

[1] The amount of one degree along a great [circle] assumed on the surface of the Earth is, as the ancients found, $66^2/_3$ miles; according to what the moderns found, it is $56^2/_3$ miles. One mile is by consensus $^1/_3$ parasang. According to the moderns, [a mile] is 4000 cubits, each cubit being 24 digits. According to the ancients, [a mile] is 3000 [cubits], each cubit being 32 digits. A digit is by consensus six barleycorns laid side by side.

[2] Since the verifiers [*al-muḥaqqiqīn*] in this discipline chose the perspective of the ancients because their investigation was more reliable, we follow them and say: If one multiplies the parasang [value] of a degree adopted by the ancients, which is $22^2/_9$ parasangs, by 360, one obtains 8000 parasangs, which is the magnitude of the circumference of the terrestrial great circle. As explained in the introduction [of this Part], once [this value] is divided into 22, after being multiplied by seven, the result is the diameter [of that great circle], which is $2545^1/_2$ parasangs approximately. What is yielded from the multiplication of its diameter by its circumference is the surface area of the Earth, which is 20,364,000 parasangs. Its quarter is the area of the populated quarter.

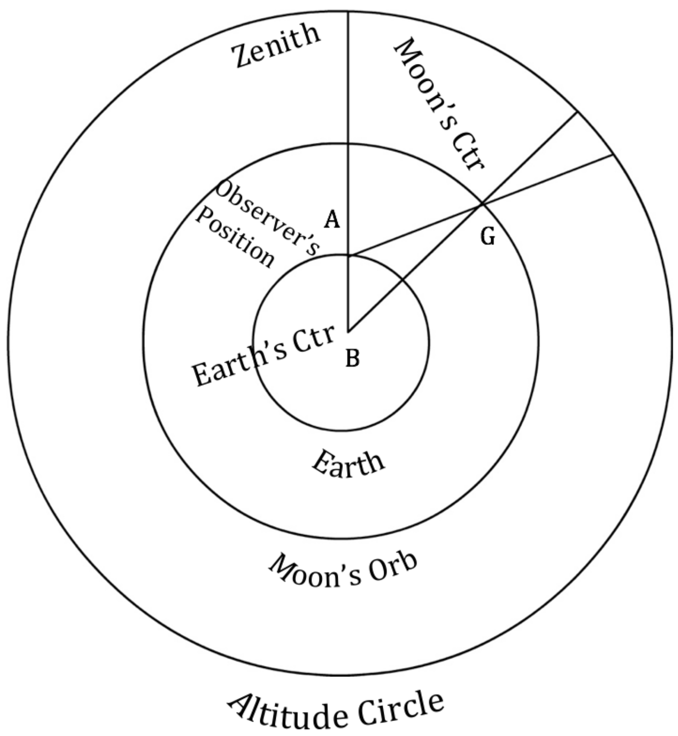
[3] The area of the inhabited part is the section enclosed by: the equinoctial half circle in the southerly direction; in the north direction the half day-circle of a point whose distance from the equator is equal to the complement of the total obliquity; and in the east and west directions two equivalent segments along the horizon of the cupola that are equal to the complement of the total obliquity. The method [to determine it] is

that first one measures the northern complete segment on the Earth, whose pole is the intersection point of the horizon of the Earth's cupola and its meridian. Its base is the day-circle of the aforementioned point. [Then,] one subtracts the area [of this segment] from the area of half the surface area of the Earth; and [then] one takes half the remaining [part]. As mentioned in the introduction [of this Part], the surface area of a complete segment on the sphere is equal to the circle whose radius is equal to the line extending from the pole of the segment to the circumference of the base, I mean, the chord of the total obliquity. However, [this is the case] based upon the circle's diameter being 114 parts [i.e. the true diameter], not being 120 parts [i.e. the conventional diameter]. The method for obtaining [the chord based upon the true diameter] is that the chord of the total obliquity is taken from the [astronomical] table and one half of a tenth [of the chord] is subtracted. The remaining is what is sought-after.

Chapter 2 [of Part 3]

On Finding the Distances of the Moon from the Center of the World Based Upon the Earth's Diameter Being One; On Finding the Ratio of the [Moon's] Diameter and the Diameter of the Shadow and Their Amount in Terms of the Parts of the Revolution

[1] Ptolemy observed the Moon in order to learn the first [matter mentioned in the title, i.e. the Moon's distances from the center of the World] at the time of its minimum altitude on the meridian line. [The Moon's] apparent altitude, which was 39 degrees and five minutes, was less than its true altitude, known by calculation, by 1 degree and seven minutes. [This difference] is the lunar parallax. If one draws its figure, it is as such:



[Figure 15]

[2] In the triangle $\overline{ABG}$, angle $\overline{G}$, which is the angle of difference, angle $\overline{B}$, which is the complement of the true altitude, and side $\overline{AB}$, which is assumed to be one, are known. Then the remaining [values] can be known according to what was mentioned in the introduction [of this part], namely that if two angles and one side of a triangle are known, the remaining [side] can be known by the 4-number proportion [method]. The side $\overline{BG}$, which is the distance of the Moon from the center of the World, is found by calculation to be 39 parts and 55 minutes, on the assumption that we take $\overline{AB}$ to be the standard unit of one.

[3] At the time of [the Ptolemy's observation], the distance [of the Moon to the center of the World] was (40 + ¼ + $^{1}/_{6}$) parts, on the basis of the inclined [orb's] radius being 60, its epicycle's radius[clxi] being (5+ $^{1}/_{5}$), and the eccentricity being 10 parts and 23 minutes. On the basis of the Earth's radius being one, the inclined orb's radius is 59 parts and 8 minutes and 11 seconds[clxii]; the epicycle' radius is 5 parts and 7 minutes and 31 seconds[clxiii]; the eccentricity is 10 parts and 14 minutes and 2 seconds[clxiv]; the radius of the deferent's orb is 48 parts and 54 minutes and nine seconds.[clxv] So on the basis of the Earth's radius being one, the farthest distance of the Moon is 64 parts and 15 minutes and 42 seconds[clxvi]; the closest [distance] is 33 parts and 32 minutes and 36 seconds[clxvii]; its mean with respect to distance is 48 parts and 54 minutes and 9 seconds.[clxviii]

[clxi] its epicycle's radius] β, γ = the epicycle's radius: α.
[clxii] 8 minutes and 11 seconds] γ = 15 minutes: α, β.
[clxiii] 7 minutes and 31 seconds] γ = 8 minutes: α, β.
[clxiv] 14 minutes and 2 seconds] γ = 15 minutes: α, β.
[clxv] 48 parts and 54 minutes and nine seconds] γ = 49 parts: α, β.
[clxvi] 15 minutes and 42 seconds] γ = 23 minutes: α, β.
[clxvii] 32 minutes and 36 seconds] γ = 37 minutes: α, β.
[clxviii] 48 parts and 54 minutes and 9 seconds] γ = 49 parts: α, β.

[4] In order to know the second [matter, i.e. the ratio of the [Moon's] diameter and the diameter of the shadow and their amount in terms of the parts of the revolution], [Ptolemy] observed two [lunar] eclipses when the Moon was at the epicyclic apex. During one of them, a quarter of its diameter was eclipsed, and its latitude was $48^1/_2$ minutes. During the other, half [its diameter was eclipsed], and its latitude was $40^2/_3$ minutes. And he knew[clxix] that [the Moon's] diameter at its farthest distance was four times the difference [between the two latitudes]—I mean $31^1/_3$ minutes because the difference, which is 7 minutes and 50 seconds, is a quarter of the diameter as it is the disparity between a half and quarter of the diameter. Its latitude for the second eclipse was the radius of the shadow circle as it was passing through the center [of the Moon], which was approximately twice plus its $^3/_5$ the radius of the Moon. For many [other] eclipses, he found this [same] ratio between them. Ptolemy also judged that the diameter of the Sun at its mean distance is equal to the diameter of the Moon in its farthest distance.

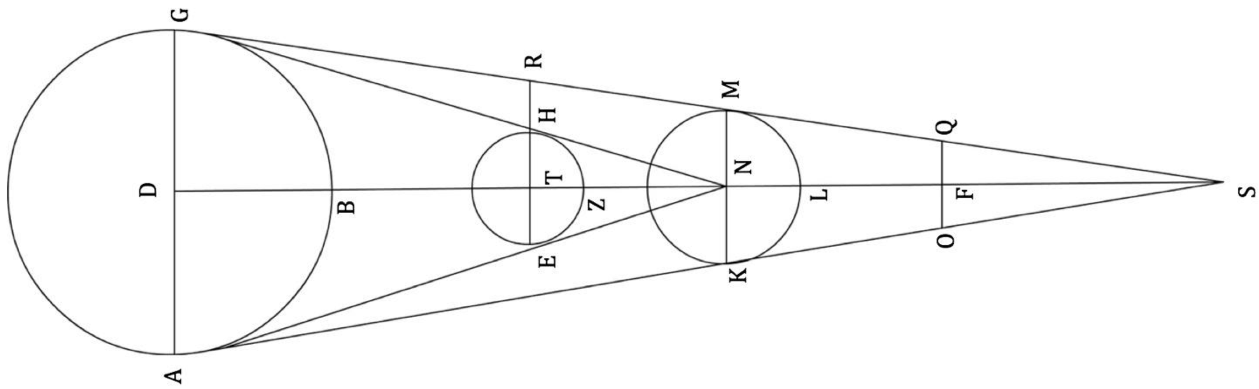
[clxix] and he knew] β, γ = then he knew: α.

Chapter 3 [of Part 3]

On Finding the Size of the Diameters of the Moon and Shadow, the Distances of the Mean Sun and of the Head of the Shadow Cone from the Center of the Earth Based Upon the Earth's Radius Being One

[1] Let $\overline{ABG}$ be a great [circle] about $\overline{D}$, which passes through the center of the Sun; $\overline{EZH}$ [a great circle] around $\overline{T}$, which passes through [the center of] the Moon at its farthest distance; $\overline{KLM}$ be about $\overline{N}$[clxx], which passes through [the center of] the Earth; $\overline{ASG}$ be the common section between the plane passing [through the centers of the Sun, Moon, and the Earth, as well as through the shadow that occurs], and the [larger] cone [that occurs with] the Sun and Earth; $\overline{ANG}$ be the common section between [the aforementioned plane] and the cone [that occurs with] the Sun and Moon; $\overline{DS}$ be the common axis for [both of the shadow cones]; $\overline{AG}$ $\overline{EH}$ $\overline{KM}$ be the lines that pass through the tangent points; and $\overline{QO}$ be the [line] that passes through the two points tangent to the shadow circle at the Moon's farthest distance at opposition. These [three] lines are parallel[clxxi] [to one another], intersecting the axis perpendicularly. By perception, they are equivalent to the diameters of the circles [within which they] are located.

[clxx] $\overline{N}$] β, γ = $\overline{G}$: α.
[clxxi] parallel] the word is in Form VI in Arabic (*mutawāziya*): γ = the word is in Form III (*muwāziya*): α, β.



[Figure 16]

[2] Each of [lines] $\overline{FN}$ $\overline{TN}$, which are the distances of the two centers of the shadow and Moon [respectively] from the center of the Earth, is 64 parts and 15 minutes and 42 seconds[clxxii], based upon the Earth's radius, which is the standard unit, being 1. Since in the triangle $\overline{NTH}$, the angle $\overline{N}$ is known on account of $\overline{TH}$, which is the Moon's radius known in terms of the parts of a revolution, and likewise $\overline{T}$, a right [angle] is also [known]. Thus, since in the triangle $\overline{NTH}$, two angles and one side are known in terms of the parts of a revolution, then the remaining sides and angles also come to be known, according to what is presented in the Introduction [of this part]. However, $\overline{NT}$ is 64 parts and 15 minutes and 42 seconds[clxxiii] based upon the standard unit being one. Therefore, since you have learned how to convert quantities from one unit to another, $\overline{TH}$, the Moon's radius, is 17 minutes and 34 seconds[clxxiv] in this unit. The shadow's radius [in the same unit] is 45 minutes and 40[clxxv] seconds, since their ratio [i.e. the radii of the Moon and shadow] is the ratio of 1 to $2^3/_5$.

[3] Since $\overline{TF}$, which is the [distance] between the centers of the Moon and shadow, is twice $\overline{TN}$, [the distance] between the centers of the Moon and the Earth,

[clxxii] and 15 minutes and 42 seconds] γ = 23 minutes: α, β.
[clxxiii] 15 minutes and 42 seconds] γ = 23 minutes: α, β.
[clxxiv] and 34 seconds] γ = 23 seconds: α, β.
[clxxv] and 40] γ = 12: α, β.

according to what was presented in the Introduction [of this Part], the sum of $\overline{FQ}$ $\overline{TR}$ is twice $\overline{NM}$, the Earth's radius, and equal to the Earth's diameter, which is 2. If one subtracts $\overline{FQ}$ and $\overline{TH}$, the radii of the shadow and the Moon, which are 1 [part] and 3 minutes and 14 seconds[clxxvi] [in total], from 2, then the remainder is 56 minutes and 46 seconds[clxxvii], which is the magnitude of $\overline{HR}$. The ratio of $\overline{NM}$, being 1, to the [$\overline{HR}$] is same as the ratio of $\overline{NG}$ to $\overline{GH}$, since $\overline{NGM}$ and $\overline{GHR}$ are similar triangles, as well as to the ratio of $\overline{ND}$, the mean distance of the Sun from the Earth, to $\overline{DT}$, the distance between the two luminaries. Then, when $\overline{ND}$ is [considered to be] 1, $\overline{TD}$ will be 56 minutes and 46 seconds[clxxviii] and $\overline{TN}$, the farthest distance of the Moon from the Earth, will be 3 minutes and 14 seconds.[clxxix]

[4] Since this distance, based upon the standard unit being 1, is 64 parts and 15 minutes and 42 seconds[clxxx], then according to what you have learned of the method of conversion, the mean distance of the Sun, based upon the standard unit being 1, is 1192 [parts] and 29 [minutes] and 4 seconds[clxxxi]. This is because the ratio of $\overline{NM}$, being 1, to $\overline{FQ}$, which is 45 minutes and 40[clxxxii] seconds is equal to the ratio of $\overline{NS}$, the distance of the vertex of the earth's shadow cone from its center, to $\overline{SF}$, the distance of the vertex from the center of the shadow, given the similarity of triangles $\overline{SNM}$ and $\overline{SFQ}$. If $\overline{SN}$ is [considered to be] 1, then $\overline{SQ}$ will be 45 minutes and 40[clxxxiii] seconds, and $\overline{FN}$, the distance of the shadow's center from the center of the World, 14 minutes and 20

[clxxvi] 3 minutes and 14 seconds] γ = 2 minutes and 35 seconds: α, β.
[clxxvii] 56 minutes and 46 seconds] γ = 57 minutes and 25 seconds: α, β.
[clxxviii] 56 minutes and 46 seconds] γ = 57 minutes and 25 seconds: α, β.
[clxxix] 3 minutes and 14 seconds] γ = 2 minutes and 35 seconds: α, β.
[clxxx] and 15 minutes and 42 seconds] γ = and 23 minutes: α, β.
[clxxxi] 1192 [parts] and 29 [minutes] and 4 seconds] γ = 1495 [parts]: α, β.
[clxxxii] and 40] γ = and 12: α, β.
[clxxxiii] and 40] γ = and 12: α, β.

seconds.[clxxxiv] However, this distance, based upon the standard unit being 1, is 64 parts and 15 minutes and 42 seconds.[clxxxv] Based on this, according to what you have learned, the distance of the shadow cone's vertex from the center of the shadow [circle] is 204 times the Earth's radius plus 44 minutes[clxxxvi]; [its distance] from the center of the Earth is 269 times the Earth's radius plus 8 seconds.[clxxxvii]

[clxxxiv] and 20 seconds] γ = 48 minutes: α, β.
[clxxxv] and 15 minutes and 42 seconds] γ = and 23 minutes: α, β.
[clxxxvi] 204 times the Earth's radius plus 44 minutes] γ = 197 times the Earth's radius: α, β.
[clxxxvii] 269 times the Earth's radius plus 8 seconds] γ = 261 times the Earth's radius: α, β.

Chapter 4 [of Part 3]

On Finding the Size of the Diameter of the Sun Based Upon the Standard Unit Being One and [On] the Ratio of Its Body[clxxxviii] to the Earth's Body

[1] **It has been established in the science of optics that for any two bodies that are equal in appearance but are at different distances**,[24] the ratio of the nearer radius to the farther one is as the nearer distance to the farther one. [This is because] two light rays will encompass them due to their being equal in appearance and the two ensuing triangles being similar. Thus, the ratio of the Moon's radius, which is 17 minutes and 34[clxxxix] seconds, to the Sun's unknown radius is as the ratio of the farthest distance of the Moon, which is 64 parts and 15 minutes and 42 seconds[cxc], to the mean distance of the Sun, which is 1192 times the standard measure plus 29 minutes and 4 seconds[cxci] based upon the standard unit being 1. Then when we multiply the first [value above] by the fourth one and divide the result by the third one, the unknown second [value] is obtained, which is 5 [parts] and 49 minutes[cxcii]. [This value] is the amount of the Sun's radius, based upon the Earth's radius being 1.

[2] Euclid has proven in the 12th [book] in his work that the ratio of a sphere to another sphere is as the ratio of the cubes of their diameters. Then when one takes the cubes of the diameters of the Earth and the Sun, it is clear that the Sun is 197 times[cxciii] the Earth.

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clxxxviii Its Body] "it" is referred to by the feminine pronoun: γ = "it" is referred to by the masculine pronoun: α, β.
clxxxix and 34] γ = 23: α, β.
cxc and 15 minutes and 42 seconds] γ = 23 minutes: α, β.
cxci 1192 times the standard measure plus 29 minutes and 4 seconds] γ = 1495 times the standard measure: α, β.
cxcii 5 [parts] and 49 minutes] γ = 6 [parts] and 44 minutes: α, β .
cxciii 197 times] γ = 244 times: α, β.

Chapter 5 [of Part 3]

On Finding the Remaining Distances Pertaining to the Sun and the Distances of the Two Lower Planets Based Upon the Standard Unit Being One

[1] Since the ratio of the Sun's eccentricity, which is, according to our new observation (*raṣadunā al-jadīd*), 2 parts and 1 minute and 20 seconds[cxciv], to 60, is as the ratio of the required [value]—I mean the amount of the eccentricity based on the standard unit being 1—to the amount of the mean distance [of the Sun] in terms of this unit, which is 1192 times the standard unit plus 29 minutes and 4 seconds.[cxcv] As a result, when we multiply the first [value] with the fourth one by levelling (*munḥaṭṭan*), the amount of the eccentricity based upon the standard unit being 1, which is 40 times plus 11 minutes and 28 seconds[cxcvi], is obtained. [It also follows that the Sun's] farthest distance is 1232 times plus 40 minutes and 32 seconds[cxcvii]. The nearest distance [of the Sun] is 1152 [times] plus 18 minutes[cxcviii]. This is the farthest distance for Venus, which is 104 parts and 2 minutes based on its deferent's radius being 60. Its nearest distance on the same basis is 15 parts and 58 minutes. It is obvious that the ratio of Venus' farthest and nearest distances in the parts of its deferent's diameter is as the ratio of the amount of the farthest distance, based upon the standard unit being 1, to the amount of the nearest distance in the same units, which is the required [value].

[2] Then we multiply the second [value], which is 15 [parts] and 58 minutes[cxcix], by the third one, which is 19,12;17,36, [that is 1152 [times] plus 17 minutes and 36

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cxciv and 20 seconds] γ = −α, −β.
cxcv 1192 times the standard unit plus 29 minutes and 4 seconds] γ = 1495 [times]: α, β.
cxcvi 40 times plus 11 minutes and 28 seconds] γ = 50 [times] and a fourth: α, β.
cxcvii 1232 times plus 40 minutes and 32 seconds] γ = 1545 times the standard unit plus a quarter: α, β.
cxcviii 1152 [times] and 18 minutes] γ = (1444 + ¾) times: α, β.
cxcix minutes] β, γ = −α.

seconds][cc] [cci], the result of which we divide by the first [value], which is 104 [parts] and 2 minutes, then the required result is obtained, 2,56;51[ccii], which is 176 parts and 51 minutes[cciii]; this is exactly the farthest distance of Mercury. [This value corresponds to] 91 parts and 30 minutes, based upon its deferent's radius being 60. [Mercury's] nearest distance[cciv], using the same units, is 28 parts and 30 minutes.

[3] It has already been presented that the ratio of the farthest distance to the nearest one, using the units of the deferent's diameter, is as the ratio of the amount of the farthest distance, based upon the standard unit being 1, to the amount of the nearest distance with those units. When we multiply the second [value], which is 28 parts and 30 minutes[ccv], by the third one, which is 2,56;51 [that is 176 parts and 51] minutes[ccvi], and then we divide the result by the first [value], which is 91 parts and 30 minutes[ccvii], then one obtains what is required, I mean the amount of the distance of the convexity of Mercury's orb based upon the Earth's radius being 1, 55;5[ccviii], that is[ccix] 55 times the Earth's radius plus 5 minutes [ccx]

[cc] 19,12;17,36, [that is 1152 times plus 17 minutes and 36 seconds]] γ = 24, 4; 45, [that is (1444 + ¾) times]: α, β.
[cci] 19,12;17,36] at the end of the *abjad* expression is the word "minute" is added: β, γ = the "minute" is not included after "24,4; 45": α.
[ccii] 2,56;51] γ = 3, 41;44: α, β.
[cciii] which is 176 parts and 51 minutes] γ = I mean 221 parts and 44 minutes]: α, β.
[cciv] Mercury's] nearest distance] "Mercury" is referred to by the feminine pronoun: γ = it is referred to by the masculine pronoun: α, β.
[ccv] minutes] β, γ = –α.
[ccvi] 2,56;51 [that is 176 parts and 51] minutes] γ = 3, 41;44 [that is 221 parts and 44 minutes]: α, β.
[ccvii] minutes] β, γ = –α.
[ccviii] 55;5] γ = 1,9; 3: α, β.
[ccix] that is] γ = I mean: α, β.
[ccx] 55 times the Earth's radius plus 5 minutes] γ = 69 degrees 3 minutes more than the farthest distance that was extracted, for the Moon, from the calculation of the parallax observation, which is, as mentioned earlier, 4 times the standard measure and 40 minutes; this is the thickness of the Moon's *jawzahr*: α (the word "degrees" is missing in α), β.

Chapter 6 [of Part 3]

On Finding the Distances of the Upper Planets and Fixed Stars

[1] As for Mars, its nearest distance, based on the radius of its deferent being 60, is 14 parts and 3 minutes[ccxi]; since [its nearest distance] is equal to the farthest distance of the Sun, its amount, based on the standard unit being 1, is 1232 times and 40 minutes and 32 seconds[ccxii], I mean 20, 32;40, 32[ccxiii]. The farthest of the distances of Mars, based on its deferent being 60, is 1, 45 [namely 105] parts and 57 minutes. Its ratio to the 14 parts and 3 minutes[ccxiv] is as the ratio of the required [value] to 20,32; 40, 32[ccxv] [that is 1232 times and 40] minutes[ccxvi] [and 32 seconds. Then we divide the area of the two extremities [i.e. the result of the multiplication of the first and fourth values] into the remaining [known value] in order to obtain the amount of [Mars'] farthest distance, based on the standard unit. [We thus obtain] 2, 34, 55; 30[ccxvii], I mean 9295 times and 30 minutes[ccxviii], which is the amount of Mars' farthest distance, based on the standard unit.

