Al-Ghazālī and Quantum Physics:

A Comparative Analysis of
The Seventeenth Discussion of *Tahāfut al-Falāsifa*
and
Quantum Theory

Ümit Yoksuloglu Devji

A Thesis submitted to the Faculty of Graduate Studies and Research in partial
fulfillment of the requirements of the degree of
Master of Arts

Institute of Islamic Studies, McGill University,
Montreal, Canada

August, 2003

Your file Votre référence
ISBN: 0-612-98431-1
Our file Notre référence
ISBN: 0-612-98431-1

ABSTRACT

Author: Ümit Yoksuloglu Devji

Title: Al-Ghazālī and Quantum Physics: A Comparative Analysis of the Seventeenth Discussion of *Tahāfut al-Falāsifa* and Contemporary Quantum Theory.

Department: Institute of Islamic Studies, McGill University

Degree: Master of Arts

This thesis compares the concepts presented in the Seventeenth Discussion of al-Ghazālī's *Tahāfut al-Falāsifa* with concepts currently being discussed in the field of quantum physics. Written as an attack on the neo-Platonic and Aristotelian thinking which challenged the orthodox theology of Medieval Islam, *Tahāfut al-Falāsifa* (Incoherence of the Philosophers) questions the understanding of physical reality forwarded by the philosophers of al-Ghazālī's times. The Seventeenth Discussion ('On causality and miracles') in particular, with its aim of proving the possibility of miracles, questions the acceptance of notions such as necessary causality and the validity of scientific observation in the natural world.

The dilemmas posed by al-Ghazālī in this work find a complement in contemporary quantum theorizing, which questions formerly accepted notions of the nature of physical reality. The causal and deterministic nature of the physical world presented by Newtonian classical physics is giving way to new schema in quantum physics, which rejects the possibility of objective scientific observation. Whereas

al-Ghazālī's thinking is based on logical premises, the work of quantum physicists such as Niels Bohr, Werner Heisenberg and Max Born is grounded in scientific experimentation. Nonetheless, the ideas put forth by both have brought about philosophical reevaluations of the limits of human understanding of the physical universe.

Although several scholars have examined al-Ghazālī's argument in the Seventeenth Discussion in terms of causality, observation and the nature of human conceptions of physical reality, and many others have noted the implicit potential connections between quantum theory and concepts of religiosity, only one, Karen Harding, has attempted a synthesis of the ideas put forth within these two seemingly diverse subjects. This thesis, then, carries forward from the ideas of Harding and attempts an original comparative analysis of the two.

Parallels drawn between the two points to the contemporary nature of al-Ghazālī's thinking as well as to the applicability of current discoveries in quantum physics to a reexamination of eleventh century Islamic theology. As such, this thesis attempts to move beyond the intellectual boundaries of fields of inquiry, time and milieu towards a holistic apprehension of human understanding of the physical and metaphysical constructs of the universe.

RÉSUMÉ

Auteur: Ümit Yoksuloglu Devji

Titre: Al-Ghazālī et la Physique Quantique: Une Analyse Comparative de la Dix-septième Discussion de *Tahāfut al-Falāsifa* et Théorie Quantique Contemporaine.

Département: Institut des Études Islamiques, Université McGill

Diplôme: Maîtrise est Arts

Ce mémoire met en comparaison les concepts présentés dans la Dix-septième Discussion de l'œuvre *Tahāfut al-Falāsifa* d'al-Ghazālī avec des concepts qui sont actuellement très discutés dans le domaine de la physique quantique. Envisagée comme une attaque contre la pensée néoplatonicienne et aristotélicienne qui s'opposait à la théologie orthodoxe de l'islam médiéval, la *Tahāfut al-Falāsifa* (L'incohérence des philosophes) met en question la compréhension de la réalité physique proposée par les philosophes de l'époque d'al-Ghazālī. La Dix-septième Discussion en particulier, avec son but de démontrer la possibilité des miracles, met en doute l'acceptation de notions comme la causalité nécessaire et la sûreté de l'observation scientifique du monde naturel.