[2] [This value] is exactly the same as the nearest distance of Jupiter; however, it is 45 parts and 26 minutes[ccxix], based on its deferent being 60. Its farthest distance is 1,14 [namely 74] parts and 34 minutes[ccxx]. The ratio of the 1,14 [namely 74] parts and 34 minutes to 45 degrees and 26 minutes is as the ratio of the required [value] to

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ccxi minutes] β, γ = –α.
ccxii 1232 times and 40 minutes and 32 seconds] γ = 1545 $^1/_4$ times the standard unit: α, β.
ccxiii 20, 32; 40, 32] γ = 25, 45;15 minutes: α (the "minutes" is missing), β.
ccxiv minutes] β, γ = –α.
ccxv 20,32; 40, 32] γ = 25,45;15 [namely, 1545 $^1/_4$ times]: α, β.
ccxvi minutes] β, γ = –α.
ccxvii 2, 34, 55; 30] γ = 3, 14, 12; 37 minutes: α (the "minutes" is missing), β.
ccxviii 9295 times and 30 minutes] 11652 times and 37 minutes: α (the "times" is missing), β.
ccxix minutes] β, γ = –α.
ccxx minutes] β, γ = –α.

2,34,55;30 [namely, 9295 times and 30 minutes].[ccxxi] Then we divide the area of the two extremities by the second one in order to obtain the required third [value]. [We thus obtain] 4, 14, 16; 5[ccxxii], which is 15256 times and 5 minutes.[ccxxiii] [This value] is the amount of the farthest distance of Jupiter based upon the standard unit.

[3] [This value] is exactly the same as the nearest distance of Saturn; however, its nearest distance, based on its deferent's radius being 60, is 49 parts and 40 minutes[ccxxiv]; its farthest distance, in the same unit, is 1,10 [namely 70 parts] and 20 minutes.[ccxxv] The ratio of its farthest distance to the nearest distance is as the ratio of the required [value] to 4,14,16;5 [namely, 15256 times and 5 minutes].[ccxxvi] The area of the two extremities is divided into the second [value] to obtain the required [value]: 6, 0, 4; 8, namely, 21604 times the standard unit and 8 minutes.[ccxxvii] [This value] is the amount of the distance of the concavity of the orb of the fixed stars from the center of the World, based on the Earth's radius being 1.[ccxxviii]

[4] In order to find the amount of the radius of the stars of first magnitude among the fixed stars based upon the standard unit being 1, we say: the ratio of the distance of the fixed stars to the mean distance of the Sun is as the ratio of the required [value] to the proportion (*ḥiṣṣa*) of those stars, which is $^1/_{20}$ of the Sun's radius. [The Sun's radius]

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ccxxi 2,34,55;30 [namely, 9295 times and 30 minutes]] γ = 3, 14, 12; 37 [namely, 11652 times and 37 minutes]: α, β.
ccxxii 4, 14, 16; 5] γ = and it is 5, 18, 44; 38 minutes: α (the "minutes" is missing), β.
ccxxiii which is 15256 times and 5 minutes] γ = I mean 19124 times the standard unit and 38 minutes: α, β.
ccxxiv minutes] β, γ = –α.
ccxxv minutes] β, γ = –α.
ccxxvi 4,14,16;5 [namely, 15256 times and 5 minutes]] γ = 5, 18, 44; 38 [namely, 19124 times and 38 minutes]: β = 5, 18, 44; 35 [namely, 19124 times and 35 minutes]: α.
ccxxvii 6, 0, 4; 8, namely, 21604 times the standard unit and 8 minutes] γ = –α, –β.
ccxxviii based on the Earth's radius being 1] γ = + and that is 27082 times the standard unit and 32 minutes; I mean 7, 31, 22 times the standard unit and 32 minutes: α, β.

is, based upon the standard unit, 5;49 [namely, 5 [parts] and 49] minutes[ccxxix], as mentioned before. Then, we divide [this amount] by 20, and the result is 0;17,27 [namely, 17 [minutes] and 27] seconds[ccxxx]; this is the proportion [i.e. measure, *ḥiṣṣa*] of those stars. Then we multiply it by the distance of the fixed stars, and divide the result by the Sun's mean distance. As a result, one obtains 5;16 [namely, 5 parts and 16 minutes][ccxxxi], which is the required [value]. Thus, the distance of the convexity of the orb of the fixed stars, I mean the concavity of the greatest orb, is 6, 0, 9; 24[ccxxxii] minutes. God knows best of the distance of the convexity of this orb; as there is no way for a human being to know it. It is clear from what we have mentioned that the diameter of the stars of first magnitude among the fixed stars is 5 times the diameter of the Earth and 16 minutes [ccxxxiii]. We cube them in order to show that the volume of these stars[ccxxxiv] is 146 times[ccxxxv] the volume of the Earth.[ccxxxvi]

[ccxxix] 5;49 [namely, 5 [parts] and 49] minutes] γ = 6; 44 [namely, 6 parts and 44 minutes]: α, β.
[ccxxx] 0;17,27 [namely, 17 minutes and 27] seconds] γ = 0;20, 12 [namely, 20 minutes and 12 seconds]: α, β.
[ccxxxi] 5;16 [namely, 5 parts and 16 minutes]] γ = 6;6 [namely, 6 parts and 6 minutes]: α, β.
[ccxxxii] 6, 0, 9; 24] γ = 7, 31, 28; 38: α, β.
[ccxxxiii] 5 times the diameter of the Earth and 16 minutes] γ = 6 times the diameter of the Earth and 6 minutes: α, β.
[ccxxxiv] these stars] β, γ = this star: α ("this" is referred to by the feminine demonstrative pronoun (*hādhihi*)).
[ccxxxv] 146 times] γ = 227 times: α, β.
[ccxxxvi] the body of the Earth] β, γ = + God knows best: α.

References

[1] The translation of this verse (3: 191) is taken from Seyyed Hossein Nasr et al., trans., *The Study Quran: A New Translation and Commentary* (New York, NY: HarperOne, 2015), 182.
[2] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 254 (*Tadhkira,* III.2[1], lines 15-18).
[3] Ibid., p. 258 (*Tadhkira,* III.2[4], lines 1-5).
[4] Savadi, *The Historical and Cosmographical Context*, 289 (*Nihāya*, III.3.[1], line 1).
[5] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 258 (*Tadhkira,* III.3[1], lines 15-16).
[6] Ibid., 266 (*Tadhkira,* III.4[5], lines 8-14).
[7] Ibid., 266 (*Tadhkira,* III.4[5], lines 18-21).
[8] Ibid., 268. (*Tadhkira,* III.5[1], line 23).
[9] Ibid., 280 (*Tadhkira,* III.6[2], lines 5-13).
[10] Ibid.,280 (*Tadhkira,* III.6[2], lines 16-20).
[11] Savadi, *The Historical and Cosmographical Context*, 368 (*Nihāya*, III.12.[15], lines 17-20).
[12] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 294 (*Tadhkira,* III.9[1], lines 3-5).
[13] Savadi, *The Historical and Cosmographical Context*, 332 (*Nihāya*, III.9.[1e], lines 26-28).
[14] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 294 (*Tadhkira,* III.9[1], lines 10-15).
[15] Ibid., 296 (*Tadhkira,* III.9[2], lines 1-4).
[16] Ibid., 286 (*Tadhkira,* III.8[2], lines 20-25).
[17] Ibid., 288 (*Tadhkira,* III.8[2], lines 1-4).
[18] Savadi, *The Historical and Cosmographical Context*, 344 (*Nihāya*, III.10.[2a], lines 26-28).
[19] Ibid., 349 (*Nihāya*, III.10.[5], lines 9-10).
[20] Ibid., 348 (*Nihāya*, III.10.[3], lines 20-21).
[21] Ibid., 353 (*Nihāya*, III.10.[7], line 16).
[22] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 304 (*Tadhkira,* III.11[2], lines 11-12).
[23] Nasr et al., trans., *The Study Quran*, 53-54.
[24] Ragep, *al-Ṭūsī's Memoir on Astronomy*, 326 (*Tadhkira,* IV.4[1], lines 3-5).

CHAPTER 7

COMMENTARY TO THE EDITION AND TRANSLATION

[Preface]

Preface [1]. ...Sultan of the two continents, ruler (*khāqān*) of the two seas: This is one of the titles for Meḥmed II, to whom Qūshjī dedicated the *Fatḥiyya*. He adopted this title for himself, since he ruled parts of the Asian and European continents, and his reign extended to the Black and Mediterranean seas.[1]

Preface [1]. ...The Father of the Conquest, Sultan Muḥammad Khān: Meḥmed II started to be called al-Fātiḥ after his conquest of Constantinople in 1453. This title and the previous one ("Sultan of the two continents") are also found in an Arabic inscription that was placed on the Imperial Gate of the Topkapı Palace after it was built, revealing that they were commonly used titles for the Sultan.[2]

Preface [1]. Two-Calf stars (*farqadān*): In modern astronomy, these stars are known as Kochab and Pherkad in the Little Dipper in the constellation Ursa Minor, which are very close to each other, and also close to Polaris and the North Pole.[3]

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[1] Halil İnalcık, "Osmanlı Sultanlarının Unvanları (Titülatür) ve Egemenlik Kavramı," in *Doğu Batı Makaleler II* (Ankara: Doğu Batı Yayınları, 2008), 189.
[2] Gülru Necipoğlu, "From Byzantine Constantinople to Ottoman Kostantiniyye: Creation of a Cosmopolitan Capital and Visual Culture under Sultan Mehmed II," in *From Byzantion to Istanbul: 8000 Years of a Capital* (Istanbul: Sakıp Sabancı Museum, 2010), 268.
[3] Paul Kunitzsch and Tim Smart, *A Dictionary of Modern Star Names: A Short Guide to 254 Star Names and Their Derivations*, 2nd ed. (Cambridge, Massachusetts: Sky Publishing, 2006), 58; Larry Sessions, "The Guardians of the Pole," *EarthSky*, accessed June 15, 2017, https://earthsky.org/brightest-stars/kochab-and-pherkad-guard-the-north-celestial-pole.

Preface [1]. …one who raised the flags of science after their degeneration…with the flowering of their verges and surroundings: Qūshjī uses almost the same praise found in *Sharḥ al-Mawāqif*, in which Jurjānī praises Pīr Muḥammad Iskandar, the then governor of Fars in Shīrāz.[4]

Preface [1]. Who remember God standing, sitting, and lying upon their sides, and reflect upon the creation of the heavens and the earth, "Our Lord, Thou hast not created this in vain: This Qur'anic verse (3/191) is one of the most-cited verses in *hayʾa* works. It expresses the significance of the discipline in glorifying God's creation. Quṭb al-Dīn al-Shīrāẓī also refers to the same verse in the *Tuḥfa*.[5]

Preface [1]. …I named it *The Treatise of Conquest*: For the political context in which this text was compiled and dedicated, see the section "Qūshjī as a Diplomatic Mediator between the Ottomans and Āq Qoyūnlūs" in Chapter 2: ʿAlī al-Qūshjī's Intellectual Biography.

Preface [2]. I arranged it according to an introduction and three parts: In a marginal note in the autograph copy of his commentary on the *Fatḥiyya*, Mīrim Chalabī mentions that he saw this expression as a marginal note in Qūshjī's handwriting in the autograph copy of the *Fatḥiyya*. As I have pointed out in the "Editorial Procedures", I argue that the

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4 Al-Sayyid al-Sharīf al-Jurjānī, *Sharḥ al-Mawāqif*, ed. Maḥmūd ʿUmar al-Dimyāṭī (Beirut: Dār al-kutub al-ʿilmiyya, 1998), 12.

5 Quṭb al-Dīn al-Shīrāzī, *al-Tuḥfa al-shāhiyya*, Köprülü Manuscript Library, Fazıl Ahmed Paşa Collection, MS 927, f. 1b.

Mashhad copy includes marginal notes in Qūshjī's handwriting. One wonders if this copy is the one that Mīrim Chalabī refers to.[6]

Introduction

Intro [1]. A point has a position and is not divisible: Qūshjī's definition of a point is consistent with the theory of atomism (*al-jawhar al-fard*) accepted by the majority of the *mutakallims*.[7] The same definition is also seen in Shams al-Dīn al-Samarqandī's *Ashkāl al-taʾsīs*: "The point is something having position [but] not divisible."[8] On the other hand, in both his *Taḥrīr Uṣūl al-handasa wa-al-ḥisāb* and the *Tadhkira*, Ṭūsī follows the Euclidean definition: the atom is "that without part."[9] Interestingly, in his *Risālah,* Qūshjī uses the same definition of a point as one finds in Ṭūsī's *Muʿīniyya* and Shīrāzī's *Tuḥfa*, namely: "anything that the senses can point to (*al-ishāra al-ḥissiyya*) [but which] is not divisible at all, this is called a point."[10]

Intro [1]. A line… a surface: Qūshjī's definitions of these terms are the same as those given by Ṭūsī and Samarqandī,[11] but there is an important difference. Qūshjī adds to the definitions the following condition: "[…] if it ends positionally," which makes more sense

[6] Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Süleymaniye Manuscript Library, Feyzullah Efendi Collection, MS 1347, f. 8a.
[7] For the details of this theory see, Dhanani, *The Physical Theory of Kalām*, 90-140.
[8] Gregg De Young, "The *Ashkāl al-Taʾsīs* of al-Samarqandī: A Translation and Study,"*Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 14 (2001): 79.
[9] F. J. Ragep, *Tadhkira,* 92-93, 376; Nasîrüddin Tûsî, *Tahrîru Usûli'l-Hendese ve'l-Hisâb*, ed. İhsan Fazlıoğlu (Istanbul: Türkiye Yazma Eserler Kurumu Başkanlığı, 2012), 2-3.
[10] ʿAlī al-Qūshjī, *Risālah dar hayʾah*, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2640, f. 1b; Naṣīr al-Dīn al-Ṭūsī, *Risāla-yi Muʿīniyyah,* Süleymaniye Manuscript Library, Ayasofya Collection, MS 2670, f. 5a; Shīrāzī,*Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 2a: "[...] *al-nukṭa mā yaqbal al-ishāra al-ḥissiyya wa-lā juzʾ lahu* [...]"
[11] F. J. Ragep, *Tadhkira,* 92-93, 376; De Young, "The *Ashkāl al-Taʾsīs,*" 79.

given Qāḍizāda's explanation in his *Sharḥ Ashkāl al-taʾsīs*: "[…] if it ends positionally, not only in terms of the amount."[12] Contrarily, Qūshjī's definitions in the *Risālah* do not include the condition of being positional.[13]

Intro [1]. A solid is that which has length, width, and depth and ends in a surface; it can also terminate in a line or a point: Qāḍizāda describes a solid as "the mathematical (*taʿlīmī*)" one in this context. More importantly, unlike Ṭūsī and Samarqandī who state that a solid ends in a surface, Qūshjī expresses that it may also terminate in a line or a point. Additionally, Ṭūsī describes "the ends" as boundaries (*ḥudūd*).[14]

Intro [1]. A straight line is the shortest line joining two points: Qūshjī's definition differs from that of Ṭūsī whose definition is as such: "A straight line is the one on which all the given points are facing one another."[15] However, Qūshjī uses Ṭūsī's definition in the *Risālah*.[16]

Intro [1]. A plane surface is such that when any two points on it are connected with a straight line, that line does not depart from this surface: Qūshjī's definition is close to Ṭūsī's non-Euclidean definition: "A plane surface is the one on which the assumption of straight lines in all directions is possible."[17]

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12 "[...] *in kāna muntahiyan fī al-waḍʿ, lā fī al-miqdār faqaṭ* [...]" Qāḍīzāda al-Rūmī, *Sharḥ Ashkāl al-Taʾsīs*, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2640, f. 78a.
13 Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 1b.
14 F. J. Ragep, *Tadhkira,* 92-93, 376; De Young, "The *Ashkāl al-Taʾsīs,*" 79.
15 F. J. Ragep, *Tadhkira*, 92-93, 376.
16 Qūshjī, *Risālah,* Ayasofya, MS 2640, f. 1b; Ṭūsī, *Muʿīniyyah*, Ayasofya, MS 2670, ff. 5a-5b.
17 F. J. Ragep, *Tadhkira*, 92-93, 376-77.

Intro [2]. A solid angle is the meeting of one or more surfaces that bound a body at one point on the [body]: Unlike the other copies used in the critical edition and commentaries by Ghulām Sinān and Mīrim Chalabī, the Ghazi copy of the *Fatḥiyya* (f. 3a) writes "[…] of two or more surfaces".[18] It is notable that unlike Qūshjī, Ṭūsī assumes a solid angle bounded by "surfaces," putting aside the possibility of forming an angle with one surface.[19] Mīrim Chalabī gives the angle of a circular cone's vertex as an example of forming a solid angle with one surface.[20]

Intro [2]. An angle is right if its two sides, after their extension, encompass four equal angles: Ghulām Sinān's account regarding this sentence reveals the importance of Qūshjī's in-class explanations. Reportedly, in his lectures on the *Fatḥiyya*, Qūshjī says that his definition of a right angle is preferable and better (*awlā wa-aḥsan*) than the one given in the *Tadhkira* and *Ashkāl al-taʾsīs*.[21] Qūshjī's reasoning is that the angle might also be bounded by two circular lines, as is the case with the circle passing through the four poles and with the circles of the equinoctial and ecliptic.[22] This explanation resonates with the fact that while Qūshjī gives the definition of a circular line earlier, Ṭūsī does not do.[23] Mīrim

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[18] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Süleymaniye Manuscript Library, Fatih Collection, MS 5396, f. 85a; Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Feyzullah Efendi, MS 1347, f. 14a.
[19] F. J. Ragep, *Tadhkira*, 94-95.
[20] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 14a.
[21] Ṭūsī's definition is as such: "If a straight line stands erect on another straight line and there result two equal angles on its two sides." F. J. Ragep, *Tadhkira*, 94-95. Samarqandī's definition is as such: "The right angle is one of the equal angles formed at the sides of a straight line standing upright upon a straight line." De Young, "The *Ashkāl al-Taʾsīs,*" 79.
[22] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 86a.
[23] F. J. Ragep, *Tadhkira*, 92-93.

Chalabī elaborates the subject further with reference to Shīrāzī's *Tuḥfa*.[24] One should also note that in the *Risālah*, Qūshjī uses the same definition as in the *Fatḥiyya*.[25]

Intro [4]. A figure is that which… the chord is called the base of the segment: Qūshjī quotes the *Tuḥfa* almost *verbatim*.[26]

Intro [4]. The straight sine [sinus rectus] is… complete sine is the opposite of the versed sine, so it may exceed [the radius]: For a survey of trigonometry in Islamic history and trigonometric definitions, one can consult J. L. Berggrens' *Episodes in the Mathematics of Medieval Islam*.[27]

Intro [6]. The information given in this paragraph is similar to that of the *Tadhkira* and *Tuḥfa*.[28] But again Qūshjī's style of writing is closer to that of the latter.

Intro [7]. A circular cone is a solid enclosed by a circle…: Although Qūshjī's definition is almost identical with that of the *Tuḥfa*, one difference is that the *Tuḥfa* uses "a solid figure (*shakl mujassam*)" instead of what Qūshjī calls "a solid (*jism*)." This difference is interesting as it reveals how the *Tuḥfa* and *Fatḥiyya* was received by Mīrim Chalabī in his commentary on the latter. The autograph copy of Mīrim Chalabī's commentary (Feyzullah Efendi, MS 1347) includes the wording one finds in the *Tuḥfa*, namely writing "a solid figure" as

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[24] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 14b-15a.
[25] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 2a.
[26] Shīrāzī*, Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 2a.
[27] J. L. Berggren, *Episodes in the Mathematics of Medieval Islam*, 2nd Edition (Berlin, Heidelberg, New York: Springer, 2016), 155-88.
[28] Shīrāzī*, Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 2b; F. J. Ragep, *Tadhkira*, 96-97, 377-78.

though it is in the main text of the *Fatḥiyya*. However, another copy of the same commentary (Hüseyin Çelebi, MS 755), which was copied by Ṭāshkubrīzāda, Mīrim Chalabī's student, uses the same phrase ("a solid") written in the original *Fatḥiyya* text. In this respect, one should note that Ṭāshkubrīzāda copied Mīrim Chalabī's commentary from the autograph copy. Since Qūshjī's definition in the *Fatḥiyya* is very close to that of *Tuḥfa*, one might, then, assume that when Mīrim Chalabī was first writing his commentary, he used the same wording as the *Tuḥfa*, with the assumption that Qūshjī should have quoted it directly.[29] Apart from this, Ṭūsī and Shīrāzī also deal with the definition of cylinder, but Qūshjī does not in the *Fatḥiyya*.[30] The *Risālah*, in turn, does not mention the definitions of cone or cylinder.[31]

[29] Shīrāzī*, Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 2b; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 19a; Mīrim Chalabī, *Sharḥ al-Fathiyya*, Hüseyin Çelebi, MS 755, f. 19b.
[30] F. J. Ragep, *Tadhkira*, 98-99; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 3a.
[31] Qūshjī, *Risālah,* Ayasofya, MS 2640, ff. 2a-2b.

The First Part

On an Explanation of the Situations of the Celestial Bodies

Chapter 1 [of Part 1]

On Explaining the Total Number of Orbs and the Manner of Their Arrangement

I. …their arrangement: With reference to Jurjānī's *Sharh al-Mulakhkhaṣ*, Ghulām Sinān states that one can learn the order of the planets through eclipses and parallax, both of which will be explained later.[32]

I.1 [1]. The orbs are nine…: The term *falak*, which is translated as orb in this context, was used in different meanings to denote circle, sphere, and orb. Mīrim Chalabī explains its different meanings.[33] According to Y. Tzvi Langermann, the "orb" can be translated in any of four meanings: spherical body, spherical surface, plane of a circle, and circumference of a circle.[34]

I. 1. [1]. …the *aṭlas* orb: Both Ghulām Sinān and Mīrim Chalabī touch upon the reason for the naming of the greatest orb as the *aṭlas.* Its literal meaning is satin.[35] Related to this, Ghulām Sinān writes that the reason of this name is that it is "being devoid of the inscribing of the stars (*li-khalwa ʿan nuqūsh al-kawākib*)."[36] The commentators of the *Tadhkira* also

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[32] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 94b.
[33] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 20b-21a.
[34] Y. Tzvi Langermann, "Arabic Cosmology," *Early Science and Medicine* 2, no. 2 (1997): 190.
[35] Hans Wehr, *A Dictionary of Modern Written Arabic (Arabic-English)*, ed. J. Milton Cowan, 4th Edition (Urbana, IL: Spoken Language Service, 1994), 24.
[36] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 95a.

relates its naming to the orb being devoid of stars.[37] Furthermore, Mīrim Chalabī's elaboration is interesting with respect to the cosmological discussions in the pre-modern world. He tells us that it is named as the *aṭlas* since "we do not see any star [on this orb], and therefore it is like a satin not being inscribed." He goes on to say as follows: "It is not because [the *aṭlas* orb] is devoid of having stars. If you say: if it was starred, we would see it, since the heavens do not veil the vision from contemplating what exists behind them, then, I say: it is permissible that [some] stars are not seen because they are small. We admit (*sallamnā*) that the bigger ones are capable of being seen. However, we do not admit that all that we see other than the planets (*kull mā narāhu ghayr al-sayyārāt*) moves slowly since the observation is as such (*li-anna al-marṣūd ka-dhālik*). Among those we do not observe might be those that do not have that slow motion."[38] If I understand Mīrim Chalabī correctly, he is not foreclosing the possibility that the *aṭlas* might have stars, at least on the theoretical level. Given the question of whether all the fixed stars are contained within a single orb has been the subject of contention in Islamic intellectual history, Mīrim Chalabī's explanation deserves further study regarding cosmological issues that were debated over the course of time.[39]

I.1. [1]. ... the orb of the fixed stars; all the fixed stars are embedded in it: It is a general assumption in pre-modern Islamic astronomy that all the fixed stars are located in one orb. Yet, along with following this assumption, Ṭūsī stresses the possibility of other

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[37] F. J. Ragep, *Tadhkira*, 390-91.
[38] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 21b-22a.
[39] For instance, İshak Arslan elaborates that the possibility of numerous orbs beyond the orb of the fixed stars was discussed in the *Ishrāqī* tradition. See İshak Arslan, "Pushing the Boundaries of the Universe: The Criticisms of Peripatetic Cosmology in *Ḥikmat al-ishrāq* and its Commentaries," *Nazariyat Journal for the History of Islamic Philosophy and Sciences* 1, no. 1 (2014): 129-55.

configurations for the fixed stars: "Since the rest of the stars did not have any motion other than the two primary motions, they were satisfied with using one of these two orbs as the place for them even though their being on manifold orbs was conceivable."[40]

I. 1. [1]. ...the sphere of fire, [followed respectively by] the spheres of air, water and earth: Like Jaghmīnī, Qūshjī prefers to use the term sphere (*kura*) for the divisions of the sublunary region and differs from Ṭūsī who prefers to call them levels (*ṭabaqa*).[41]

I. 1. [2]. ... Divine Providence requires that some [parts] of the Earth's surface are uncovered above the water so that it will become a habitat for breathing beings: Like Qūshjī, Ṭūsī and Qāḍizāda also point out that the uncovering of the Earth for plants and animals is providential.[42] On the other hand, Qūshjī does not mention this in the *Risālah*.[43]

I. 1. [2]. The undulations on the surface of the Earth ... do not deviate [the sphere of the Earth] from perceptible sphericity, for [those undulations] do not have a sensible value compared to [the Earth]. Jaghmīnī also mentions the undulations. In his commentary on the *Mulakhkhaṣ*, Qāḍizāda calculates the ratio of the largest mountain on the Earth to its diameter, demonstrating that those undulations are too small, and therefore ignorable.[44] Besides this, partially quoting Qāḍizāda's commentary, Mīrim Chalabī also

[40] F. J. Ragep, *Tadhkira*, 108-9.
[41] F. J. Ragep, *Tadhkira*, 110-11, 391; Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 86-87.
[42] F. J. Ragep, *Tadhkira*, 110-13, 392; Qāḍizāda al-Rūmī, *Sharḥ al-Mulakhkhaṣ* (Istanbul[?], 1271/1864), 12.
[43] Qūshjī, *Risālah,* Ayasofya, MS 2640, f. 3a.
[44] Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 87; Qāḍizāda, *Sharḥ al-Mulakhkhaṣ*, 10-12.

recommends it for those who wish to acquire further explanation.[45] Like the *Fatḥiyya*, the *Risālah* also mentions this matter.[46]

Chapter 2 [of Part 1]

On the Well-Known Great and Small Circles, and the Well-Known Arcs

I. 2. One of the major revisions Qūshjī made in the final version of the *Fatḥiyya* is that this chapter was Chapter 3 in the first version, in which Chapter 2 was "On Explaining the Configuration of the Ninth and Eighth Orbs, Their Motions, and the Manner of the Division of the Eighth Orb into Zodiacal Signs and an Account of a Few Situations Regarding the Fixed Stars" (Ayasofya, 2733). In effect, he reverses their order in the last two revisions. As Ahmad Dallal points out, these two chapters are treated under a single title: "that there are two different primary motions in the heavens" in Ptolemy's *Almagest*, whereas the *Tadhkira* presents them in two separate chapters, the first of which is "on the well-known great circles," and the other on "the circumstances occurring due to the two primary motions, and the situation of the fixed stars."[47] Given the fact that the *Risālah*'s order of those chapters is also the same as the final version of the *Fatḥiyya*, it is not clear why Qūshjī's ordering in the first version is different even from the *Risālah*, let alone the later versions of the *Fatḥiyya*.[48] Maybe it was a simple confusion on the part of Qūshjī.

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[45] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 25b-26a.
[46] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 3a.
[47] Ahmad S. Dallal, *An Islamic Response to Greek Astronomy: Kitāb Taʿdīl hayʾat al-aflāk of Ṣadr al-Sharīʿa* (Leiden & New York: E.J. Brill, 1995), 328; F. J. Ragep, *Tadhkira*, 112-13, 120-21.
[48] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 3a.

I. 2. [1]. [Mathematicians] divided the circumference of each circle into 360 parts…Then they divided each degree into 60 parts and named each part a minute: In the first version, Qūshjī mistakenly assigns the definition of a degree to a minute, which would be corrected in the other versions. This paragraph is generally comparable to the first paragraph of the chapter on the same topic in the *Tadhkira*.[49]

I. 2. [2]. …the equinoctial: Ṭūsī explains the reason of this naming as such: "…because of the equality of night and day at all locations when the Sun occurs on it."[50] In addition, Mīrim Chalabī provides a rather lengthy explanation of it.[51]

I.2. [2]. …the circle passing through the four poles: Ragep proposes the "solstitial colure" to designate this term.[52]

I. 2. [5]. The ecliptic meridian circle: It can be translated literally as "midheaven circle of appearances." Ragep explains that this term "is analogous to the meridian line in that it divides the visible and invisible halves of the ecliptic orb just as the meridian does for the equinoctial."[53]

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49 F. J. Ragep, *Tadhkira*, 112-13.
50 Ibid., 112-113.
51 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 28a-28b.
52 F. J. Ragep, *Tadhkira*, 114.
53 For further linguistic and technical explanations, see ibid, 118, 393.

Chapter 3 [of Part 1]

On Explaining the Configuration of the Ninth and Eighth Orbs, Their Motions, and the Manner of the Division of the Eighth Orb into Zodiacal Signs and an Account of a Few Situations Regarding the Fixed Stars

I. 3. As mentioned above in the commentary section of I.2., this and previous chapters were in reverse order in the first version of the *Fatḥiyya*.

I.3. …a few situations regarding the fixed stars: As Mīrim Chalabī reminds us, Qūshjī deals with the fixed stars in a limited way, and therefore one can consult ʿAbd al-Raḥmān al-Ṣūfī's *Suwar al-kawākib* for further information.[54]

I. 3. [1]. The ninth orb completes its rotation approximately in a nychthemeron: Qūshjī has a chapter that covers the definition of a nychthemeron (Chapter 6 [of Part 2]: On the Nychthemerons, Their Daytime and Nighttime Parts, Equal and Unequal Hours, and Dawn and Dusk). Both Ghulām Sinān and Mīrim Chalabī explain the reason why Qūshjī uses the word "approximately" here. Mīrim Chalabī states that if one calculates the mean motion, the duration of a rotation is a nychthemeron. However, the real duration is a bit longer due to the fact that the Sun has its own proper motion in reverse.[55]

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[54] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 43a.

[55] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, ff. 108b-110a; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 43a-43b. Jaghmīnī clarifies that when one mentions the mean motion, it is referred to that of the Sun. Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 100-1.

I. 3. [1]. The eighth orb traverses 1 degree in every 70 solar years, completing its rotation in 25200 years: As Qūshjī explains further in "Chapter 7 of [Part 2]: On the Months, Years, and Epochs," a solar year is the duration of the Sun's single revolution along the ecliptic equator. The more interesting point in this sentence, however, has to do with a long history of the accounts regarding whether and how fast the eighth orb, which carries the fixed stars, rotates. Although Ghulām Sinān touches on this matter, based on Qāḍizāda's commentary on the *Mulakhkhaṣ*, Mīrim Chalabī presents a good summary of the varying parameters attributed to the motion of the eighth orb. He first remarks that there was a disagreement over the amount of this motion, adding that some of the "Ancients (*al-mutaqaddimūn*)" including Aristotle did not attribute precession to the eighth orb. Although Hipparchus, he continues, proposed that the orb of the fixed stars moves, he did not calculate its amount. Ptolemy, however, calculated it to be 1 degree in every 100 years. The "moderns (*al-mutaʾakhkhirūn*)" such as the astronomers who were involved in observations made under the patronage of Caliph Ma'mūn, calculated it to be 1 degree in 66 solar years. Some "verifiers (*qawm min muḥaqqiqīn*)" such as Ibn al-Aʿlam determined it to be 1 degree in 70 solar years, a value compatible with the observations made under the supervision of Naṣīr al-Din al-Ṭūsī at the Maragha Observatory. Mīrim Chalabī notes that the value "found by the author [i.e. Qūshjī] for the new observations (*al-raṣad al-jadīd*) in

Samarqand" is also 1 degree in 70 years.[56] This account should be considered significant since it is an indication of Qūshjī's active role in the Samarqand observations.[57]

I. 3. [1]. ...called the total obliquity. Different [values for the total obliquity] were found at [various] observations; according to our observation, it is 23;30;17: Various values for the total obliquity were calculated since Ptolemy. Unlike Jaghmīnī in the *Mulakhkhaṣ* and Ṭūsī in the *Tadhkira*, who adopted 23;35 (though the latter would revise it to be 23;30 in his *Zīj-i Īlkhānī*), Qūshjī, unsurprisingly, used the parameter that was given in *Zīj-i Ulugh Beg*, in both the *Risālah* and *Fatḥiyya*.[58]

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[56] One can find this value in *Zīj-i Ulugh Beg*. Ulugh Beg, *Zīj-i Ulugh Beg,* Topkapı Manuscript Library, Revan Collection, MS 1714, f. 115a. This value is given as 1 degree in 60 years in the French translation of the *Zīj*. It is not clear as to whether this discrepancy stems from the copy Sédillot used or it is simply a typing mistake. M. L. P. E. A. Sédillot, *Prolégomènes des tables astronomiques d'OlougBeg: Traduction et commentaire* (Paris: Imprimeurs de l'Institute de France, 1853), 200

[57] For further information regarding the history of its varying parameters, see Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 252; F. J. Ragep, *Tadhkira*, 122-25, 396, 398-400; F. Jamil Ragep, "Al-Battānī, Cosmology, and the Early History of Trepidation in Islam," in *From Baghdad to Barcelona: Studies in the Islamic Exact Sciences in Honour of Prof. Juan Vernet*, eds. Josep Casulleras and Julio Samsó, vol. 1 (Barcelona: Instituto "Millás Vallicrosa" de Historia de la Ciencia Arabe, 1996), 267-98.

[58] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 122, 259; F. J. Ragep, *Tadhkira*, 120-21, 394; Ulugh Beg, *Zīj-i Ulugh Beg*, Revan, MS 1714, f. 17a.

Chapter 4 [of Part 1]

On the Configuration of the Orbs of the Wandering Planets

I. 4. [1]. The Sun has two orbs [enclosed by] two parallel surfaces…called the pareclīptic…called the eccentric: In the *hayʾa* literature, configurations of the orbs and their motions are explained with hypotheses, known as *uṣūl*.[59] As far as the configuration of the Sun is concerned, there are two models: the eccentric and the epicyclic models. Ṭūsī writes that since the eccentric model is simpler, Ptolemy selected it to explain the configuration of the Sun. This paragraph reveals that Qūshjī follows this Ptolemaic choice.[60] Another historically significant detail is provided by Ghulām Sinān. After stating that the epicyclic hypothesis is not preferred for the configuration of the Sun, he quotes from Jurjānī's *Sharḥ al-Tadhkira* in which he says that while any of the epicyclic and eccentric hypotheses is possible for the upper planets, the epicyclic hypothesis is the only possible one for the lower planets (*yumkin fī al-ʿulwiyya kull min al-uṣūlayn wa-fī al-sufliyyayn lā yumkin illā aṣl al-tadwīr*). Ghulām Sinān's report reveals that this topic was discussed in one of Qūshjī's classes. Qūshjī told his students that the same statement is found in a marginal note in Shīrāzī's handwriting in the copy of the *Tuḥfa* Qūshjī possessed. Ghulām Sinān also adds that he saw that particular copy.[61] Ghulām Sinān does not give further details as to how the discussion went on, but it is likely that Qūshjī mentioned to his

[59] For a discussion of the *uṣūl* (hypotheses) with respect to Shīrāzī's *Tuḥfa*, see Robert Morrison, "Quṭb al-Dīn al-Shīrāzī's Hypotheses for Celestial Motions," *Journal for the History of Arabic Science* 13, nos.1 & 2 (2005): 21-140.
[60] F. J. Ragep, *Tadhkira*, 144-45.
[61] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 116b.

students his treatise in which he had showed that the eccentric hypothesis is also possible for the lower planets.[62]

I.4.[1]. The sun is a solid…in such a way that [the Sun's] surface is tangent to the surfaces of [the eccentric orb] at two common points: In his expanded Turkish rendition of Qūshjī's *Risālah*, completed in Aleppo in 955/1548 and presented to Sultan Süleyman I (d. 974/1566), Saydī ʿAlī Raʾīs (d. 970/1562) adds a valuable note after this phrase, which demonstrates that Ibn al-Shāṭir's non-Ptolemaic models were known in Ottoman circles by the mid-sixteenth century. He writes that Ibn al-Shāṭir in his *zīj*, whose title is not given by Saydī ʿAlī Raʾīs, and in *Nihāyat al-suʾl*, omitted the eccentricity "completely" and recorded all the motions better by adding epicycles and some concentric circles into his models. He also adds that the Ancients (*mutaqaddimūn*) used eccentric models.[63] As the growing literature on Ibn al-Shāṭir's astronomy has revealed, one of his major contributions was to propose non-Ptolemaic models "by dispensing with eccentric orbs […] and using only Earth-centred orbs and epicycles."[64] Moreover, let me note the following points that can be the basis for further inquiry: 1) Ottoman astronomers knew the main points of Ibn al-Shāṭir's non-Ptolemaic models, even before Taqī al-Dīn al-Rāṣid (d. 993/1585), the founder of Istanbul Observatory, who had copies of Ibn al-Shāṭir's works in his collection; 2) Since the literature on Ibn al-Shāṭir has demonstrated the

[62] For a critical edition and translation of this treatise, see F. Jamil Ragep, "ʿAlī Qushjī and Regiomontanus: Eccentric Transformations and Copernican Revolutions," *Journal for the History of Astronomy* 36, no. 4 (2005): 359-71.
[63] Seydī ʿAlī Reʾīs, *Khulāṣat al-hayʾa*, Süleymaniye Manuscript Library, Aşir Efendi Collection, MS 223, f. 13b. In her master's thesis on Seydī ʿAlī Reʾīs, Tuba Uymaz also notes the mentioning of Ibn al-Shāṭir in this respect. Uymaz, "Seydî Ali Reis'in Hülâsa El-Hey'e (Astronominin Özeti) Adlı Eseri," 66-68, 122.
[64] Sajjad Nikfahm-Khubravan and F. Jamil Ragep, "Ibn Al-Shāṭir," in *Encyclopedia of Islam, THREE*, ed. Kate Fleet et al., accessed April 22, 2019, http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_32244.

similarities between his and Copernican models, this comment by Saydī ʿAlī Raʾīs indicates the significance of Ottoman Istanbul as a venue for the transmission of Islamic astronomical knowledge into Renaissance Europe: this point has been made by Robert G. Morrison with reference to Moses Galeano, a Jewish scholar who served at Sultan Bāyazīd II's court in Istanbul and made visits to Europe.[65]

I. 4. [3]. ...it is called the *jawzahr.* For the meaning and possible origins of this term, consult F. J. Ragep's explanations in his commentary to the *Tadhkira*.[66]

I. 4. [5]. The point between the parecliptic and dirigent [orbs] is called the apogee of the dirigent or its perigee. And the common point between the dirigent and deferent [orbs] is called the apogee of the deferent or its perigee: Although Qūshjī refers to one point for both the apogee and perigee, actually he should mean two different points, one for apogee and the other for perigee. After this sentence, Mīrim Chalabī adds an interesting explanation related to discussions on non-Ptolemaic models in Islamic history. He states that the configurations of Mercury and other planets, which are expounded by Qūshjī, are based on what is widely-accepted in this discipline (*ʿalā mā huwa al-mashhūr*). He goes on to say that the moderns (*mutaʾakhkhirūn*) added new models to the commonly held ones for the orbs of the vacillating planets and the Moon. He also writes that although these new models are not covered in his abridgement (*hādhā al-mukhtaṣar*), his intention is to collect them in a treatise he promises to write as an appendix (*īrād jamʿihā fī al-risāla al-mawʿūda*

[65] Robert Morrison, "A Scholarly Intermediary between the Ottoman Empire and Renaissance Europe," *ISIS* 105, no. 1 (2014): 32-57.
[66] F. J. Ragep, *Tadhkira*, 417.

fī al-ẓayl) if his life is long enough and God gives him success.[67] As a matter of fact, in his entry on Mīrim Chalabī, Fazlıoğlu states that Mīrim Chalabī "stated his intention to write an appendix to his commentary in which he would analyze the problems pertaining to the models of Mercury and the Moon."[68] I have not come across in Mīrim Chalabī's commentary where he declares his aim of writing an appendix specifically on the models of Mercury and the Moon. However, based on his own words, one might assume that Mīrim Chalabī's intention was to write a general account of the non-Ptolemaic models that had been proposed until his time. This shows that attempts to propose non-Ptolemaic models were of interest to Ottoman astronomers. In supporting this claim, it is notable that Akhawayn (d. 904/1499), an Ottoman scholar contemporaneous with Qūshjī and Mīrim Chalabī, wrote a treatise in which he summarized the main difficulties (*ishkālāt*) pertaining to the Ptolemaic models.[69]

Chapter 5 [of Part 1]

On the Motions of the Orbs of the Wandering Planets

This chapter includes various parameters pertaining to motions of the orbs. In her commentary to the *Mulakhkhaṣ*, Sally Ragep compares similar parameters given by Jaghmīnī to those found in Ptolemy's *Almagest*, al-Farghānī's *Jawāmī*, al-Battānī's *Zīj al-ṣābiʾ*, and Ṭūsī's *Tadhkira*. She presents them in useful charts.[70] By using her way of

[67] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 51a-51b.
[68] İhsan Fazlıoğlu, "Mīram Čelebī: Maḥmūd ibn Quṭb al-Dīn Muḥammad ibn Muḥammad ibn Mūsā Qāḍīzāde," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, eds. Thomas Hockey et al. (New York: Springer, 2007), 788-89.
[69] Akhawayn's treatise was used by George Saliba in an article. Saliba only mentions the author's name and the title of the treatise without introducing him as an Ottoman scholar or the Ottoman context within which it was written. George Saliba, "Arabic Planetary Theories After the Eleventh Century AD," in *Encyclopedia of the History of Arabic Science*, ed. Roshdi Rashed, vol. 1: Astronomy- Theoretical and Applied (London and New York: Routledge, 1996), 59-128.
[70] For her explanation of the sources she consulted see, S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 253.

presenting the parameters, I will compare the parameters given in the *Fatḥiyya* to those in his work *Risālah dar hayʾah*, *Zīj-i Ulugh Beg*, Shīrāzī's *Tuḥfa*, Ṭūsī's *Tadhkira*, Jaghmīnī's *Mulakhkhaṣ*, and the *Almagest*. The selection of these works is based on the fact that they are directly linked to his educational and teaching background in both Samarqand and Istanbul contexts, as I have presented in the chapter on Qūshjī's intellectual biography.

[WE]: West to East (in the sequence of the signs)

[EW]: East to West (counter-sequence of the signs)

I. 5. [1]. One of them is [the motion] from west to east…The motion of the Sun's eccentric, which is in a nychthemeron, 0; 59, 8: As is shown in the following table, Qūshjī's parameter is basically compatible with those given in other works.

<u>The motion of the Sun's eccentric in a nychthemeron</u>

Fatḥiyya	***Risālah***	***Zīj-i Ulugh Beg***[71]	***Tuḥfa***	***Tadhkira***	***Mulakhkhaṣ***	***Almagest***
0; 59, 8 (I. 5. [1])	0; 59, 8 (Ayasofya, MS 2640, f. 7a)	0; 59, 8 (Revan, MS 1714, f. 116a)	0; 59 (Fazıl Ahmed Paşa, MS 927, f. 24a)	0; 59 (*Tadh.* 2.7. [11], pp. 152-53)	0; 59, 8, 20 (*Mul.* I. 2. [8], pp. 102-3)	0; 59, 8, 17 *Alm.*, III. 2 (p. 143)

[71] I have also consulted this article for the parameter given in *Zīj-i Ulugh Beg*: S. Mohammad Mozaffari, "An Analysis of Medieval Solar Theories," *Archive for History of Exact Sciences* 72, no. 2 (2018): 191–243.

I. 5. [1]. The motions of the deferent orbs, which per day are: The following table reveals an important fact regarding the parameters in *hay'a* texts. The *Fatḥiyya* and *Risālah* present the same parameters for the motions of the deferent orbs of the planets, and the reason being that both of them use the parameters provided in *Zīj-i Ulugh Beg*. The *Mulakhkhaṣ*' parameters are almost the same as those in the *Fatḥiyya* and *Risālah*, but they differ in the case of Mars, in which the latter two agree with the *Zīj-i Ulugh Beg*.

<u>The motions of the deferent orbs per day</u>

	Fatḥiyya	***Risālah***	***Zīj-i Ulugh Beg***	***Tuḥfa***	***Tadhkira***	***Mulakhkhaṣ***	***Almagest***
Saturn [WE]	0;2 (I. 5. [1])	0;2 (Ayasofya, MS 2640, f. 7a)	0; 2 (Revan, MS 1714, f. 133b)	0; 2 (Fazıl Ahmed Paşa, MS 927, f. 35a)	0; 2 (*Tadh.* 2.9. [8], pp. 180-81)	0; 2, 0, 35 (*Mul.* I. 2. [9], pp. 102-3)	0; 2, 0, 33 (*Alm.*, IX. 4 p. 429)
Jupiter [WE]	0; 4, 59 (I. 5. [1])	0; 4, 59 (Ayasofya, MS 2640, f. 7a)	0; 4; 59 (Revan Collection, MS 1714, f. 137b)	0; 5 (Fazıl Ahmed Paşa, MS 927, f. 35a)	0; 5 (*Tadh.* 2.9. [8], pp. 180-81)	0; 4, 59, 16 (*Mul.* I. 2. [9], pp. 102-3)	0; 4, 59, 14 (*Alm.*, IX. 4 p. 432)
Mars [WE]	0;31,27 (I. 5. [1])	0;31,27 (Ayasofya, MS 2640, f. 7a)	0;31,27 (Revan Collection, MS 1714, f. 140b)	0; 31 (Fazıl Ahmed Paşa, MS 927, f. 35a)	0; 31 (*Tadh.* 2.9. [8], pp. 180-81)	0;31,26,40 (*Mul.* I. 2. [9], pp. 102-3)	0; 31,26,36 (*Alm.*, IX. 4 p. 435)

Venus [WE]	Same as mean Sun [i.e. 0; 59, 8] (I. 5. [1])	Same as mean Sun [i.e. 0; 59, 8] (Ayasofya, MS 2640, f. 7a)	0; 59; 8 (Revan Collection, MS 1714, f. 144a)	Same as mean Sun [i.e. 0; 59] (Fazıl Ahmed Paşa, MS 927, f. 39a)	Same as mean Sun [i.e. 0; 59] (*Tadh.* 2.9. [8], pp. 180-81)	0;59,8,20 (*Mul.* I. 2. [9], pp. 102-3)	0;59,8,17 (*Alm.*, IX. 4 p. 438)
Mercury [WE]	Twice Venus [i.e. 1;58, 16] (I. 5. [1])	Twice Venus [i.e. 1;58, 16] (Ayasofya, MS 2640, f. 7a)	1; 58;16 (Revan Collection, MS 1714, f. 147b)	Twice mean Sun [i.e. 1; 58] (Fazıl Ahmed Paşa, MS 927, f. 40b)	Twice mean Sun [i.e. 1; 58] (*Tadh.* 2.8. [10], pp. 168-69)	1;58,16,40 (*Mul.* I. 2. [9], pp. 102-3)	1;58,16,34 (*Alm.*, IX. 4 p. 441)
Moon [WE]	24;22,53 (I. 5. [1])	24;22,53 (Ayasofya, MS 2640, f. 7a)	24; 22, 53 (Revan Collection, MS 1714, f. 125a)	24; 23 (Fazıl Ahmed Paşa, MS 927, ff. 27b-28a)	24; 23 (*Tadh.* 2.7. [10], pp. 152-53)	24;22,53,22 or 24;23,53,22 or 24;23 (*Mul.* I. 2. [9], pp. 102-3)	24;22,53,22 (*Alm.*, IX. 4 p. 187)

I. 5. [2]. Among [the motions in] the second division are: the motion of Mercury's dirigent … the motion of the Moon's *jawzahr* [nodes] … the motion of the Moon's

inclined [orb], which is 11;9,7 daily: The motion of Mercury's dirigent orb is described by Ṭūsī as: "the excess of its mean motion over the motion of its apogee."[72]

The following is a comparison of their parameters, given in degrees per day:

	Fatḥiyya	***Risālah***	***Tuḥfa***	***Tadhkira***	***Mulakhkhaṣ***	***Almagest***
Mercury [dirigent] **[EW]**	Same as mean Sun [i.e. 0;59,8] (I. 5. [2])	Same as mean Sun [i.e. 0;59,8] (Ayasofya, MS 2640, f. 7a)	Same as mean Sun [i.e. 0;59] (Fazıl Ahmed Paşa, MS 927, f. 40b)	Same as mean Sun [i.e. 0;59] (*Tadh.* 2.8. [9], pp. 166-67)	0; 59, 8, 20 (*Mul.* I. 2. [3], pp. 100-1)	0;59.8,17 (*Alm.*, IX. 4 p. 441)
Moon [*jawzahr*] **[EW]**	0;3,11 (I. 5. [2])	0;3,11 (Ayasofya, MS 2640, f. 7a)	0;3 plus a fraction (Fazıl Ahmed Paşa, MS 927, f. 27a)	0;3 plus a fraction (*Tadh.* 2.7. [8], pp. 150-51)	0;3,10,37 (*Mul.* I. 2. [4], pp. 100-1)	
Moon [inclined] **[EW]**	11; 9, 7 (I. 5. [2])	11; 9, 7 (Ayasofya, MS 2640, f. 7a)	11;9 (Fazıl Ahmed Paşa, MS 927, f. 27a)	11;9 (*Tadh.* 2.7. [9], pp. 152-53)	11;9,7,43 (*Mul.* I. 2. [5], pp. 100-1)	

72 F. J. Ragep, *Tadhkira*, 166-67.

I. 5. [3]. ...the vacillating [planets]: This term is used for five planets, namely Saturn, Jupiter, Mars, Mercury and Venus that experience retrograde motion. Mīrim Chalabī's explanation for this naming is that their motions are changing, sometimes fast, sometimes slow, or even sometimes stationary. The term "*al-sayyāra*" (the wandering planets) is, in turn, used to denote all the seven planets.[73]

I. 5. [3]. The motion of the epicycle is called the proper motion. The comparison of the relevant parameters is presented below:

	Fatḥiyya	***Risālah***	***Zij-i Ulugh Beg***	***Tuḥfa***	***Tadhkira***	***Mulakhkhaṣ***	***Almagest***
Saturn	= the difference between Sun's mean and planet's mean I. 5. [3]	= the difference between Sun's mean and planet's mean (Ayasofya, MS 2640, f. 7a)	0; 57,8 (Revan Collection, MS 1714, f. 133b)	= excess of mean Sun over planet's mean (Fazıl Ahmed Paşa, MS 927, 36a)	= excess of mean Sun over planet's mean (*Tadh.* 2.9. [11], pp. 182-83)	0;57,7,44 (*Mul.* I. 2. [10], p. 104)	0; 57,7, 43 (*Alm.*, IX. 4 p. 429)

73 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 53b; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 255.

Jupiter	= the difference between Sun’s mean and planet’s mean I. 5. [3]	= the difference between Sun’s mean and planet’s mean (Ayasofya, MS 2640, f. 7a)	0;54, 8 (Revan Collection, MS 1714, f. 137b)	= excess of mean Sun over planet’s mean (Fazıl Ahmed Paşa, MS 927, 36a)	= excess of mean Sun over planet’s mean (*Tadh.* 2.9. [11], pp. 182-83)	0;54,9,3 (*Mul.* I. 2. [10], p. 104)	0;54,9,2 (*Alm.*, IX. 4 p. 432)
Mars	= the difference between Sun’s mean and planet’s mean I. 5. [3]	= the difference between Sun’s mean and planet’s mean (Ayasofya, MS 2640, f. 7a)	0;27,42 (Revan Collection, MS 1714, f. 140b)	= excess of mean Sun over planet’s mean (Fazıl Ahmed Paşa, MS 927, 36a)	= excess of mean Sun over planet’s mean (*Tadh.* 2.9. [11], pp. 182-83)	0;27,41,40 (*Mul.* I. 2. [10], p. 104)	0;27,41,40 (*Alm.*, IX. 4 p. 435)
Venus	0;36,53 I. 5. [3]	0;36,59 (Ayasofya, MS 2640, f. 7a)	0;36,59 (Revan Collection, MS 1714, f. 144a)	0;37 (Fazıl Ahmed Paşa, MS 927, 41b)	0;37 (*Tadh.* 2.9. [11], pp. 182-83)	0;36,59,29 or 0;37 or 0;37,19,29 (*Mul.* I. 2. [10], pp. 104, 256)	0; 36,59,25 (*Alm.*, IX. 4 p. 438)

Mercury	3;6,4 I. 5. [3]	3,6,24 (Ayasofya, MS 2640, f. 7a)	0;3,6,24 (Revan Collection, MS 1714, f. 147b)	3;6 (Fazıl Ahmed Paşa, MS 927, 41b)	3;6 (*Tadh.* 2.8. [13], pp. 170-71)	3;6,24,7 (*Mul.* I. 2. [10], p. 104)	3;6,24,6 (*Alm.*, IX. 4 p. 441)
Moon	13;3,54 I. 5. [3]	13;3,54 (Ayasofya, MS 2640, f. 7a)	13;3,54 (Revan Collection, MS 1714, f. 124a)	13;4 (Fazıl Ahmed Paşa, MS 927, 28a)	13;4 (*Tadh.* 2.7. [13], pp. 182-83)	13;3,53,56 (*Mul.* I. 2. [10], p. 104)	13;3,53,56 (*Alm.*, IX. 4 p. 186)

As seen in the table, the *Fatḥiyya* parameters for Venus and Mercury are different from those in the *Risālah* and *Zīj-i Ulugh Beg*. According to the commentators, the reason for this discrepancy is that Qūshjī wrote them by mistake in the *Fatḥiyya*. Interestingly enough, the copies I use in my critical edition include those "wrong" parameters. As far as the parameter for the motion of Venus' epicycle is concerned, while Ghulām Sinān gives the parameter found in the *Risālah* and *Zīj-i Ulugh Beg* (0;36,59) in the main text of the *Fatḥiyya*, Mīrim Chalabī's main text of the *Fatḥiyya* includes the "wrong" parameter (0;36,53). However, Mīrim Chalabi states in the commentary section that although the main text gives this value, it should in fact have been 0;36,59, following what Qūshjī wrote in his commentary on *Zīj-i Ulugh Beg*. The case is the opposite for the parameter for Mercury's epicycle. While Ghulām Sinān writes the "wrong" parameter (3;6,4) in his main *Fatḥiyya* text, the "true" parameter (3,6,24) is found in the main text Mīrim Chalabī used. Despite the commentators' corrections, one must also consider that Qūshjī might have recalculated these parameters, but this awaits further examination.[74]

Chapter 6 [of Part 1]

On What Occurs to the Planets, in 4 Sections

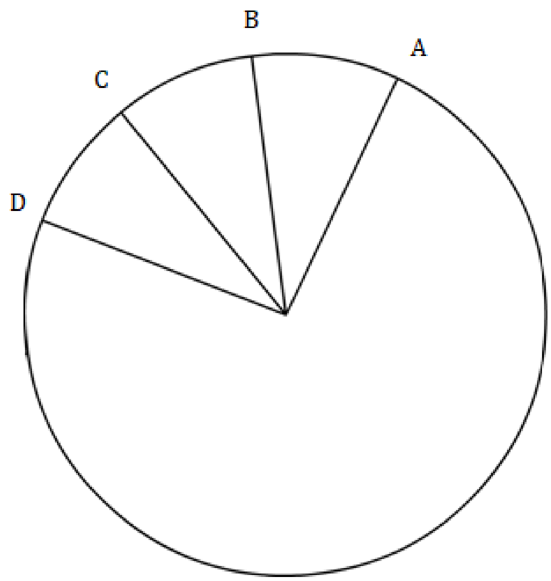
Section 1 [of Chapter 6]

On What Occurs to the Planets in Longitude

I.6.1: This chapter covers anomalies or irregularities that an observer sees in the motions of the planets. Jaghmīnī prefers to call them anomalies (*ikhtilāfāt*). At the very beginning of his account of this subject, Ṭūsī expresses that these irregularities are from the observer's perspective, and not because of the celestial bodies' own movement. He writes: "If a celestial motion is irregular from our perspective, we must require that it have a model according to which that motion is uniform; this model should also bring about its irregularity with respect to us. For irregular [motion] does not arise from the celestial bodies."[75] To put it simply, an irregular motion with respect to the observer is indeed the combination of regular motions of the orbs pertaining to a planet.

74 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 120a. Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 54a.
75 F. J. Ragep, *Tadhkira*, 130-31; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ,* 126, 260.

I.6.1.[2]. … not all of their motions are uniform about the center of the World: Mīrim Chalabī's explanation with a figure is helpful to better understand the meaning of a motion being uniform about a point:



Let's assume that AB, BC and CD are equal in length, which means that the angles that occur at the center O when extending lines from it to the endpoints of those arcs are equal. If these lengths are traversed in equal times, then this motion is called uniform.[76]

I.6.1.[2]. The other [orb of the Sun] is the eccentric [one] whose motion is uniform about its center, which is not the center of the World. Thus, [the Sun's] true motion about the center of the World varies. Since the eccentric center is different from the center of the World, from an observer's perspective, the Sun's motion is slower along the half of the eccentric circle that includes its apogee, faster along the other half that includes

[76] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 51b-52a.

its perigee.[77] A more detailed explanation of the information Qūshjī summarizes is found in the *Tadhkira*.[78]

I.6.1.[3]. … which is among the difficulties in this discipline: In this chapter, Qūshjī describes several difficulties (*mushkilāt*) pertaining to *hay'a*. Describing the problematic aspects of Ptolemaic astronomy and attempting to resolve them started to be an important aspect of Islamic theoretical astronomy as early as the eleventh century when Ibn al-Haytham expressed his doubts (*shukūk*) towards Ptolemaic planetary models. Thereafter, a number of Islamic astronomers contributed to this genre by proposing planetary models that overcome these difficulties. Here, Qūshjī defines, as one of the difficulties in theoretical astronomy, the non-uniform motion of the Moon's deferent orb, since one of the central principles assumed in this tradition is that the motion of each orb must be uniform at its center. According to Mīrim Chalabī, the moderns (*muta'akhkhirūn*) resolved this problem by devising epicycles for the Moon and the vacillating planets. Afterwards, he promised to write a separate treatise in which he would explain, in detail, their solution to this difficulty. Yet, we do not know whether he ever wrote this work and whether it came down to us.[79]

I.6.1.[6]. What is meant by the line of the mean position is…as is the case for the other wandering planets: This part where Qūshjī defines the line of the mean position for the planets is noteworthy not only because it reveals how and why the *Fatḥiyya* text was

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[77] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 55b; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 126-27.
[78] F. J. Ragep, *Tadhkira*, 144-49.
[79] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 55b-56a.

revised by Qūshjī over time, but also because it shows how the composition of the text was a dynamic process that involved the active participation of both teacher and students. In his commentary, Ghulām Sinān relates his conversation with Qūshjī in a class when they were reading this part of the text. He says that the copy they consulted (*fī aṣl al-nuskha*) did not include the phrase "or the planet" in the following sentence: "[…] the point about which the motion of the epicycle center or the planet is uniform." Accordingly, the earlier meaning was that the line of the mean position could only be determined with reference to the epicyclic center. Ghulām Sinān raised his objection to this sentence on the ground that according to the common acceptance in the discipline, the Sun does not have an epicycle, due to which this definition cannot be comprehensive. For this reason, he proposed to use the phrase found in what he calls the draft form (*musawwada*): "[…] and ending at the equator of the inclined orb. And in the Sun is a line extending from the center of the World [i.e. the line of the mean position] that is parallel with a line extending from the center of the eccentric orb to the center of the Sun. In the vacillating [orbs] it is a line extending from the center of the World that is parallel with a line extending from the equant center to the epicyclic center." It is important to note that this expression is exactly found in the first version of the Fatḥiyya (Ayasofya, MS 2733). In other words, Ghulām Sinān wanted the description of the line of mean position to be clearer for each of the planets. The important thing to emphasize here is that in this class, the *Fatḥiyya* text they consulted was not in the first version.

Ghulām Sinān goes on to say that although Qūshjī accepted Ghulām Sinān's main point, he did not prefer to use the phrase in the first version. Instead, he added the phrase "or the planet" to mark out the Sun from planetary bodies that had epicycles. As for the reason why Qūshjī did not keep the sentence in the first version or did not write the Sun instead of "the planet," Ghulām Sinān clarifies this was to render the phrase shorter (*lil-ikhtiṣār*), and to articulate the definition in question in a general manner while the intention is particular (*dhikr al-ʿām wa-irādat al-khaṣṣ*). Based on this account, it is important to note that what I propose in my critical edition as the first version of the text was regarded by both Qūshjī and his students as the draft form (*musawwada*). Furthermore, Ghulām Sinān's account demonstrates that the evolution of the *Fatḥiyya* was strongly linked to Qūshjī's teaching activities. In other words, in-class conversations between the teacher and students on the *Fatḥiyya* had a significant role in its development.[80] Furthermore, another interesting point regarding the textual evolution from the *Risālah* to the *Fatḥiyya* is that the relevant section in the *Risālah* is exactly the same as the one found in the draft/autograph copy of the *Fatḥiyya*.[81]

I.6.1.[8-16]. As Qūshjī states earlier in I.6.1.[6], in order to find the true position of a planet, one should basically know two parameters pertaining to it: the mean motion and the equation. Throughout the paragraphs [8-16], Qūshjī describes the various equations that are calculated depending on the motions of the planets. In his *al-Kashshāf*, al-Tahānawī provides a detailed and historical account of the various definitions of the equation in Islamic astronomical tradition.[82]

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80 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, ff. 122b-123a.
81 Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 8a.
82 Muḥammad Aʿlā b. ʿAlī al-Tahānawī, *Mawsūʿat Kashshāf iṣṭilāḥāt al-funūn*, eds. Rafic Al-Ajam et al., vol. 1 (Beirut: Librairie du Liban Publishers, 1996), 476-81.

I.6.1.[11]. [This amount] is called the first equation… called the second equation. They called the sum of [these] two equations the adjusting equation: As Mīrim Chalabī notes, the reason for the second equation is that since the epicyclic center moves along the eccentric orb, its size changes with respect to us, following the insights of the science of optics (*al-manāẓir*). In other words, the epicyclic circle becomes larger as it approaches to the perigee, and it is the opposite when it is closer to apogee. In this respect, Mīrim Chalabī refers to Niẓām al-Dīn al-Nīsābūrī's explanation of the difference between the first and second equations in his commentary on the *Tadhkira*.[83]

I.6.1.[12]. The figure as part of the explanation in this paragraph is another intriguing example of the evolution of the *Fatḥiyya* text and Ghulām Sinān's role in it. He relates that in a class in which Qūshjī was teaching this subject based on Qūshjī's *Fatḥiyya* autograph copy (*aṣl al-nuskha*), Ghulām Sinān objected to the figures since they were "disagreeable (*qabīḥan*)", as they were not compatible with reason and knowledge transmitted from earlier works on the subject (*al-maʿqūl wa-al-manqūl*). After considering this objection for some time, Qūshjī accepted that Ghulām Sinān was right and revised the figure. Actually, the figure in the autograph copy is also mistakenly drawn (Ayasofya, MS 2733, f. 23b). The question then is whether this Ayasofya version is the one Qūshjī consulted in that class. The answer is a bit complicated. In addition to the correct figures, Ghulām Sinān also drew the earlier "incorrect" ones to which he had objected in class, by noting that these were the ones in Qūshjī's copy at hand (*fī aṣl al-nuskha*). However, a marginal note on top of these "incorrect" figures in Ghulām Sinān's commentary suggests that they were not the ones

[83] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 61b-62a.

Qūshjī and Ghulām Sinān discussed. It says that these are not from the draft copy (*huwa ghayr al-musawwada*). In other words, one can safely infer that there should be another copy that represented a later version of the text. The figures in the copies I use in my critical edition are not completely the same as the ones given by Ghulām as Qūshjī's earlier mistake figures. Unfortunately, I have not come across a copy that includes a different version of the "incorrect" figures during my research. All in all, Ghulām Sinān's note reveals again the significance of in-class conversations in the evolution of the text. Moreover, this is also compatible with the theory I propose in the "Editorial Procedures," namely that Qūshjī revised the text more than once until his death.[84] For the difference between the figures in the copies used in the critical edition, one can consult the figure apparatus.

I.6.1.[14]. ...observations showed that these three matters diverge for the Moon: In his *Risālah*, Qūshjī uses the phrase "the observation and calculation" instead of "observations" given in the *Fatḥiyya*.[85]

I.6.1.[15]. ...this is also among the difficulties in this discipline: Mīrim Chalabī reiterates his desire to write an "appendix (*dhayl*)" to address the difficulties observed in *hayʾa*.[86]

I.6.1.[17]. what occurs to the five vacillating planets in longitude are retrogradation, direct motion, and station: Further explanations for the various stages of the planetary

[84] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, ff. 126a-126b.
[85] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 9b.
[86] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 65a.

motions can be found in other *hay'a* works, including Jaghmīnī's *Mulakhkhaṣ*, Qāḍizāda's commentary on it, and Ṭūsī's *Tadhkira*.[87]

I.6.1.[20]. What occurs to the seven wandering planets is variation in their situations in ascending, descending, elevation, and depression….into four parts called the planetary sectors: Qūshjī's account of the planetary sectors is comparable with those in the *Mulakhkhaṣ* and *Tadhkira*.[88] E. S. Kennedy points out that some of the *zīj*es include tables for the planetary sectors. More interestingly, he remarks that sectors seem to have been devised in the Islamic period, and that astrological concerns was the main factor in their introduction.[89] Given this observation, one might curiously ask why major *hay'a* works would include them.

I.6.1.[22]. The paragraph includes parameters presented below in comparison with those in other major works:

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[87] F. J. Ragep, *Tadhkira*, 136-37, 414; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 140-41,266; Qāḍizāda al-Rūmī, *Sharḥ al-Mulakhkhaṣ*, 81-82.
[88] Qāḍizāda al-Rūmī, *Sharḥ al-Mulakhkhaṣ*, 57-62; S. P. Ragep, 118-121; F. J. Ragep, *Tadhkira*, 240-41, 463.
[89] E. S. Kennedy, "A Survey of Islamic Astronomical Tables," *Transactions of the American Philosophical Society* 46, no. 2 (1956): 143.

The Distance of the Eccentric Center from the World Center

	Fatḥiyya	*Risālah*	*Zīj-i Ulugh Beg*	*Tuḥfa*	*Tadhkira*	*Mulakhkhaṣ*	*Almagest*
Sun	2;1,20 I,6.1.[22]	2;1,20 (Ayasofya, MS 2640, f. 11a)	2;1,20 (Revan Collection, MS 1714, f. 108a)	2;5,51 [also given 2;30] (Fazıl Ahmed Paşa, MS 927, f. 25a)	2;5 [also given 2;30] (*Tadh.* 2.6. [4], pp. 146-47)	2;29,30 (*Mul.* I. 5. [111], p. 130)	2;29 (*Alm.*, III. 4 p. 155)
Moon	10;23 I,6.1.[22]	10;23 (Ayasofya, MS 2640, f. 11a)	10;23[90]	10;19 (Fazıl Ahmed Paşa, MS 927, f. 29b)	10;19 (*Tadh.* 2.7. [18], pp. 156-59)	10;19 (Mul. I. 5. [111], p. 130)	10;19 (*Alm.*, V. 4 p. 226)

The Radius of the Moon's Epicycle based on the Inclined Orb being 60

Fatḥiyya	*Risālah*	*Zīj-i Ulugh Beg*	*Tuḥfa*	*Tadhkira*	*Mulakhkhaṣ*	*Almagest*
5;12 I,6.1.[22]	5;12 (Ayasofya, MS 2640, f. 11a)	5;12[91]	5;15 (Fazıl Ahmed Paşa, MS 927, f. 29a)	5;15 (*Tadh.* 2.7. [16], pp. 156-57)	5;15 (*Mul.* I. 5. [3], p. 261)	5;14 (*Alm.*, IV. 6 p. 202)

[90] I take this value from Julio Samsó, "On the Lunar Tables in Sanjaq Dār's *Zīj al-Sharīf*," *The Enterprise of Science in Islam: New Perspectives*, ed. Jan P. Hogendijk and Abdelhamid I. Sabra (Cambridge, Massachusetts & London, England: The MIT Press, 2003), 305.

[91] I take this value from Sédillot's translation of *Zīj-i Ulugh Beg*. Sédillot, *Prolégomènes des tables astronomiques d'Oloug Beg*, 150.

The Distances of the Deferent Centers from the Center of the World

	Fatḥiyya	*Risālah*	*Tuḥfa*	*Tadhkira*	*Mulakhkhaṣ*[92]	*Almagest*
Saturn	3;29 I,6.1.[22]	3;29 (Ayasofya, MS 2640, f. 11a)	$3+{}^{1}/_{4}+{}^{1}/_{6}$ [i.e. 3;25] (Fazıl Ahmed Paşa, MS 927, f. 35b)	$3+{}^{1}/_{4}+{}^{1}/_{6}$ [i.e. 3;25] (*Tadh.* 2.6. [4], pp. 182-83)	3;25 (*Mul.* I. 5. [12], pp. 130-33)	3;25 (*Alm.*, XI. 5 p. 537)
Jupiter	2;47 I,6.1.[22]	2;47 (Ayasofya, MS 2640, f. 11a)	$2^{3}/_{4}$ [i.e. 2;45] (Fazıl Ahmed Paşa, MS 927, f. 35b)	$2^{3}/_{4}$ [i.e. 2;45] (*Tadh.* 2.6. [4], pp. 182-83)	2;45 (*Mul.* I. 5. [12], pp. 130-33)	2;45 (*Alm.*, XI. 3 p. 524)
Mars	6;14 I,6.1.[22]	6;14 (Ayasofya, MS 2640, f. 11a)	6;0 (Fazıl Ahmed Paşa, MS 927, f. 35b)	6;0 (*Tadh.* 2.6. [4], pp. 182-83)	6;0 (*Mul.* I. 5. [12], pp. 130-33)	6;0 (*Alm.*, X. 7 p. 498)
Venus	0;52 I,6.1.[22]	0;52 (Ayasofya, MS 2640, f. 11a)	${}^{3}/_{4}$ Sun's eccentricity (Fazıl Ahmed Paşa, MS 927, f. 38b)	ca. ${}^{1}/_{2}$ Sun's eccentricity (*Tadh.* 2.6. [4], pp. 182-83; 2.6. [4], pp. 146-47)	1;2 ½ (*Mul.* I. 5. [12], pp. 130-33)	$1^{1}/_{4}$ [i.e. 1;15] (*Alm.*, X. 2 p. 472)

[92] As Jaghmini writes, "[the distance of the eccentric center from the World center] is equal to half the distance of the equant center to it," and therefore parameters given in the *Mulakhkhaṣ* pertain to the distance of the equant center from the World center. I divided them into 2 to get the parameters for the distance of the eccentric centers to the center of the World. S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 130-133.

<u>The Radii of the Epicycles based on the Deferent Orb Being 60</u>

	Fatḥiyya	*Risālah*	*Tuḥfa*	*Tadhkira*	*Mulakhkhaṣ*	*Almagest*
Saturn	6;51 I.6.1.[22]	6;51 (Ayasofya, MS 2640, f. 11a)	$6^1/_2$ [i.e. 6;30] (Fazıl Ahmed Paşa, MS 927, f. 36a)	$6^1/_2$ [i.e. 6;30] (*Tadh.* 2.9. [13], pp. 184-85)	6;30 (*Mul.* I. 5. [3], p. 128-29)	6;30 (*Alm.*, XI. 6 p. 540)
Jupiter	11;47 I.6.1.[22]	11;47 (Ayasofya, MS 2640, f. 11a)	$11^1/_2$ [i.e. 11;30] (Fazıl Ahmed Paşa, MS 927, f. 36a)	$11^1/_2$ [i.e. 11;30] (*Tadh.* 2.9. [13], pp. 184-85)	11;30 (*Mul.* I. 5. [3], p. 128-29)	11;30 (*Alm.*, XII. 3 p. 570)
Mars	39;43 I.6.1.[22]	39;43 (Ayasofya, MS 2640, f. 11a)	$39^1/_2$ [i.e. 39;30] (Fazıl Ahmed Paşa, MS 927, f. 36a)	$39^1/_2$ [i.e. 39;30] (*Tadh.* 2.9. [13], pp. 184-85)	39;30 (*Mul.* I. 5. [3], p. 128-29)	39;30 (*Alm.*, XII. 4 p. 574)
Venus	43;10 I.6.1.[22]	43;10 (Ayasofya, MS 2640, f. 11a)	$43^1/_6$ [i.e. 43;10] $39^1/_2$ [i.e. 39;30] (Fazıl Ahmed Paşa, MS 927, f. 42a)	$43^1/_6$ [i.e. 43;10] (*Tadh.* 2.9. [13], pp. 184-85)	45;0 (*Mul.* I. 5. [3], p. 128-29)	43;10 (*Alm.*, X. 2 p. 472)

Mercury	22;30 I.6.1.[22]	22;30 (Ayasofya, MS 2640, f. 11a)	$22^{1}/_{2}$ [i.e. 22;30] (Fazıl Ahmed Paşa, MS 927, f. 42a)	$22^{1}/_{2}$ [i.e. 22;30] (*Tadh.* 2.8. [13], pp. 170-71)	25;0 (*Mul.* I. 5. [3], p. 128-29)	22;30 (*Alm.*, IX. 9 p. 460)

I.6.1.[23]. All of these amounts are based on our observations: That Qūshjī's phrase "our observations" alludes to the observational activities in Samarqand is also confirmed by Mīrim Chalabī in his commentary.[93]

Section 2 [of Chapter 6]

On What Occurs to the Planets in Latitude

I.6.2.[3]. … called inclined orbs. The maximum value for this inclination is: The values are comparatively given as follows:

Maximum Inclination of the Planets

	Fatḥiyya	***Risālah***	***Tuḥfa***	***Tadhkira***	***Mulakhkhaṣ***	***Almagest***
Saturn	2;30 I.6.2.[3]	2;30 (Ayasofya, MS 2640, f. 11b)	$2^{1}/_{2}$ [i.e. 2;30] (Fazıl Ahmed Paşa, MS 927, f. 57b)	$2^{1}/_{2}$ [i.e. 2;30] (*Tadh.* 2.10. [1], pp. 188-89)	2;30 (*Mul.* I. 5. [16], p. 132-33)	$2^{1}/_{2}$ [i.e. 2;30] (*Alm.*, XIII. 4 p. 605)

[93] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 73b.

Jupiter	1;20 I.6.2.[3]	1;30 (Ayasofya, MS 2640, f. 11b)	$1^{1}/_{2}$ [i.e. 1;30] (Fazıl Ahmed Paşa, MS 927, f. 57b)	$1^{1}/_{2}$ [i.e. 1;30] (*Tadh.* 2.10. [1], pp. 188-89)	1;30 (*Mul.* I. 5. [16], p. 132-33)	$1^{1}/_{2}$ [i.e. 1;30] (*Alm.*, XIII. 3 p. 605)
Mars	1;0 I.6.2.[3]	1;20 (Ayasofya, MS 2640, f. 11b)	1;0 (Fazıl Ahmed Paşa, MS 927, f. 57b)	1;0 (*Tadh.* 2.10. [1], pp. 188-89)	1;0 (*Mul.* I. 5. [16], p. 132-33)	1;0 (*Alm.*, XIII. 3 p. 604)
Venus	0;10 I.6.2.[3]	0;10 (Ayasofya, MS 2640, f. 11b)	$^{1}/_{6}$ [i.e. 0;10] (Fazıl Ahmed Paşa, MS 927, f. 61a)	$^{1}/_{6}$ [i.e. 0;10] (*Tadh.* 2.10. [1], pp. 188-89)	0;10 (*Mul.* I. 5. [16], p. 132-33)	$^{1}/_{6}$ [i.e. 0;10] (*Alm.*, XIII. 3 p. 601)
Mercury	0;45 I.6.2.[3]	0;45 (Ayasofya, MS 2640, f. 11b)	¾ [i.e. 0;45] (Fazıl Ahmed Paşa, MS 927, f. 61a)	½+$^{1}/_{4}$ [i.e. 0;45] (*Tadh.* 2.10. [1], pp. 188-89)	0;45 (*Mul.* I. 5. [16], p. 132-33)	¾ [i.e. 0;45] (*Alm.*, XIII. 3 p. 601)
Moon	5;0 I.6.2.[3]	5;0 (Ayasofya, MS 2640, f. 11b)	5;0 (Fazıl Ahmed Paşa, MS 927, f. 26b)	5;0 (*Tadh.* 2.7. [4], pp. 150-51)	5;0 (*Mul.* I. 5. [16], p. 132-33)	5;0 (*Alm.*, V.7 p. 237)

Interestingly, the parameters for Jupiter and Mars in the *Fatḥiyya* and *Risālah* differ. Unfortunately, the *Fatḥiyya* commentators do not give any clue as to why Qūshjī revised the parameters in the *Fatḥiyya*. Additionally, in his commentary on the *Risālah*, Muṣliḥ al-Dīn al-Lārī writes that Qūshjī's parameters are different from the previous observations without offering any further detail.[94]

I.6.2.[6]. The inclination attains its maximum at the two nodes… And the maximum [value] for this inclination is: The following table provides the parameters:

Maximum Inclination of Apex and Perigee

	Fatḥiyya	*Risālah*	*Tuḥfa*	*Tadhkira*	*Almagest*[95]
Saturn	6;0 I.6.2.[6]	6;0 (Ayasofya, MS 2640, f. 12a)	4 1/2 [i.e. 4;30] (Fazıl Ahmed Paşa, MS 927, f. 60a)	4 1/2 [i.e. 4;30] (*Tadh.* 2.10.[4], pp. 190-91)	4 1/2 [i.e. 4;30]
Jupiter	2;46 I.6.2.[6]	2;46 (Ayasofya, MS 2640, f. 12b)	2 1/2 [i.e. 2;30] (Fazıl Ahmed Paşa, MS 927, f. 60a)	2 1/2 [i.e. 2;30] (*Tadh.* 2.10.[4], pp. 190-91)	2 1/2 [i.e. 2;30]
Mars	2;07 I.6.2.[6]	2;07 (Ayasofya, MS 2640, f. 12b)	2 1/4 [i.e. 2;15] (Fazıl Ahmed Paşa, MS 927, f. 60a)	2 1/4 [i.e. 2;15] (*Tadh.* 2.10.[4], pp. 190-91)	2 1/4 [i.e. 2;15]

94 Muṣliḥ al-Dīn al-Lārī, *Sharḥ Risālah dar hay'ah*, Kandilli Collection, MS125, f. 36a.
95 Values are taken from Noel M. Swerdlow, "Ptolemy's Theories of the Latitude of the Planets in the *Almagest*, *Handy Tables*, and *Planetary Hypotheses*," in *Wrong for the Right Reasons*, ed. Jed Z. Buchwald and Allan Franklin (Dordrecht, Berlin, Heidelberg, and New York: Springer, 2005), 45-46,63.

Venus	2;30 I.6.2.[6]	2;30 (Ayasofya, MS 2640, f. 12b)		$2^{1}/_{2}$ [i.e. 2;30] (*Tadh.* 2.10.[4], pp. 192-93)	2;30
Mercury	6;15 I.6.2.[6]	6;15 (Ayasofya, MS 2640, f. 12b)		$6^{1}/_{4}$ [i.e. 6;15] (*Tadh.* 2.10.[4], pp. 192-93)	6;15

The commentators point out the difference between some parameters given in the *Fatḥiyya* and other major *hayʾa* works, relating it to the observations done by Qūshjī in Samarqand. As an example, Ghulām Sinān underlines that Qūshjī's value for Saturn is different from those given in the *Mulakhkhaṣ* and *Tuḥfa*.[96]

I.6.2.[7]. … the inferior planets particularly have another latitude called the latitude of the slope [*wirāb*], the slant [*inḥirāf*], the twist [*iltiwāʾ*], and the winding [*iltifāf*] …The maximum [value] for this inclination is $3^{1}/_{2}$ for Venus, and 7;0 for Mercury: Jaghmīnī uses Ptolemaic values (2½) for both Mercury and Venus, whereas Qūshjī's parameters in both the *Fatḥiyya* and *Risālah* are the same as those used by Ṭūsī.[97]

[96] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 134b; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 77a.
[97] Ptolemy, *Almagest*, 633-34; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 134, 264; F. J. Ragep, *Tadhkira*, 194-95 425; Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 12b.

I.6.2.[8]. We say that in the beginning of Muḥarram, 841 years after migration of the Prophet (peace and prayers be upon him), the date on which we composed *al-Zīj al-Jadīd*, [the apogee were at]: The values given in the *Fatḥiyya*, *Risālah* and *Zīj-i Ulugh Beg* are as follows:

Locations of the Apogees

	Fatḥiyya	***Risālah***	***Zij-i Ulugh Beg***
Sun	**Cancer** 2;26 1.6.2.[8]	**Cancer** 2;26 (Ayasofya, MS 2640, f. 12b)	**Cancer** 0;30,04,48 (Revan Collection, MS 1714, f. 115b)
Saturn	**Sagittarius** 16;56 1.6.2.[8]	**Sagittarius** 16;56 (Ayasofya, MS 2640, f. 12b)	**Sagittarius** 9;55,31 (Revan Collection, MS 1714, f. 133a)
Jupiter	**Virgo** 29;32 1.6.2.[8]	**Virgo** 29;32 (Ayasofya, MS 2640, f. 12b)	**Virgo** 17;31,31 (Revan Collection, MS 1714, f. 137a)
Mars	**Leo** 21;57 1.6.2.[8]	**Gemini** 22;25 (Ayasofya, MS 2640, f. 12b)	**Leo** 21;56,48 (Revan Collection, MS 1714, f. 140a)
Venus	**Gemini** 22;25 1.6.2.[8]	**Gemini** 22;25 (Ayasofya, MS 2640, f. 12b)	**Gemini** 22;25,25 (Revan Collection, MS 1714, f. 143b)

Mercury	**Scorpio** 4;28 1.6.2.[8]	**Scorpio** 14;28 (Ayasofya, MS 2640, f. 13a) **Scorpio** 4;28 (Esad Efendi, MS 2023, f. 103a; Ayasofya MS 2639, f. 41b)	**Scorpio** 4;28,28 (Revan Collection, MS 1714, f. 147b)

This part is significant in the following ways. First, this phrase can be considered evidence for the date of *Zīj-i Ulugh Beg*'s 'official' publication. As a matter of fact, the first of *Muḥarram* in 841/5 July 1437 is the first date for which the *Zīj* provides parameters; therefore, it is obvious that its preparation started before this date. That being said, as I have briefly dealt with in the chapter on Qūshjī's intellectual biography, the *Zīj* continued to be revised even after this date. The second interesting point regarding these parameters is that there are differences in some values between the *Fatḥiyya*, *Risālah* and *Zīj-i Ulugh Beg*. One of them is that in the extant oldest copy of the *Risālah* (Ayasofya, MS 2640), Mercury's apogee is given as 14;28 instead of 4;28, which seems to be a mistake given other copies of the work (i.e. Esad Efendi, MS 2023, and Ayasofya, MS 2639). The second difference between these works is that again in the *Risālah*, the apogees of Mars and Venus are located in the same place. My assumption is that when Qūshjī was writing his work, he forgot to write the value for Mars, which leads one to think that he gave the same value for both Mars and Venus that was mentioned after it *(…wa-awj Mirrīkh wa-awj Zuhrah dar bist wa dū darajah wa bist wa panjdaqīqah Jawza…*). More interestingly, while some copies of the

Risālah include this mistake (i.e. Esad Efendi MS 2023, f. 103a; Ayasofya MS 2639, f. 41b; Feyzullah, MS 1337, f. 80b), others do not (Greaves, MS 21, f. 47b; Kütahya, Vahid Paşa, MS 797, f. 14a). Additionally, the Turkish translations of the *Risālah* use the same parameter for Mars as those in the *Fatḥiyya* and *Zīj*.[98] The main *Risālah* text used in Lārī's commentary also includes the correct parameter.[99] More interestingly, next to the first table provided for the motions of the Sun in *Zīj-i Ulugh Beg* is a marginal note quoted from Qūshjī's *Risālah.*[100] This quotation gives the same parameters as those in the *Fatḥiyya*. Even though we do not know from which copy of the *Risālah* this quotation was taken, it is likely that the wrong parameter for Mars' apogee in the *Risālah* was corrected later. That being said, the circulation of the wrong parameter is still an intriguing case regarding the evolution and reception of the *Risālah* text.

But the most surprising discrepancy occurs when it comes to the parameters for the apogees of the Sun, Saturn, and Jupiter. While the *Fatḥiyya* and *Risālah* have the same values, *Zīj-i Ulugh Beg* has different parameters. Another marginal note in Arabic right above the aforementioned quotation in the *Zīj* from Qūshjī's *Risālah* explains the reason (Revan Collection, MS 1714, f. 147b). The note, which does not give any clue as to who might have written it, states that the parameters for the apogee of the Sun (*awj al-shams al-mawḍūʿ*), Saturn and Jupiter given in the *Zīj-i Ulugh Beg* are not correct (*ghayr ḥaqīqī*), since they lack the values of the maximum equation (*nāqiṣ bi-ghāyat taʿdīlihā*). It gives those parameters for the maximum equations (1;56,58,12 for the Sun; 7;0 for Saturn; 12;0 for Jupiter). When we add those parameters to the values in the *Zīj*, the values found in

[98] Seydī ʿAlī Reʾīs, *Khulāṣat al-hayʾa*, Aşir Efendi, MS 223, f. 19a; Parwīz ʿAbd Allāh, *Mirqāt al-samāʾ*, Süleymaniye Manuscript Library, Halet Efendi Collection, MS 533, f. 21a.
[99] Muṣliḥ al-Dīn Lārī, *Sharḥ Risālah dar hayʾah*, Kandilli, MS 125, f. 39a.
[100] Ulugh Beg, *Zīj-i Ulugh Beg*, Revan, MS 1714, f. 115b.

Fatḥiyya and *Risālah* are obtained. Neither the *Fatḥiyya* commentators, Ghulām Sinān and Mīrim Chalabī, nor the *Risālah* commentator, Lārī, address the discrepancies summarized above.[101]

I.6.2.[9]. For the definitions of "in advance (*mutaqaddim*)" and "beyond (*muta'akhkhir*)" used in this paragraph, one can consult S. P. Ragep's explanation and the relevant section in Qāḍīzāda's commentary.[102]

I.6.2.[9]. As for the [positions] of the *jawzahr*s, Saturn's head is 3 degrees beyond its apogee: As Mīrim Chalabī remarks, Qūshjī gives a wrong value. The correct phrase should be that Saturn's tail is 30 degrees beyond its apogee, as its head is 150 degrees in advance of its apogee.[103] Another evidence that this is probably a mistake on the side of Qūshjī is that he gives the correct value in the *Risālah*.[104] Another important point is that the main text in Ghulām Sinān's commentary writes the correct value. But I believe that an earlier value was deleted in that line of the commentary and then corrected. In terms of the transmission of Qūshjī's parameters, a striking example is that among the available copies of the *Fatḥiyya*, only two copies include the correct value (Kandilli MS 122 and Islamic University of Madinah Collection, catalogue number not available). Although Ghulām Sinān's correction might have been connected to Qūshjī, it still remains unclear.

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[101] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 135b; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 78b; Muṣliḥ al-Dīn Lārī, *Sharḥ Risālah dar hay'ah*, Kandilli, MS 125, ff. 39a-39b.
[102] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 138-39; Qāḍīzāda al-Rūmī, *Sharḥ al-Mulakhkhaṣ*, 79-80.
[103] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 79a.
[104] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 13a.

Section 3 [of Chapter 6]

On What Occurs to the Planets in Longitude and Latitude Together

I.6.3.[1]. What is meant by the apparent position is the endpoint of a line extending from the center of the World, being parallel with the line extending from the perspective of sight to the center of the planet, and terminating on the greatest orb: This chapter covers the theory of parallax with a particular attention to the Moon. One can find information about it in Bīrūnī's *Tafhīm* and Jaghmīnī's *Mulakhkhaṣ*,[105] and there is a lengthy separate chapter in the *Tadhkira* (II. 11: "On Parallax") on this subject.[106] The striking part of this chapter in the *Fatḥiyya* is that Qūshjī's definition of parallax differs from the one held by the majority of his predecessors, including Ṭūsī. According to the commonly held assumption, parallax is the difference between the true and apparent positions of a planet. However, Qūshjī has a different understanding of "apparent position." Ṭūsī regards it as the endpoint of the line extending from the observer's position, passing through the planet and ending on the zodiacal orb. Ghulām Sinān also remarks that Qūshjī left the commonly held understanding of parallax in favor of the one held by Jurjānī in *Sharḥ al-Tadhkira*. According to him, the apparent position of a planet should always be closer to the horizon, as readily observed by someone with "a sound disposition (*al-fiṭra al-salīma*)."[107] Ghulām Sinān ascribes the first definition of the parallax to the *mutaqaddimūn*, and the one held by Qūshjī and Jurjānī to the *muta'akhkhirūn*, though it is not clear whom

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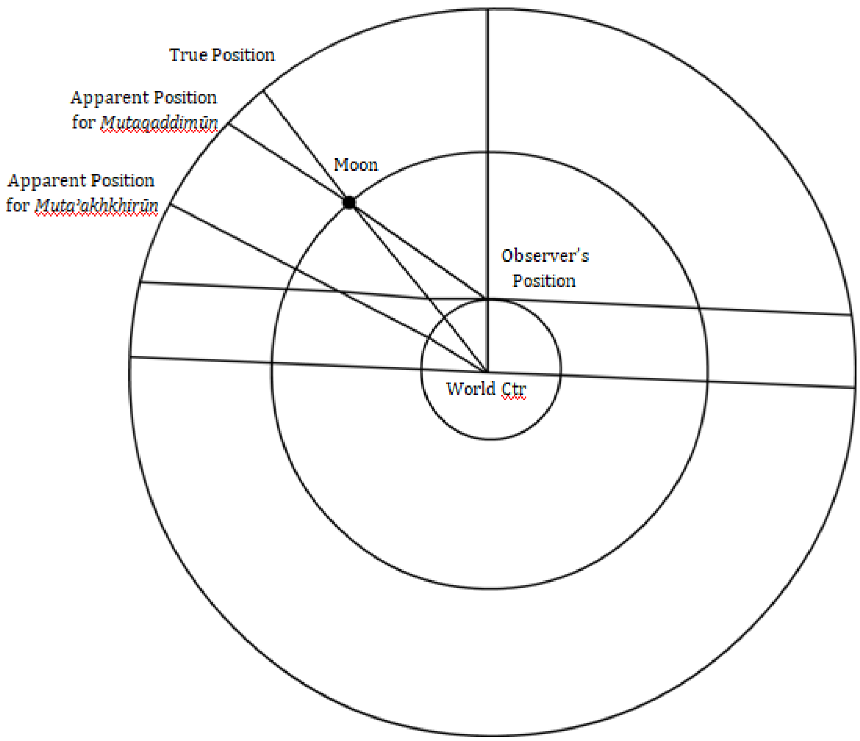
[105] Bīrūnī, *The Book of Instruction in the Elements of the Art of Astrology*, trans. Robert Ramsay Wright (London, Luzac & Co., 1934), 158-59; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 122-123. For a mathematical analysis of the parallax theory in Islamic context, see also E. S. Kennedy, "Parallax Theory in Islamic Astronomy," *ISIS* 47 (1956): 33-53.

[106] F. J. Ragep, *Tadhkira*, 222-28.

[107] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 136b.

he is referring to specifically. He draws the following figure in his commentary to show where the *mutaqaddimūn* and *mutaʾakhkhirūn* take as the apparent position.



Nevertheless, accepting the definition given by Ṭūsī, Mīrim Chalabī objects to Qūshjī's approach and reminds the reader that its definition is well elaborated in Shīrāzī's *Tuḥfa* and *Nihāya*.[108] The topic deserves further research as being at the intersection of theoretical astronomy, optics, and philosophy.

108 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 79b-80a.

Section 4 [of Chapter 6]

On What Occurs to the Planets in their Relative Positions to One Another

I.6.4.[1-2]. Qūshjī's explanation of the phases of the Moon and solar and lunar eclipses in these two paragraphs rely largely on the *Mulakhkhaṣ* in terms of its structure and content.[109] However, Figures 10 and 11 are not found in the *Mulakhkhaṣ*. Presumably they are taken from the *Tuḥfa*, where the same figures can be found.[110] The *Risālah* does not contain Figure 11. Further elaboration of the subject can be found in the *Tadhkira* and *Tuḥfa*, as well as Mīrim Chalabī's commentary.[111]

I.6.4.[5]. … the diameter of Mars' epicycle is much bigger than the diameter of the Sun's parecliptic [orb] with the [addition] of the thickness of the complementary body of Mars: Mīrim Chalabī's explanation is helpful since he compares the values pertaining to the sizes of the orbs of the Sun and Mars.[112]

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109 Compare S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 142-45.
110 Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 65a 68b.
111 F. J. Ragep, *Tadhkira*, 228-39; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 63b-71a; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 83a-90a.
112 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 89a-89b.

The Second Part

On an Explanation of the Configuration of the Earth and Its Division into Climes; An Explanation of [the Consequences] Accruing to it Due to the Positions of the Celestial Bodies

Chapter 1 [of Part 2]

An Explanation of the Configuration of the Earth and Its Division into Climes

II.1.[1]. The Earth is spherical in form: With reference to Chapter 1 of Part 1, entitled "On Explaining the Total Number of Orbs and the Manner of Their Arrangement," in which Qūshjī says that there are undulations on the surface of the Earth, Mīrim Chalabī reminds us that the sphericity of the Earth is in accordance with our sensible perception, not in reality (*bi-ḥasab al-ḥissī lā bi-ḥasab al-ḥaqīqī*).[113]

II.1.[1]. If it were possible to travel around the entire Earth and three individuals were assumed to split apart from a single location…it is answered positively and [so] is found to be strange: First, this example is not given in the *Risālah*.[114] The structure of this chapter in the *Fatḥiyya* seems to rely on the *Tadhkira*, as the same example is also found in the beginning of the first chapter of Book III. Mīrim Chalabī's commentary and Shīrāzī's *Nihāya* offer helpful elaborations on this issue.[115]

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[113] Ibid, f. 90a.
[114] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 15a.
[115] Savadi, *The Historical and Cosmographical Context*, 125-26, 262-63; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 90b-92b.

II.1.[2]. The inhabited of them is one of the northern quarters, and it is well-known as the populated quarter: In the *Nihāya*, Shīrāzī makes a striking objection to this idea by saying that "it is possible that in the other quarters there are many inhabited lands we are not aware of, since there are drowning seas and towering mountains between us and them."[116]

II.1.[2]. …not all of that quarter is inhabited, but the latitude of the inhabited part is 66½ degrees: This value is rounded down to 66 degrees in the *Mulakhkhaṣ*. As Qūshjī mentions in the *Risālah*, the limit of the inhabited part of the northern region of the Earth is the value corresponding to the complement of the total obliquity.[117] According to Ṭūsī, the reason for this is that the region with a higher latitude is too cold to live. Qūshjī's value of total obliquity is 23;30,17, as mentioned earlier in Chapter 3 of Part 1. Accordingly, he gives a rough calculation of its complement as 66.5 degrees. More interestingly, as Jaghmīnī informs us, Ptolemy stated that "he found habitation below the equator to a distance of 16;25."[118] However, Qūshjī does not mention this, most probably because he is in favor of Ṭūsī's position that there was no habitation in the southern region.[119]

II.1.[2]. …some of [the Greeks] take it to be from the coast of the Western Ocean and some of them from islands called the Eternal Islands and Fortunate Islands, whose distance from the coast is 10 degrees: Here, Qūshjī mentioned two positions from which

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[116] Savadi, *The Historical and Cosmographical Context*, 264.
[117] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 15a.
[118] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 148-49.
[119] F. J. Ragep, *Tadhkira*, 246-49.

the initial longitude should be located. Qūshjī's position is the same one found in *Zīj-i Ulugh Beg*, which takes the Eternal or Fortunate Islands as the initial longitude.[120]

II.1. [2]. …[The islands] were inhabited in the past, but now are submerged: A marginal note found in a copy of Ghulām Sinān's commentary (Fatih MS 5396) shows the potential of *hayʾa* works for tracing the reception of new knowledge by the Islamic Empires, including the Ottomans, that resulted from European overseas explorations during the early modern period. A reader of this copy whose nickname was al-Riyāḍī wrote that the Portuguese people went to the Eternal or Fortunate Islands and found them not submerged, but inhabited (*maʿmūra*).[121] This little note resonates remarkably with the fact that the sixteenth-century witnessed a global rivalry between the Ottoman and Portuguese powers in the Mediterranean Sea and even in the Indian Ocean.[122]

II.1.[2]. …called cupola of the Earth: Mentioning that this location is always 90 degrees distant from the initial longitude, both Ghulām Sinān and Mīrim Chalabī remark that its location differs depending on where one takes the initial point.[123] This explanation is also in line with Ṭūsī's account.[124]

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[120] Ulugh Beg, *Zīj-i Ulugh Beg*, Revan, MS 1714, f. 102a.
[121] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 142a.
[122] For the Ottoman-Portuguese rivalry, see Giancarlo Casale, *The Ottoman Age of Exploration* (Oxford & New York: Oxford University Press, 2010).
[123] Ghulām Sinān, *Fatḥ al-Fatḥiyya,* Fatih, MS 5396, f. 142b; Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 94b-95a.
[124] F. J. Ragep, *Tadhkira*, 250-51.

II.1.[3]. The initial and midpoints of the climes and [their] longest periods of daylight are as follows: In the *Fatḥiyya*, Qūshjī uses Ṭūsī's values in the *Tadhkira*. As for the comparison between the *Fatḥiyya* and *Risālah*, if one ignores the scribal error for the latitude of the endpoint of the seventh clime in the *Risālah* (53 is written instead of $50^1/_3$), the values are the same.[125] The *Fatḥiyya* does not include a figure depicting the seven climes, but the *Risālah* does.

II.1.[3]. It is obvious that once the latitudes of the initial points, midpoints and endpoints of the climes are known…Once this principle is [accepted], there is no need to list the localities in each clime, as has been done conventionally: The *Fatḥiyya* follows the *Tadhkira* in not listing the names of the major localities for each clime. Nevertheless, Mīrim Chalabī seems to have not been satisfied with Qūshjī's terse approach, listing instead the major localities, mentioning the number of mountains and rivers, and even providing the skin colors of the people who lived in those climes. His justification in doing this is that the nature of the learners (*ṭibāʿ al-mutaʿallimīn*) is to be inclined to know such things.[126] Indeed, as Ghulām Sinān informs us, this justification seems to be adopted from Jurjānī's *Sharḥ* al-*Tadhkira*, which lists some of the localities given in the *Nihāya*.[127] It is also notable that Mīrim Chalabī's list of localities seems to be more extensive than the one in the *Nihāya*.[128]

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[125] Qūshjī, *Risālah*, f. 15b. Interestingly enough, this scribal error was present in the *Risālah* copies I have examined (Ayasofya MS 2639, f. 52a; Greaves 21, f. 51b; Esad Efendi MS 2023, 109b).
[126] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff.101a-101b.
[127] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 145a; Al-Sayyid al-Sharīf al-Jurjānī, *Sharh al-Tadhkira*, Süleymaniye Manuscript Library, Ayasofya Collection, MS 2645, ff. 89-90a.
[128] For the localities listed in the *Nihāya* see, Savadi, *The Historical and Cosmographical Context*, 141-45, 278-82.

Chapter 2 [of Part 2]

On the Characteristics of the Equator

II.2.[1]. The turning of the orb there is wheel-like there, and therefore their horizons are called the horizons of the right orb: First, the extent to which the main structure and content of this chapter is largely based on the *Tadhkira* is such that one can identify several direct quotations from it. As far as this paragraph is concerned, the *Fatḥiyya*'s account is more extensive than that of the *Risālah*. One of the examples for the connection of the *Fatḥiyya* to the *Tadhkira* is the definition of the horizons of the right orb, which is not included in the *Risālah*. Ragep remarks that the term "the right orb" is the same as *sphaera recta*, which was used in medieval Latin astronomy.[129] Grammatically speaking, as Ghulām Sinān remarks with reference to the *Tadhkira*, the feminine usage of the word "right (*al-mustaqīma*)" is wrong; it should be in the masculine form since the word *falak* is masculine. This little detail speaks of Ghulām Sinān's commitment to the *Fatḥiyya* text in the form he received from his teacher, even when it comes to subtle grammatical mistakes on the side of Qūshjī.[130]

II.2.[2]. The grand master Abū ʿAlī b. Sīnā … The most erudite Imām Fakhr al-Dīn al-Rāzī…judged…the judicious sage Naṣīr al-Dīn al-Ṭūsī: The comparison of Ibn Sīnā and al-Rāzī regarding the most temperate clime is dealt with by Ṭūsī, who also put forth his own opinion on the subject. This paragraph in the *Fatḥiyya* is a summary of the relevant

[129] F. J. Ragep, *Tadhkira*, 472.
[130] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 146a.

section in the *Tadhkira*.[131] Being more in line with al-Rāzī's opinion, Ṭūsī's approach seems to be adopted by Qūshjī as well. The striking difference between the *Risālah* and *Fatḥiyya*, in turn, is that the *Risālah* only mentions Ibn Sīnā's approach briefly without naming him, as well as some localities and dispositions of the people who lived in those localities. Yet, Qūshjī's account in the *Risālah* gives the impression that he does not accept Ibn Sīnā's position.[132] An extensive elaboration of the subject can be found in the *Nihāya*.[133]

Chapter 3 [of Part 2]

On the Characteristics of the Oblique Horizons in a General Manner

Complementing each other, this chapter and the following one cover the characteristics of the localities with oblique horizons, namely those having a latitude less than 90 degrees (other than the equator). In this chapter Qūshjī deals with the subject "in a general manner (*al-wajh al-kullī*)," introducing the divisions of the oblique horizons with a brief account concerning their visible and invisible parts. When one compares this chapter to the corresponding section in the *Risālah*, Qūshjī uses almost the same content in both the texts. In fact, Qūshjī seems to draw largely on the *Tadhkira*, *Nihāya* or *Tuḥfa* as a few direct quotations from them and the structure of their chapters on this subject suggest. That being said, Qūshjī's one is much shorter. Thus, one can consult the relevant parts of the *Nihāya* and *Tadhkira* for further information.[134]

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131 F. J. Ragep, *Tadhkira*, 256-59, 473.
132 Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 16b.
133 Fateme Savadi also examines the subject in her study of the *Nihāya*. Savadi, *The Historical and Cosmographical Context*, 81-92, 148-51, 284-88.
134 F. J. Ragep, *Tadhkira*, 258-63; Savadi, *The Historical and Cosmographical Context*, 152-59, 289-96; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 81a-82a.

II.3.[1]. … when the Sun reaches one of the equinoxes, day and night is equal in all of these horizons: As Jaghmīnī informs us, the days in which the equinoxes occur were commonly known in Islamic astronomical tradition as Nayrūz (for the vernal equinox) and Mihrjān (for the autumnal equinox).[135]

II.3.[1]. They divide the day-circuits in two unequal parts: the largest of them is the visible part that is on the side of the visible pole; the invisible [part] is on the side of the invisible pole: For the demonstration of how a circle is divided into two unequal parts by another circle, Mīrim Chalabī directs his reader to Proposition 19 in the Second Book in Theodosius' *Spherics*.[136]

II.3.[2]. [**Regarding] any two day-circuits with equidistant from either side of the equinoctial, the visible part of one of them is equal to the invisible part of the other**: Once again Mīrim Chalabī refers to Proposition 19 in the Second Book in Theodosius' *Spherics*.[137]

II.3.[2]. [**The circuit] whose distance on the [same] side is less than the local latitude intersects [the prime vertical] at eastern and western points at which the star has zero azimuth**: Ghulām Sinān says that if the latitude of what he calls "our city (*baladunā*)," was 40 degrees, then the altitude of the visible pole would also be this amount. Given the

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[135] S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*,154-55, 273-74.
[136] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, ff. 107a-107b. For the details of the Proposition, see Naṣīr al-Dīn al-Ṭūsī, *Taḥrīr al-ukar li-Thāwudhūsiyūs (Majmūʿ al-rasāʾil)*, vol. 1 (Hyderabad: Dāʾirat al-maʿārif al-ʿuthmāniyya, 1385), 26-27.
[137] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 108a.

fact that the *Zīj-i Ulugh Beg* gives Istanbul's latitude as 41 degrees, it seems that Ghulām Sinān wanted to take a round value for pedagogical concerns, and his example of Istanbul also seems to aim to make the subject more understandable for his readers in the city.[138]

Chapter 4 [of Part 2]

On the Characteristics of Each of the Five Divisions for the Oblique Horizons

This chapter is a continuation of the previous one in which Qūshjī divided the horizons into five and summarized their main characteristics. In this chapter, he deals with each of these divisions and explains the visible and invisible parts of some great circles on the celestial sphere, as well as their rising and setting. Like the previous one, this chapter is also largely drawn from the relevant two chapters covered in the *Tadhkira*.[139] Again, Qūshjī's account is much shorter than the *Tadhkira*.

II.4.[1]. As for the first division: As explained in the previous chapter, it is "the [horizon] whose latitude is less than the total obliquity" (II.3.[1]).

II.4.[2]. As for the second division: It is "the one whose latitude is equal to the total obliquity" (II.3.[1]).

II.4.[3]. As for the third division: It is "the one whose latitude is more than the total obliquity and less than its complement" (II.3.[1]).

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138 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 148a. For the latitude parameter for Istanbul in *Zīj-i Ulugh Beg*, see Ulugh Beg, *Zīj-i Ulugh Beg*, Revan, MS 1714, f. 102a.
139 F. J. Ragep, *Tadhkira*, 262-81.

II.4.[4]. As for the fourth division: It is "the one whose latitude is equal to the complement [of the total obliquity]" (II.3.[1]).

II.4.[5]. As for the fifth division: It is "the one whose latitude is more than the complement of the [total] obliquity and less than 90" (II.3.[1]).

II.4.[5]. The visible zodiacal pole and visible solstice will be on the meridian simultaneously, but in opposite directions from the zenith and their altitudes are at opposite [extremes]: This chapter in the *Fatḥiyya* ends with this sentence, but the *Risālah* covers an example to aid the reader's understanding. Qūshjī assumes a latitude with 70 degrees and explains the rising and setting of the stars and zodiacal signs for that horizon.[140] As a matter of fact, the very same example, namely assuming a 70-degree latitude, is also given in the *Tadhkira* and *Tuḥfa*.[141] Why then did Qūshjī prefer to omit this example in the *Fatḥiyya*? The *Tadhkira* and *Tuḥfa* are larger works than the *Fatḥiyya*, but even if one compares it to the *Mulakhkhaṣ*, which gives examples to make the subject more understandable[142], Qūshjī's omission of the example already included in the *Risālah* is revealing. The reason might be his intention to keep his work "small in words […] diminutive in volume" as he states in the Introduction (See, Intro.[1]).

140 Qūshjī, *Risālah*, Ayasofya, MS 2640, ff. 19a-20a.
141 F. J. Ragep, *Tadhkira*, 268-79; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 83b-85a.
142 S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 158-61.

Chapter 5 [of Part 2]

On the Characteristics of Locations Whose Latitude is One-Quarter Revolution

This chapter is almost identical with the relevant chapter in the *Tadhkira* (III.6), as is suggested by many direct quotations. Yet, there are a couple of changes made by Qūshjī either to correct what he thinks is a mistake on the side of Ṭūsī or to update the data.

II.5.[2]. Beneath the northern pole at this time, the period of daytime is longer than [that of] night by nine of our nychthemerons: As Ragep points out in his commentary to the *Tadhkira* Ṭūsī writes it as 7 days, even though Ptolemy calculated the difference between the period for spring and summer, during which the Sun is always above the horizon, and the period for fall and winter, during which the Sun is always below the horizon, as $8^3/_4$ days. Later Shīrāzī also writes it as 7 days in the *Nihāya*.[143] As Ragep points out, Birjandī, one of the commentators of the *Tadhkira*, thought it was "a slip of the pen on Ṭūsī's part since seven and nine are very similar when written out in Arabic script."[144] As Ghulām Sinān informs us, Qūshjī said in his class that nine days of difference is based on Ptolemy's calculation (he basically rounds from $8^3/_4$ days). However, he remarks that according to the calculation of the moderns (*muta'akhkhirūn*), it should be approximately 8 days, which is compatible with Ragep's calculation according to the values of solar eccentricity and longitude of solar apogee accepted by the moderns.[145] Additionally, Qūshjī also thought that Ṭūsī's value was "a slip of the pen (*sahwan min al-qalam*)."[146] Then one is left to wonder why Qūshjī did not use the value of 8 days in the *Fatḥiyya*, as proposed by

[143] Savadi, *The Historical and Cosmographical Context*, 175, 311.
[144] F. J. Ragep, *Tadhkira*, 280-81, 478.
[145] Ibid., 478.
[146] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 154a.

the moderns. More interestingly, in his *Risālah*, Qūshjī uses Ṭūsī's value of 7 days.[147] Does it mean that when he was writing his *Risālah*, he was not aware of the problem associated with Ṭūsī's value? Maybe he made a hasty acceptance of Ṭūsī's value, which he would change in the *Fatḥiyya* after his verification.

II.5.[2]. This is [the case] because the apogee of the Sun is at the beginning part of Cancer and its perigee is at the beginning part of Capricorn: The apogee was at the end of Gemini and the perigee was at the end of Sagittarius in the time of Ṭūsī.[148] As the Sun's apogee moves, Qūshjī updated it with the positions of the Sun's apogee and perigee at the date the *Fatḥiyya* was compiled, which was around namely mid-August 1473. It is notable that in the *Risālah*, Qūshjī does not give this type of information for the time it was written.[149]

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[147] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 20b.
[148] F. J. Ragep, *Tadhkira*, 280-81.
[149] Qūshjī, *Risālah*, Ayasofya, MS 2640, ff. 20a-20b.

Chapter 6 [of Part 2]

On the Nychthemerons, Their Daytime and Nighttime Parts, Equal and Unequal Hours, and Dawn and Dusk

As Ghulām Sinān remarks, in this chapter Qūshjī summarizes the three chapters of the *Tadhkira*: III.8. "On the Lengths of the Nychthemerons"; III.9. "On Dawn and Dusk"; III.10. "On Understanding the Units of the Day, Namely Hours, and What Is Composed of Days, Namely Months and Years."[150] Qūshjī quotes several sentences from the *Tadhkira*, but the *Fatḥiyya*'s chapter is much shorter than the *Tadhkira*.[151] In addition, this chapter includes direct quotations from the *Nihāya*. Another important detail related to this chapter is the difference between the *Risālah* and *Fatḥiyya*. Compared to the former, the *Fatḥiyya* underwent some changes in terms of its content and structure of the chapters. To give an example, Figure 12, which is an illustration of the emergence of dawn as the Sun's position changes with respect to the horizon of a locality, is not included in the *Risālah*. Furthermore, the subjects in this chapter are covered in two chapters in the *Risālah*: II. 8: On Dawn and Dusk; II.9: On Calendars, Years, Months, and Their Parts Such as Daytime and Night, and Hours.[152]

II.6.[2]. ... the false dawn: One can find further explanation of the term in Ragep's commentary.[153]

150 F. J. Ragep, *Tadhkira*, 286-302.
151 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 155b.
152 Qūshjī, *Risālah*, Ayasofya, MS 2640, ff. 22a-24a.
153 F. J. Ragep, *Tadhkira*, 487.

II.6.[4]. A nychthemeron, according to the practitioners of the stars, is equivalent to the period from the Sun's departure from a half of the meridian… [This period] is longer than the revolution of the equinoctial: Jaghmīnī explains well why the meridian line is considered a reference for the calculation of a nychthemeron: "the variations in the ascensions with respect to the horizons of the inhabited regions are many, [but] it has only one variation with respect to the meridian circle." Qūshjī gives two definitions of a nychthemeron: one according to astronomers, and the other according to Arabs and the majority of the people of Sharīʿa. As far as the first is concerned, it basically follows the definition given in the *Mulakhkhaṣ* and *Tadhkira*.[154] However, Shīrāzī has objections to this definition. According to him, Ṭūsī's definition is not inclusive, since it does not consider the nychthemeron observed in a locality with the latitude of 90. In other words, while Ṭūsī's definition considers a nychthemeron that occurs as a result of one complete revolution by the first motion, in the latitude of 90 degrees, there occurs more than one revolution during the same period.[155] Explaining the definitions of a nychthemeron extensively, Mīrim Chalabī is in line with Shīrāzī's point, highlighting that Qūshjī's definition is valid for most of the inhabited part of the world.[156]

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154 F. J. Ragep, *Tadhkira*, 286-87; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 170-71.
155 Savadi, *The Historical and Cosmographical Context*, 321.
156 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 134a.

Chapter 7 [of Part 2]

On the Months, Years, and Epochs

II.7.[1]. So, both the year and month are solar and lunar. …true [division] …the conventional [division] … therefore the divisions will be eight. Each division has been adopted by [a certain] group: Mīrim Chalabī speficies the calendars in which these divisions were used. Accordingly, the true solar year and month were used in the Malikī calendar, which was compiled by a group of astronomers including ʻUmar Khayyām (d. ca. 516/1123) under the patronage of the Saljūq ruler Malik Shāh (d. 485/1092)[157]; the conventional solar year and month were used in the "Ancient Calendar (*al-taʾrīkh al-qadīm*)," denoting the ancient Egyptian calendar; the true lunar year and month were used by the jurists (*ahl al-sharʿ*); the conventional lunar year and month were used by the Islamic practitioners of the stars (*al-munajjimūn fi al-Islam*).[158]

II.7.[2]. As for the epoch [*taʾrīkh*]: The meaning of *taʾrīkh* is explained at length in the *Nihāya*.[159]

II.7.[2]. Among the well-known epochs in our time are: Mīrim Chalabī says that while there are numerous calendars used in Islamic societies, six of which are the famous ones, Qūshjī lists only three of them. In the *Nihāya* and *Tuḥfa*, Shīrāzī gives the details of these six

[157] For a brief explanation of this calendar see Behnaz Hashemipour, "Khayyām: Ghiyāth al-Dīn Abū al-Fatḥ ʿUmar ibn Ibrāhīm al-Khayyāmī al-Nīshāpūrī," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, eds. Thomas Hockey et al. (New York: Springer, 2007), 627-28.
[158] Mīrīm Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 138a-138b. For a list of conventional years that were used in Islamic history, see F. J. Ragep, *Tadhkira*, 494.
[159] Savadi, *The Historical and Cosmographical Context*, 347-48.

calendars: the Byzantine (*Rūm*) calendar, *Hijra* calendar, Persian calendar, Malikī calendar, Jewish calendar and Turkish calendar. Interestingly, the *Risālah* mentions one more calendar than the *Fatḥiyya* does, which is the Malikī calendar. Its omission in the *Fatḥiyya* might be understood in relation to the changing cultural context when he came to Istanbul. While in Samarqand—where the *Risālah* was written—the Malikī calendar might have been used, it might have not received wide circulation in Istanbul. Another intriguing point in terms of the comparison of the two texts is that while the *Risālah* explains the calendars in the order of the Hijra calendar, Persian calendar, Byzantine calendar, and Maliki calendar, the *Fatḥiyya* starts with the Byzantine calendar, followed by the Hijra calendar, and then the Persian calendar.[160] By doing that, the *Fatḥiyya*'s ordering is the same as the one in the *Tuḥfa* and *Nihāya*. It may also be that the Byzantine calendar was used in Istanbul and Anatolia, which had been under the influence of Byzantine intellectual and scientific culture for a long time; Qūshjī's reordering of the calendars in the *Fatḥiyya* might thus be an attempt to adapt his work to an intellectual center where the Byzantine astronomical legacy was still relevant in post-conquest Constantinople.[161]

II.7.[4]. The first [day] of this epoch is a Thursday, based on the average [synodic period]: Mīrim Chalabī adds that this is also a statement adopted by the people of *ḥadīth*.[162]

II.7.[5]. Because the years and months of this epoch are free from fractions… Most of the *zījes* that have come down to us are based on [this epoch], indeed all of them

160 Qūshjī, *Risālah*, Ayasofya, MS 2640, ff. 23a-24a.
161 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 138b-139a; Savadi, *The Historical and Cosmographical Context*, 218-25, 349-56; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 93a-95b.
162 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* f. 141a.

except for the Zīj *al-Muʿtabar*: This phrase is not included in the *Risālah*.[163] The *Zīj al-Muʿtabar* is the astronomical handbook prepared sometime after 1118 by al-Khāzinī (fl. first half of the 12th century), who dedicated it to Seljūq Sultan Sanjar (d. 552/1157). This *zīj* was also a subject of scientific exchanges across cultures thanks to its translation into Greek by Gregory Chioniades (ca. 1320), a significant figure in the transmission of Islamic astronomy into the Byzantine context.[164] This phrase indicates that the *Tuḥfa* was a significant source for the *Fatḥiyya*, since it is a direct quotation from it. More interesting is that unlike in the *Tuḥfa*, Shīrāzī does not mention the *Zīj al-Muʿtabar* in the *Nihāya*. Moreover, Ghulām Sinān seems to draw a connection between the *Zīj al-Muʿtabar* and *Zīj-i Ulugh Beg*. In his class, Qūshjī himself stated that this *zīj* was prepared during the reign of Sultan Sanjar, and that the Hijra calendar was used in the tables, as is the case in the *Zīj-i Ulugh Beg*.[165] One may then wonder why Qūshjī mentioned the *Zīj al-Muʿtabar* in the *Fatḥiyya*, instead of the *Zīj-i Ulugh Beg* as an example of the Hijra calendar being used in astronomical tables. Is it because Qūshjī wanted to quote the *Tuḥfa* text without adding a new example? In my research, I have not come across any clue towards answering these questions. Apart from this, Qūshjī's in-class explanation reported by Ghulām Sinān raises another interesting point. E. S. Kennedy remarks that "the tables of planetary arc of visibility which appear in the Sanjarī Zīj are reproduced" in the *Zīj-i Ulugh Beg*. If one considers Kennedy's observation and Ghulām Sinān's account together, the relationship

[163] Qūshjī, *Risālah*, Ayasofya, MS 2640, f. 23b.
[164] Mohammed Abattouy, "Khāzinī: Abū al-Fatḥ ʿAbd al-Raḥmān al-Khāzinī (Abū Manṣūr ʿAbd al-Raḥmān, ʿAbd al-Raḥmān Manṣūr)," in *The Biographical Encyclopedia of Astronomers, Springer Reference*, eds. Thomas Hockey et al. (New York: Springer, 2007), 629-630.
[165] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 161b.

between the these two *zīj*es deserves further investigation.[166] One more point to address: Qūshjī does not mention Ibn al-Shāṭir's *Zīj al-Jadīd* as an example of those that used the Hijra calendar in their tables.

Mīrim Chalabī provides us with another significant detail regarding the history of astronomical tables. Qūshjī writes in the *Fatḥiyya* that the Persian calendar was used in most of the *zīj*es since it is free from fractions. As someone who wrote a commentary on *Zīj-i Ulugh Beg*, Mīrim Chalabī's statement offers another explanation for the predominant usage of the Persian calendar in *zīj* works: "[the usage of the Persian calendar is] on account of its compatibility with the Nabonassarian [Babylonian] calendar, upon which Ptolemy established the *Almagest*." Ptolemy explicitly mentions his preference for the Babylonian calendar: "we use the mean motions we have derived to compute back to the beginning of the reign of Nabonassar for the epochs we establish."[167]

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[166] For E. S. Kennedy's remarks regarding the connection of *Zīj-i Ulugh Beg* and *Zīj al-Muʿtabar*, see Kennedy, "A Survey of Islamic Astronomical Tables," 159-161, 166-67.
[167] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347*,* ff. 141b-142a; Ptolemy, *Almagest*, 166.

Chapter 8 [of Part 2]

On Co-ascensions of the Arcs along the Zodiacal Orb

Earlier Qūshjī gave general definitions of the co-ascension of the zodiacal arc and the co-ascension of a [discrete] part in I.2.[8]. Like Ṭūsī in the *Tadhkira*, and Shīrāzī in the *Tuḥfa* and *Nihāya*, Qūshjī devotes a chapter on the subject with respect to the changing horizons.[168] Qūshjī's chapter is a very short summary of the *Tuḥfa* and includes many direct quotations from it. It is also notable that the subject is covered more extensively in the *Risālah*.[169]

2.8.[1]. ...local ecliptic latitude: Qūshjī defines it in I.2.[5].[170]

Chapter 9 [of Part 2]

On the Degrees of Transit of the Stars on the Meridian and on Their Degrees of Rising and Setting

II.9.[1]. degree of transit: For an explanation of this term, see F. J. Ragep's commentary.[171]

II.9.[3]. the degree of rising and setting of a star: For their explanations see again the commentary to the *Tadhkira*.[172]

II.9.[3-5]. ... more than the total obliquity, and if [its latitude] is on the side of the visible of the poles of the World, then the star rises before its degree and sets after it.

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[168] Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 85b-87a; F. J. Ragep, *Tadhkira*, 282-87, 479-482; Savadi, *The Historical and Cosmographical Context*, 178-185, 313-320.
[169] Qūshjī, *Risālah*, Ayasofya, MS 2640, ff. 20b-21a.
[170] One can also see F. J. Ragep, *Tadhkira*, 118-19.
[171] Ibid, 495.
[172] Ibid, 495-96.

… This is a very subtle and precious [matter]: This is a striking example of how the *Fatḥiyya* underwent substantial changes across its various versions. This passage, in which the rising and setting of a star and its degree at localities whose latitude is equal to the total obliquity or less than it are explained, is not included in the first version represented in the autograph copy (Ayasofya, MS 2733). Generally speaking, this chapter has several revisions, mostly in order to present the subject in a better and more understandable way. It is also notable that compared to the *Risālah*, the *Fatḥiyya*'s account of this subject is more detailed.

Chapter 10 [of Part 2]

On Obtaining the Meridian Line and Finding the Prayer Times and the *Qibla* Bearing

II.10.[2]. … the meridian line: It was defined earlier in I.2.[4].

II.10.[2]. …the east-west line: It was defined earlier in I.2.[3].

II.10.[2]. … this circle is known as the Indian: For further explanation of the Indian circle, see the modern commentaries to the *Mulakhkhaṣ* and *Tadhkira*.[173]

II.10.[3]. As for determining the prayer times: This paragraph, which explains the beginning of the five daily prayers, includes a subject also covered in the *fiqh* literature. Qūshjī's account is largely based on the *Tuḥfa*, but shorter than it.[174] One notable difference between the *Tuḥfa* and *Fatḥiyya* is that while Shīrāzī uses "the noon amount (*qadr al-*

[173] S. P. Ragep, *Jagmīnī's Mulakhkhaṣ*, 276-77; F. J. Ragep, *Tadhkira*, 496-97.
[174] See, Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, 97a; Savadi, *The Historical and Cosmographical Context*, 237-38, 367-68.

zawāl)" to denote the amount of shadow after noon, Qūshjī uses "the noon shadow (*fayʾ al-zawāl*)" for it. As Tahānawī points out, both the terms were used in the literature, but Qūshjī seems to prefer the one that was more commonly used in the *fiqh* literature.[175]

II.10.[4]. Mecca's longitude, which is 77 degrees and 10 minutes from the [Eternal] Islands, and [Mecca's] latitude, which is 21 degrees and 40 minutes: These values are the same as those in the *Zīj-i Ulugh Beg*.[176] In fact, one can also see the same values in the *Tadhkira* and *Nihāya*.[177] However, Ṭūsī and Shīrāzī provide two different longitudes for Mecca: one from the Eternal Islands (77 degrees and 10 minutes), and the other from the coast of the western sea (67 degrees and 10 minutes). It is important to note that in the first version of the *Fatḥiyya*, Qūshjī uses the value from the coast of the western sea, replacing it with the one from the Eternal Islands in the other two versions.

II.10.[4-8]. As for the *qibla* bearing... another method [for the *qibla*-bearing]: These paragraphs introduce two methods for finding the *qibla* direction for different localities in latitude with respect to Mecca. The *Mulakhkhaṣ*, *Nihāya*, and *Tuḥfa* basically present the same methods as well. In the *Tadhkira*, however, Ṭūsī mentions that there are many ways to find the *qibla* direction, but as an example he only explains the method which appears as the second one in Qūshjī's account.[178] Besides this, one should also note that these methods

[175] Tahānawī, *Kashshāf*, 2: 1151. For an example of the usage of the term in the *fiqh* literature see Aḥmad ibn Muḥammad a-Qudūrī, *Mukhtaṣar al-Qudūrī,* ed. ʿAbd Allāh Nazīr Aḥmad Mizzī (Beirut: Muʾassasat al-Rayyān, 2005), 63.
[176] Ulugh Beg, *Zīj-i Ulugh Beg*, Revan, MS 1714, f. 101b.
[177] F. J. Ragep, *Tadhkira*, 306-7; Savadi, *The Historical and Cosmographical Context*, 245, 375.
[178] Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 98a-98b; F. J. Ragep, *Tadhkira,* 306-9. 497-99; S. P. Ragep, *Jaghmīnī's Mulakhkhaṣ*, 166-67, 276-278; Savadi, *The Historical and Cosmographical Context*, 245-49, 374-78.

are simpler compared to those based on spherical trigonometry. For further technical and historical accounts of the *qibla*, see David King's scholarship.[179]

II.10.[5]. Wheresoever you turn, there is the Face of God: This is a quotation from Qurʾān, *Sūrat al-Baqara* (2: 115).[180]

[179] David A. King, "Astronomy and Islamic Society: Qibla, Gnomonics, and Timekeeping," in *Encyclopedia of the History of Arabic Science*, ed. Roshdi Rashed (London & New York: Routledge, 1996), 128-84.
[180] For the context of the verse, see Nasr et al., *The Study Quran*, 53-54.

The Third Part

On Finding the Measurements of the Distances and the Bodies

First of all, one should note the main differences between the *Risālah* and *Fatḥiyya*, since they are important in terms of the development of Qūshjī's *hayʾa* works. The topic of sizes and distances of the celestial bodies are covered in the *Fatḥiyya* much more extensively than in the *Risālah*. More specifically, while the *Fatḥiyya* includes this subject as a separate Part, it is only presented in the last chapter of the Second Part (II.12) on the Configuration of the Earth in many *Risālah* copies I have examined. Generally speaking, the topics covered in the *Risālah* can be summarized as follows: The circumference of the Earth, the units of parasang, mile, cubit, digit, and barleycorns, which are also covered in the first chapter of this Part in the *Fatḥiyya*; the distances of the convexity and concavity of the planetary orbs from the center of the World, and their sizes. Notably, Qūshjī's values rely upon Kāshī's *Sullam al-samāʾ*. This is striking because Qūshjī does not use Kāshī's values in the *Fatḥiyya*. In Chapter 3 of this dissertation, I have pointed out the significance of this chapter in the *Risālah*. To summarize, the first version of the *Risālah* does not cover this subject. Although it is not certain when and where Qūshjī added it to his Persian *hayʾa* work, it is remarkable to note that the main *Risālah* text used in Lārī's commentary does not include this chapter either. In other words, the first version was in circulation in the Persian speaking world as late as the mid-sixteenth century. In this respect, this Part in the *Fatḥiyya* should be deemed to be completely different from the corresponding chapter in the *Risālah* in terms of its structure, content and numerical values used.

Introduction

Concerning That Which is Needed by Way of Introduction before Undertaking [Our] Objectives

III.Intro.[1]. They are 10 preliminary propositions: This chapter includes basic mathematical propositions and methods through which one performs calculations to reach the values given in the following chapters. In other words, instead of solely presenting the values pertaining to the distances and sizes of the celestial bodies, he also gives insight into the technical aspect of dealing with this issue. In the first paragraph of Chapter 1 ("On the Measure [*misāḥa*] of the Earth") in Book IV, Ṭūsī introduces only the first proposition one finds in this chapter of the *Fatḥiyya*.[181] In other words, Qūshjī's introduction to this Part is more mathematically-informed. Moreover, in the following chapters, he occasionally refers to propositions used to reach the value presented. Ṭūsī uses the word "*muṣādarāt*" to denote the preliminary propositions, whereas Qūshjī uses the word "*masāʾil.*"

Chapter 1 [of Part 3]

On the Measure [*misāḥa*] of the Earth and What Pertains to It

III.1.[1]. The amount of one degree along a great [circle] assumed on the surface of the Earth is, as the ancients found, 66$^2/_3$ miles; according to what the moderns found, it is 56$^2/_3$ miles: "The ancients" refers to Ptolemy and those who came after him. As for "the moderns," this refers to a group of astronomers who undertook an expedition to measure the diameter of the Earth under the commission of Caliph Maʾmūn (d. 218/833).

[181] F. J. Ragep, *Tadhkira,* 310-11, 501.

Ṭūsī's *Tadhkira* attributes the value of $66^2/_3$ miles to Ma'mūn's astronomers. Notably, in *Sullam al-Sama'*, Kāshī follows Ṭūsī's account.[182] In fact, more reliable sources suggest that the value calculated by Ma'mūn's astronomers was $56^2/_3$ miles.[183] This section reveals that Qūshjī was aware of the fact that Ma'mūn's value is different from the "ancient" one. Qūshjī's sources on the subject seems to be the *Tuḥfa*, in which Shīrāzī gives a detailed account of the values attributed to the ancients and moderns.[184] Shīrāzī covers the same subject in the *Nihāya* as well.[185]

III.1.[2]. Since the verifiers (*al-muḥaqqiqīn*) in this discipline chose the perspective of the ancients because their investigation was more reliable: Like Shīrāzī, Qūshjī accepts the Ptolemaic value. Importantly, he uses the same justification one finds in the *Tuḥfa* as to why the ancient value is preferred. This was "because the investigation of the ancients is more reliable."[186]

III.1.[2]. the result is the diameter [of that great circle], which is $2545^1/_2$ parasangs approximately ...the surface area of the Earth, which is 20,364,000 parasangs: Although Qūshjī uses the same method to calculate the surface area of the Earth, his result is different from the one found in the *Tadhkira* and *Tuḥfa*, which is 20,360,000 parasangs. The reason is that Qūshjī considers the fraction ½ parasang in his calculation.[187] On the

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182 Hamid Bohlul, "*Sullam al-samā'*: A Critical Edition, Translation and Study (in Persian)" (MA thesis, University of Tehran, 2008), 30.
183 For a detailed discussion of it, see F. J. Ragep, *Tadhkira,* 501-10.
184 Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 100b-101a.
185 F. J. Ragep, *Tadhkira*, 509-10.
186 Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, f. 101a.
187 F. J. Ragep, *Tadhkira*, 312-13; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, 101a.

other hand, Kāshī uses the precise value for the diameter of the great circle on the Earth, which, according to him, is 2545 + $^{5}/_{11}$ parasangs. Kāshī's calculation is 20,363,636 + $^{4}/_{11}$ parasangs, which is also referred to by Birjandī in his *Sharḥ al-Tadhkira*.[188] In the *Risālah*, Qūshjī seems to have made a mistake, giving the diameter as 2445 parasangs. The same error is seen in many copies of the *Risālah*.[189]

III.1.[3]. The area of the inhabited part is the section enclosed by…[Then,] one subtracts the area [of this segment] from the area of half the surface area of the Earth; and [then] one takes half the remaining [part]: Ghulām Sinān directs his reader to the *Tuḥfa* and *Nihāya* for a helpful explanation of how to calculate the surface area of the inhabited and populated parts of the Earth. Alluding to the titles of these two works, Ghulām Sinān expresses his acknowledgement of Shīrāzī's works as follows: "It is a gift (*tuḥfa*) for those who have the utmost attainment (*nihāyat al-idrāk*)."[190]

Chapter 2 [of Part 3]

On Finding the Distances of the Moon from the Center of the World Based upon the Earth's Diameter Being One; On Finding the Ratio of the [Moon's] Diameter and the Diameter of the Shadow and Their Amount in Terms of the Parts of the Revolution

As the title suggests, this chapter covers two different issues regarding the distances of the Moon. The first is based upon the Earth's radius being 1, and the second one is "with

188 Bohlul, "*Sullam al-samāʾ*," 31; ʿAbd al-ʿAlī al-Birjandī, *Sharḥ al-Tadhkira*, Harvard University, The Houghton Library, MS 4285, f. 240b (online access: https://iiif.lib.harvard.edu/manifests/view/drs:13086510$2i).

189 Heiderzadeh, "Ali Kuşçu'nun Astronomi Eserleri," 36.

190 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 176b; Shīrāzī, *Tuḥfa*, Fazıl Ahmed Paşa, MS 927, ff. 101a-101b.

respect to the Parts of the Revolution," not based on the Earth's radius being 1. The first thing to note is that Qūshjī's title for this chapter is taken from the *Tuḥfa verbatim*. Although Ṭūsī also covers the second issue in the *Tadhkira*, he does not use the phrase "with respect to the parts of the revolution." What then does "the revolution" used by Qūshjī and Shīrāzī mean? Ghulām Sinān reports that in a class Qūshjī offers the following explanation. Let's have a compass and put its part that has a spike on the center of the World. Then adjust the radius of the compass to the distance between the centers of the World and Moon, and draw a circle. This is referred to as "the revolution."[191]

Concerning Part 3 as a whole, another important point to note is that Qūshjī seems to have calculated the parameters himself, instead of borrowing from another source. Therefore, he generally differs from the *Tadhkira*, *Tuḥfa*, and *Sullam al-Samaʾ*, the latter arguably the most important work written in the fifteenth-century Islamic world on the distances of the celestial bodies. More interestingly, even his own calculations vary. The values found in the first and second versions are different from those in the last one. Unfortunately, his motivation to recalculate them and his methods are unknown to me. It is extremely interesting that the commentators also differ on the values. While Ghulām Sinān's commentary is based on the *Fatḥiyya* text that includes the latest version of parameters, Mīrim Chalabī uses the one that has mostly the earlier parameters. Thus, one wonders how Mīrim Chalabī, a descendant of Qūshjī and one of the most eminent astronomers of his period, was not informed of Qūshjī's latest revisions. As mentioned several times before, Ghulām Sinān studied the *Fatḥiyya* with Qūshjī, and it is likely that he was more aware of the development of the *Fatḥiyya* text. Mīrim Chalabī's case is interesting

[191] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 177b.

because he seems not to be satisfied with the values in the text, so much so that he appended the tables of values given in the *Sullam al-Samā᾿* . He remarks that if one finds any discrepancy between the value in the text and the one found in *Sullam al-Samā᾿*, one should rely on the latter.[192] In the following pages, I will not present a technical analysis of Qūshjī's parameters in the different versions as a way to ascertain whether his calculations were correct. Rather, by taking some parameters as examples, I will show that he differs from his predecessors like Ṭūsī, Shīrāzī and Kāshī. As a result, one will see that while Qūshjī's earlier values are closer to those of Kāshī, the later ones are closer to those of Ṭūsī and Shīrāzī.

III.2.[1]. Ptolemy observed the Moon in order to learn the first [matter mentioned in the title, i.e. the Moon's distances from the center of the World] at the time of its minimum altitude on the meridian line: As Mīrim Chalabī remarks, the reason to select the time when the Moon is at the minimum altitude on the horizon is that then the lunar parallax is at its maximum value; thus the difference can be easily perceived and calculated.[193]

III.1.[1]. ...the lunar parallax: For a detailed explanation of the lunar parallax one can refer to the *Almagest*.[194]

192 Mīrim Chalabī, *Sharḥ al-Fatḥiyya*, Feyzullah Efendi, MS 1347, f. 184a.
193 Ibid., f. 171b.
194 Ptolemy, *Almagest*, 243-44.

III.2.[1]. The side $\overline{BG}$, which is the distance of the Moon from the center of the World, is found by calculation to be 39 parts and 55 minutes: Mīrim Chalabī writes that unlike Qūshjī's value as well as Ṭūsī's, which is 39 parts and 45 minutes, he calculated it to be 39 parts and 50 minutes. Also he insists that his value be preferred by saying that "the best of affairs is the middle of them (*khayr al-umūr awsāṭuhā*)."[195]

II.2.[3]. ...the inclined orb's radius is 59 parts and 8 minutes and 11 seconds: As Mīrim Chalabī rightly points out, it is better to refer to the unit as a part (*juzʾ*) instead of a degree (*daraja*), as Qūshjī used in similar cases earlier.[196]

II.2.[3]. ... the farthest distance of the Moon is 64 parts and 15 minutes and 42 seconds; the closest [distance] is 33 parts and 32 minutes and 36 seconds; its mean with respect to the distance is 48 parts and 54 minutes and 9 seconds: Qūshjī's parameters are different from his predecessors, as can be seen in the following table:

Parameters	***Fatḥiyya (Final Version)***	***Fatḥiyya (First and Second Versions)***	***Sullam al-Samāʾ***	***Tuḥfa***	***Tadhkira***
Moon's farthest distance [Earth's radius being 1]	64 parts and 15 minutes and 42 seconds III.2.[2]	64 parts and 23 minutes III.[2].2	63 parts 34 minutes and 15 seconds (*Sullam*, p. 63)	$64^1/_6$ parts (Fazıl Ahmed Paşa, MS 927, f. 103b)	$64^1/_6$ parts (*Tadh.*, 4.2 [4]. pp. 318-19)

195 Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 172b.
196 Ibid., f. 173a.

Moon's closest distance [Earth's radius being 1]	33 parts and 32 minutes and 36 seconds III.2.[2]	33 parts and 37 minutes III.2.[2]	33 parts and 14 minutes and 13 seconds (*Sullam*, p. 63)	33 parts and 32 minutes (Fazıl Ahmed Paşa, MS 927, f. 103b)	33 parts and 33 minutes (*Tadh.*, 4.2 [4]. pp. 318-19)
Moon's mean distance [Earth's radius being 1]	48 parts and 54 minutes and 9 seconds III.2.[2]	49 parts III.2.[2]	48 parts and 24 minutes and 14 seconds (*Sullam*, p. 63)	48 parts and 51 minutes (Fazıl Ahmed Paşa, MS 927, f. 103b)	Not specifically provided

Chapter 3 [of Part 3]

On Finding the Size of the Diameters of the Moon and Shadow, the Distances of the Mean Sun and of the Head of the Shadow Cone from the Center of the Earth Based Upon the Earth's Radius Being One

III.3.[1]. …By perception, they are equivalent to the diameters of the circles [within which they] are located: Like Ṭūsī, who writes that "there is no sensible difference between them and the true ones," Qūshjī remarks that the lines in question are not the actual radii of the circles, and therefore the equivalence is only assumed "by perception."

Besides this, the translator of the *Almagest*, G. I. Toomer, summarizes this approach as one where a "simplifying approximation is fully justified."[197]

III.3.[2]. …since you have learned how to convert quantities from one unit to another: The reference is to the 8th proposition in the introductory chapter of this Part (III.Intro.[8]).

III.3.[3]. …according to what was presented in the Introduction [of this Part]: The reference is to the 10th proposition in the introductory chapter of this Part (III.Intro.[10]).

III.3.[4]. … the mean distance of the Sun, based upon the standard unit being 1, is 1192 [parts] and 29 [minutes] and 4 seconds: Again, Qūsjī's values differ from those in the *Sullam*, *Tuḥfa*, and *Tadhkira*. For example, the following table is the comparison of the values pertaining to the mean distance of the Sun to the center of the Earth.

Parameters	***Fatḥiyya* (Final Version)**	***Fatḥiyya* (First and Second Version)**	***Sullam al-Samāʾ***	***Tuḥfa***	***Tadhkira***
Mean distance of the Sun	1192 [parts] and 29 minutes and 4 seconds III.3.[4]	1495 [parts] III.3.[4]	1523 parts and 2 minutes and 5 seconds (*Sullam*, p. 64)	1210 times the Earth's radius (Fazıl Ahmed Paşa, MS 927, f. 104b)	1210 times the Earth's radius (*Tadh.*, 4.3.[4], pp. 324-25)

[197] Ptolemy, *Almagest*, 254-55 (n. 64); F. J. Ragep, *Tadhkira*, 320-21, 514.

Chapter 4 [of Part 3]

On Finding the Size of the Diameter of the Sun Based Upon the Standard Unit Being One and [On] the Ratio of Its Body to the Earth's Body

III.4.[1]. …the ratio of the nearer radius to the farther one is as the nearer distance to the farther one: This chapter basically follows the same structure as the *Tadhkira*. Based on this proposition, which is taken from optics, Qūshjī describes how to find the size of the Sun. The following is the comparison of the values for the Sun's radius used by Qūshjī, Kāshī, Shīrāzī, and Ṭūsī.

Parameters	***Fatḥiyya* (Final Version)**	***Fatḥiyya* (First and Second Version)**	***Sullam al-Samā'***	***Tuḥfa***	***Tadhkira***
Sun's radius [Earth's radius being 1]	5 parts and 49 minutes III.4.[1]	6 parts and 44 minutes III.4.[1]	6 times and 52 minutes and 54 seconds and 57 thirds (*Sullam*, p. 48)	$5^1/_2$ parts (Fazıl Ahmed Paşa, MS 927, f. 104b)	$5^1/_2$ parts (*Tadh.*, IV.4.[1], pp.326-27)
The Sun's size compared to the Earth	197 times III.4.[2]	244 times III.4.[2]	326 times (*Sullam*, p. 62)	(166 + ¼ + $^1/_8$) times (Fazıl Ahmed Paşa, , MS 927, f. 104b)	(166 + ¼ + $^1/_8$) times (*Tadh.,* IV.4.[2], pp.326-27)

III.4.[2]. Euclid has proven in the 12th [book] in his work that the ratio of a sphere to another sphere is as the ratio of the cubes of their diameters: Qūshjī simply paraphrases the Euclidean definition given in the *Tadhkira*.[198]

III.4.[2]. Then when one takes the cubes of the diameters the Earth and the Sun, it is clear that the Sun is 197 times the Earth: Mīrim Chalabī gives the result of his calculation for the ratio of the sizes of the Sun and Earth, which is 306 to 1. He also adds that his value is close to that of "the eminent verifier (*al-fāḍil al-muḥaqqiq*) Ghiyāth al-Dīn Jamshīd [al-Kāshī]", which is 326 to 1. He also notes that his and Kāshī's values are different from those in the *Tadhkira* and *Tuḥfa*. Maybe for this reason, he thinks Qūshjī's value in the text, which is 197, is simply "a copyist mistake. God knows best."[199] As a matter of fact, given the values Qūshjī uses to reach this ratio, his calculation seems to be mathematically correct. In this respect, Ghulām Sinān points to a general concern regarding the *Fatḥiyya*. Like Mīrim Chalabī, he also highlights how Qūshjī's value is different from the one given in the *Tadhkira* and its commentaries, stating that these discrepancies pertain to many parameters given in the *Fatḥiyya*. According to him, this has to do with the fact that they are determined on the basis of the observations made by the Samarqand scholars, including Qūshjī.[200]

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[198] F. J. Ragep, *Tadhkira*, 326-27, 516-17.
[199] Mīrim Chalabī, *Sharḥ al-Fatḥiyya,* Feyzullah Efendi, MS 1347, f. 178b.
[200] Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 184b.

Chapter 5 [of Part 3]

On Finding the Remaining Distances Pertaining to the Sun and the Distances of the Two Lower Planets Based Upon the Standard Unit Being One

III.5.[1]. Since the ratio of the Sun's eccentricity, which is, according to our new observation (*raṣadunā al-jadīd*), 2 parts and 1 minute and 20 seconds: Remember that this value was introduced earlier in I.6.[22].

III.5.[1]. ...when we multiply the first [value] with the fourth one by levelling: J. L. Berggren calls this method "multiplication by levelling," which was used for sexagesimal numbers. In addition, Tahānawī describes it as one of the multiplication types and references Qūshjī's definition of the "multiplication by levelling" in his commentary on *Zīj-i Ulugh Beg*.[201] We also learn from Ghulām Sinān that Qūshjī explained this method of multiplication in his class.[202]

III.5.[1]. ...and this is the farthest distance for Venus: Since it is one of the basic principles in the field of *hayʾa*, Qūshjī also assumes that the farthest distance of an orb is the nearest distance of the encompassing orb. This assumption conforms to one of the principles taken from natural philosophy that the void does not exist. In the *Tadhkira* this principle is clearly explained.[203]

201 J. L. Berggren, *Episodes in the Mathematics of Medieval Islam*, 51-52; Tahānawī, *Kashshāf*, 2:111.
202 Ghulām Sinān, *Fatḥ al-Fatḥiyya*, Fatih, MS 5396, f. 184b.
203 F. J. Ragep, *Tadhkira*, 328-29, 517.

III.5.[1-3]. Some values mentioned in these paragraphs are tabulated as follows. As mentioned above, Qūshjī's values in the first and second versions are closer to those in *Sullam al-Samāʾ*, whereas those in the final version are closer to those of the *Tadhkira.*

Parameters	***Fatḥiyya* (Final Version)**	***Fatḥiyya* (First and Second Version)**	***Sullam al-Sama***	***Tuḥfa*[204]**	***Tadhkira***
Venus' farthest distance [Earth's radius being 1]	1152 times and 18 minutes III.5.[1]	(1444 + ¾) times III.5.[1]	1452 times and 18 minutes and 58 seconds (*Sullam*, p. 63)	1160 times (Fazil AhmedPaşa, MS 927, f. 105a)	1160 times (*Tadh.,* IV.5.[1], pp. 328-29)
Mercury's farthest distance [Earth's radius being 1]	176 times and 51 minutes III.5.[2]	221 times and 44 minutes III.5.[2]	216 times and 19 minutes and 31 seconds (*Sullam*, p. 63)	175 times (Fazil Ahmed Paşa, MS 927, f. 105a-105b)	175 times (*Tadh.,* pp. 519-20)
Mercury's nearest distance [Earth's radius being 1]	55 times and 5 minutes of the Earth's radius III.5.[3]	69 times and 3 minutes III.5.[3]	67 times and 22 minutes and 50 seconds; 78 times and 10 minutes and 37 seconds[205] (*Sullam* p. 63)	64 times (Fazil Ahmed Paşa, MS 927, f. 105a-105b)	64 times (*Tadh.,* p. 523)

204 As far as I can see, Shīrāzī uses the same parameters as those in *Tadhkira*; therefore the calculations done for *Tadhkira* can also be assumed for the *Tuḥfa*.
205 Kāshī gives two values for Mercury's nearest distance. The first one is the nearest distance of its epicyclic orb and the second is the nearest distance of its center.

Chapter 6 [of Part 3]

On Finding the Distances of the Upper Planets and Fixed Stars

III.6.[1-3]. The values for the farthest distances of the superior planets are as follows:

Parameters	***Fatḥiyya* (Final Version)**	***Fatḥiyya* (First and Second Version)**	***Sullam al-Samā'***	***Tuḥfa***	***Tadhkira***
Mars' farthest distance	9295 times and 30 minutes III.6.[1]	11652 times and 37 minutes III.6.[1]	11604 times and 2 minutes and 10 seconds (*Sullam*, 65)	8820 times (Fazıl Ahmed Paşa, MS 927, f. 105b)	8820 times (*Tadh.*, IV.6.[1], pp. 334-35)
Jupiter's farthest distance	15256 times and 5 minutes III.6.[2]	19124 times and 38 minutes III.6.[2]	18844 times and 30 minutes and 21 seconds (*Sullam*, 65)	14259 times (Fazıl Ahmed Paşa, f. 106a)	14259 times (*Tadh.*, IV.6.[4], p. 336-37)
Saturn's farthest distance	21604 times and 8 minutes III.6.[3]	27082 times and 32 minutes III.6.[3]	26322 times and 58 minutes and 35 seconds (*Sullam*, 65)	19963 times (Fazıl Ahmed Paşa, f. 106a)	19963 times (*Tadh.*, IV.6.[6], p. 336-37)

III.6.[4]. In order to find the amount of the radius of stars of first magnitude ...the ratio of the distance of the fixed stars to the mean distance of the Sun is as the ratio of the required [value] to the proportion [*ḥiṣṣa*] of those stars, which is $^1/_{20}$ of the Sun's radius: For an explanation of the magnitude scale of the fixed stars one can consult F. J. Ragep's commentary. Besides this, Ṭūsī gives this ratio with respect to the diameters of

the Sun and stars of first magnitude.[206] Although there is no difference mathematically, Qūshjī prefers to introduce it as the ratio between their radii.

[206] F. J. Ragep, *Tadhkira*, 338-39, 526-30.

CONCLUSION

This dissertation aimed to show the significance of Qūshjī's *al-Risāla al-Fatḥiyya* in the history of theoretical astronomy in Islamic societies, especially in the Ottoman context in which it was written and dedicated to Ottoman Sultan Meḥmed II to honor his victory over the Āq Qoyūnlū ruler Uzun Ḥasan in the Otlukbeli War in 878/1473. My analysis relied on both internalist and externalist historiographical approaches in order to understand the characteristics of the *Fatḥiyya*, its place in the history of theoretical astronomy in the post-classical Islamic period, the scientific, historical and local dynamics that laid the foundation for its emergence, and how the *Fatḥiyya* stood in relation to the evolution of Qūshjī's understanding of astronomy.

In Chapter 1, I offered a literature review of the burgeoning secondary literature on Qūshjī that includes works in English, French, German, Persian, Russian, Turkish, and Uzbek. This literature has highlighted Qūshjī's works on theoretical, practical and observational astronomy, mathematics, *kalām*, Arabic linguistics, *tafsīr*, and legal theory. The chapter also explored Qūshjī's connections to the networks of scholars, ideas and texts that shaped the intellectual environment in the post-classical period, particularly in the Timurid Empire. I noted that despite this increased interest in Qūshjī's scholarship, most of his works still await to be studied.

In Chapter 2, I dealt with Qūshjī's educational background and scholarly activities by considering the intellectual, political, and social dynamics of the places in which he lived. The chapter emphasized that the compilation of some of his works including the *Fatḥiyya* should be understood with reference to the texts, scholars, institutions, rulers, scientific, intellectual and political situations in Samarqand, Herat, Tabriz and Istanbul, namely in the fifteenth century Islamic East. I also offered evidence that Qūshjī taught theoretical and observational astronomy, mathematics, *kalām*, and Arabic linguistics in Istanbul, writing new works in some of those fields.

Chapter 3 attempted to analyze the *Fatḥiyya* by focusing on its historical, geographical, and scientific contexts within which it was compiled. I expressed that only a small amount of research has dealt in-depth with Qūshjī's astronomical works. Likewise, the *Fatḥiyya* was one of Qūshjī's last works, but there has been little effort to make sense of it within its historical, geographical, and scientific contexts, as well as to uncover connections between Qūshjī's astronomical works. I claimed that one reason of this situation stemmed, in part, from the lack of a critical edition of the *Fatḥiyya*.

In addition to introducing the outline and content of the *Fatḥiyya*, this chapter attempted to address the following questions: By the time the *Fathiyya* was written in the late fifteenth century, *hayʾa* was already a well-established field with its standard sets of problems, principles, and authoritative texts. Especially al-Ṭūsī's *Tadhkira* and Jaghmīnī's *Mulakhkhaṣ* were widely studied and commented on by many scholars including those in the Ottoman territories. However, unlike those scholars, Qūshjī did not write a commentary on the *Mulakhkhaṣ* or *Tadhkira* as far as the available manuscript copies of his works are concerned. Rather, he compiled two original compositions, namely *Risālah dar hayʾah* and *al-Risāla al-Fatḥiyya*. What was his motivation to write original compositions? Related to this question, under which circumstances did he write the Arabic *Fatḥiyya* in the Ottoman lands around fifteen years after he compiled the Persian *Risālah* in the Timurid Empire? What is the relationship between these two texts? Equally important, do these texts indicate any changes in Qūshjī's intellectual and scientific outlook over the course of time?

How can one describe the pedagogical aspect of the *Fatḥiyya*? How was Qūshjī engaged with the earlier *hayʾa* literature in his *Fatḥiyya* project? And what are the distinctive characteristics of the *Fatḥiyya* in the history of *hayʾa*?

In order to deal with these questions, one should first consider the outline and content of the *Fatḥiyya*, which I presented in this chapter. As a result of my investigation, I could safely say that Qūshjī drew on such earlier authoritative texts as Jaghmīnī's *Mulakhkhaṣ*, al-Ṭūsī's *Tadhkira*, and al-Shīrāzī's *Tuḥfa* and *Nihāya*. However, his treatment of those works was selective and critical in accordance with his astronomical background and understanding of *hayʾa*, which is different from his predecessors in certain aspects.

Most of the parameters presented in the *Fatḥiyya* are taken from *Zīj-i Ulugh Beg*, the astronomical tables prepared in the Samarqand Observatory. This is quite important because it reveals Qūshjī's active engagement with the Samarqand observations. Moreover, as I elaborated, Qūshjī calls those observations "our observations" in the *Fatḥiyya*. Equally important, he also provided technical details regarding the methods of calculation to derive parameters in the *Zīj*, which leads us to ask why he was particularly interested in introducing such subtle and technical details pertaining to observational astronomy to his potential readers, including madrasa students and practitioners of various astral sciences. At present, I don't have a satisfactory answer to this issue, which requires further research, but I highlight that the *Fatḥiyya* should be regarded as an interesting example to investigate the relationship between the genres of the *zīj* and *al-hayʾa al-basīṭa*.

As far as the relationship between the *Risālah* and *Fatḥiyya* is concerned, the former was one of the major sources of the latter. As I have pointed out, their connection had been mentioned by some historians, but how the *Risālah* was used as a source of the *Fatḥiyya* had not been studied in an extensive manner. My investigation concluded that part of the answer must take into account that both the *Fatḥiyya* and *Risālah* were involved in dynamic processes, as suggested by the fact that Qūshjī revised them over the course of time. To be more precise, the *Risālah* has at least two versions, whereas the *Fatḥiyya* has three versions. An important implication of this phenomena is that the teaching and production of *hayʾa* works went hand in hand, adjusting one another according to scientific and pedagogical concerns of their writers.

In this respect, I showed that when Qūshjī was composing the *Fatḥiyya*, he adopted three major processes through which he used the *Risālah*: Translating, revising, and rewriting the text. Among these processes, the most discernible one is that Qūshjī translated the *Risālah* extensively. Having said this, there is enough evidence that the *Fatḥiyya* was more than a translation of the *Risālah*. The adaptation of the *Risālah* to the Arabic corpus took place as a result of many revisions in the content and structure of the Persian *Risālah*. One can find the most discernible example of these revisions in the Introductory Chapters. The *Risālah*'s Introduction has two sections, one devoted to geometry and the other to natural philosophy. On the other hand, the *Fatḥiyya*'s Introduction does not include a section on natural philosophy, which has to do with the development of Qūshjī's understanding of the role of natural philosophy in a *hayʾa* text.

One of the most interesting differences between the *Risālah* and *Fatḥiyya* is on the subject of the distances and sizes of the planets. The values they adopt are entirely different. The *Risālah* depends mostly on Jamshīd al-Kāshī's *Sullam*, whereas the *Fatḥiyya*'s values are different from both the *Sullam* and *Tadhkira*, although its structure in the Third Part is based on the latter. Equally interesting, Qūshjī changed values he had calculated in the first version of the *Fatḥiyya* with the new ones in the other versions. This section can be considered a remarkable example of the way in which Qūshjī rewrote the entire Part on the distances and sizes of the planets.

As far as how the *Risālah* and *Fatḥiyya* were received by Ottoman scholars, Saydī ʿAlī Raʾīs' *Khulāṣat al-Hayʾa* written in Turkish provides an excellent example to examine. Although it is based on Qūshjī's *Risālah*, it is more than a mere translation, being expanded by the addition of new knowledge derived from various *hayʾa* works. As I remarked, Saydī ʿAlī Raʾīs was aware of the *Fatḥiyya* to the extent that he used Mīrim Chalabī's commentary in his rendition of the *Risālah*, but he still preferred Qūshjī's Persian *hayʾa* text as the base text of his work. It is a remarkable indication that should stimulate further research regarding the place of Persian scientific literature in the Ottoman Empire.

Let me here summarize three main characteristics of the *Fatḥiyya*. First and foremost, compared to the earlier authoritative *hayʾa* works, the most distinctive aspect of the *Fathiyya* is that its Introduction only comprises geometrical premises, excluding natural philosophical ones. In his *Sharḥ al-Tajrīd*, Qūshjī defended the idea that principles drawn from Aristotelian natural philosophy and metaphysics are not needed in the science of *hayʾa*. According to him, one can establish this science without presenting the physical principles underlying astronomical ones, which was a common practice of many earlier astronomers. For him, observation and mathematics are primarily important in establishing the principles of the discipline. These ideas are quite remarkable within the context of the relationship between astronomy and natural philosophy, but equally important is that Qūshjī's notion of astronomy without natural philosophy can also be traced in the *Fatḥiyya*. He applies it there by ignoring a section on natural philosophy in its

Introduction, which only includes an explanation of geometrical terms that are necessary to study theoretical astronomy. But what is more remarkable is that the application of this understanding of astronomy evolved over the course of time, as suggested by the fact that unlike the *Fatḥiyya*, Qūshjī's *Risālah* has a section on natural philosophy. But even in the *Risālah,* this section does not comprise a typical account of natural philosophy as compared to other major *hayʾa* works. The *Risālah*'s natural philosophy section introduces definitions of the body, the division of the World into sublunary and heavenly parts, and celestial motion. Qūshjī does not talk about the natural philosophical principles (*mabādīʾ*) as one can see in earlier major works. However, it should be mentioned that he still includes a section for what he calls *ṭabʿiyyāt*, which means that he has not yet fully abandoned the standard practice of the authoritative texts, at least as far as the structure of his work is concerned. In other words, while Qūshjī minimizes the natural philosophical subjects in the *Risālah*, he follows his predecessors in terms of the structure of his work. Therefore, I proposed that the *Risālah* should be regarded as the first step in omitting natural philosophy in Qūshjī's astronomical scholarship. Unlike the *Risālah*, however, the *Fatḥiyya* does not give any space to discussions pertaining to natural philosophy, and so it can be regarded as the final form of Qūshjī's understanding of astronomy.

The second main characteristic of the *Fatḥiyya* is that it is an Ottoman *hay'a* work, but bearing the intellectual outlook that was shaped in the Samarqand Madrasa and Observatory. Curiously enough, unlike the *Risālah,* which was studied across the Islamic East including the Ottoman Empire as late as the twentieth century, the *Fatḥiyya* attracted less attention even in the Ottoman context. All of the *Fatḥiyya*'s derivative works (namely its commentaries and translation) were prepared by Ottoman scholars. Moreover, almost all of its extant copies were copied in Ottoman lands. In the dissertation, I did not deal with the reception of the *Fatḥiyya* in an in-depth way; such a study, involving the competition among *hayʾa* works with various perspectives, deserves further research.

The third characteristic of the *Fatḥiyya* is that it represents a new synthesis in the *hayʾa* literature. Qūshjī's approach, namely selective use of earlier *hayʾa* works and the incorporation of up-to-date parameters taken from *Zīj-i Ulugh Beg* into his *Fatḥiyya*, allowed him to offer a new synthesis in a new intellectual setting, namely in Ottoman Istanbul.

Chapter 4 includes two sections. In the first one, I listed all the extant copies that I am aware of in order to provide a more reliable list of the *Fatḥiyya* copies, since some manuscript catalogs have the *Fatḥiyya* and *Risalah* copies confused. In the second section, I explained my approach for establishing my critical edition of the *Fatḥiyya*. After examining all the copies available to me, I argued that the *Fatḥiyya* has three versions. The copies I used in the critical edition were selected to establish a "final" version, since they bear evidence of Qūshjī's direct or indirect interventions. The critical edition in Chapter 5 was prepared in a way that one can trace the development of the *Fatḥiyya* from one version to another. In order to make the text accessible for further discussions not only in the history of Islamic sciences studies, but, more generally, in the history of astronomy, I translated the *Fatḥiyya* into English, which can be found in Chapter 6. My main concern was to translate the text as literally as possible, and to maintain its terminological consistency with the available translations of pre-modern astronomical texts. The commentaries on the *Fatḥiyya* were quite helpful to understand obscure parts of the text, which were indeed quite a few. In addition, I have identified several sentences in which Qūshjī's wording is the same as such works as al-Ṭūsī's *Tadhkira* and al-Shīrāzī's *Nihāya*. In those cases, I quoted Jamil Ragep's translation of the *Tadhkira* and Fateme Savadi's partial translation of the *Nihāya*. Sally P. Ragep's translation of the *Mulakhkhaṣ* was also beneficial in terms of its terminology and translation style.

The final chapter of the dissertation is a commentary to the edition and translation. I aimed to address parts of the *Fatḥiyya* that needed further explanation. In addition to the authoritative texts mentioned earlier, I consulted two commentaries on the *Fatḥiyya* extensively: one written by Ghulām Sinān, a student of Qūshjī in Istanbul, and the other by Mīrim Chalabī, a descendant of Qūshjī and an eminent astronomer of his period in Istanbul. Apart from technical and scientific explanations, thanks to Ghulām Sinān's commentary, I offered evidence regarding the dynamic process of writing a *hayʾa* text in the early modern period. Ghulām Sinān's commentary includes numerous in-class notes he took when he studied the *Fatḥiyya* under Qūshjī's supervision. To give an example, Qūshjī discussed parts of the *Fatḥiyya* with his students in class, and he decided to make revisions according to their feedback.

To conclude, as I hope I have demonstrated, the *Fatḥiyya* is an example of Qūshjī's idiosyncratic way of writing a *hayʾa* text. To establish this particularity further, one needs more research regarding discussions of theoretical astronomy in the Samarqand intellectual networks in which Qūshjī flourished as an established astronomer, and in Istanbul to whose intellectual circle the *Fatḥiyya* was presented. Broadly speaking, the *Fatḥiyya* will be better situated only after our knowledge of theoretical astronomy and related disciplines in the fifteenth century increases. Therefore, let me finish my words by expressing my hope that this study of the *Fatḥiyya* has provided at least some definitive answers to some of the questions related to fifteenth-century *hayʾa*, and will stimulate new ones for further research.

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