Les dilemmes posés par al-Ghazālī dans son œuvre sont comparables à la théorie quantique contemporaine, qui elle met en question des notions acceptées au sujet de la nature de la réalité matérielle. Le caractère causal et déterministe du monde matériel, tel comme présenté dans la physique classique de Newton, commence à s'effondrer en face d'un nouveau schéma de la physique quantique qui nie l'objectivité de l'observation

scientifique. Tandis que la pensée d'al-Ghazālī se base sur les prémisses de la logique, le travail de physiciens quantiques comme Niels Bohr, Werner Heisenberg et Max Born est fondé sur l'expérience scientifique. Néanmoins, les deux ont provoqué une réévaluation philosophique des limites de la compréhension humaine face à l'univers matériel.

Bien que plusieurs spécialistes aient examiné les arguments d'al-Ghazālī à propos de la causalité, l'observation et la nature de la conception humaine de la réalité matérielle dans la Dix-septième Discussion, et beaucoup d'autres aient noté un rapport potentiel et implicite entre la théorie quantique et les concepts de la religiosité, il n'y a qu'une, Karen Harding, qui ait tenté une synthèse des idées proposées par ces deux domaines apparemment divers. Par conséquent, ce mémoire, à l'exemple de Harding, tâche de formuler une nouvelle analyse comparative des deux.

Les parallèles tracés entre les deux indiquent l'esprit moderne de la pensée d'al-Ghazālī, ainsi que la possibilité d'appliquer des découvertes actuelles de la physique quantique à une réévaluation de la théologie islamique de du l'onzième siècle. De cette façon, ce mémoire tente de franchir les frontières de certains domaines intellectuels, et celles du temps et de l'espace, afin de mieux pénétrer la compréhension humaine de sa propre conceptualisation matérielle et métaphysique de l'univers.

ACKNOWLEDGEMENTS

I am most of all grateful to *Allāh*, The Most Merciful, who clearly has helped me in every step of this thesis.

I am indebted to the faculty of the Institute of Islamic Studies at McGill University for helping me build my ideas and for the encouragement and support I received, both financial and academic, during my studies. Without such encouragement, this thesis could not have been written.

I would like to thank Dr. Eric L. Ormsby, my thesis supervisor, who always encouraged and helped me with patience. I also would like to thank Dr. Üner Turgay, the head of the department, and the professors Issa J. Boullata, Sajida Alwi, and Wael Hallaq for their constant support and guidance. I will forever benefit from their encouragement and I am extremely grateful to them.

Special thanks must go to Dawn Richard, Ann Yaxley, and all the staff members and friends in the Institute of Islamic Studies, who encouraged me and helped me through my research and hard work. I also would like to thank the librarians of the Islamic Studies Library, Adam Gacek for his general support, and Salwa Ferahian for her assistance in providing and locating sources.

Finally, I would like to add a note of personal gratitude. I would like to thank my husband, Asif Devji, who edited my work, and who helped me with patience and supported me every time I needed encouragement. My special thanks are also due to my mother Zahide Özkan Yoksuloglu and father, Ali Yoksuloglu, thousands of miles away in Adana, Turkey, without whose guidance I would not be the person I am today.

TABLE OF CONTENTS

INTRODUCTION

Abū Hāmid Muhammad Ibn Muhammad al-Tūsī al-Ghazālī (450/1058-505/1111) is considered among the foremost of Islamic academics, jurists, theologians, mystics and philosophers of the last millennium. As impressive as the breadth of his learning was the originality of al-Ghazālī's thought and the depth of his influence on the Islamic sciences. He gathered in his works all the important intellectual and religious movements of his time, and attempted to negotiate among them successfully in his pious search for truth and his desire to serve God. The degree of respect and distinction which al-Ghazālī attained during his lifetime is reflected in the terms of honour with which he was acclaimed: the Proof of Islam (*hujjat al-Islām*), the Ornament of Faith (*zain al-dīn*) and the Renewer of Religion (*mujaddid*).[1]

During his lifetime, al-Ghazālī is thought to have written about four hundred books some of which are lost to us today. However, within the abundant work which survives, his ideas are as insightful and influential today as they were during his own time.[2]

---

[1] W. Montgomery Watt, "Al-Ghazālī," Encyclopedia of Islam, (New York: E.J. Brill, 1960) 1038-1042; Saeed Sheikh, "Al-Ghazālī: Metaphysics," A History of Muslim Philosophy, ed. M. M. Shariff (Karachi: Royal Book Company, 1983) 581-593; Majid Fakhry, A History of Islamic Philosophy, New York: Colombia University Press, 1970) 244- 261; Fray Luciano Rubio, El Occasionalismo de los Teólogos Especulativos del Islam, (Ediciones Escurialences, 1987) 161-166; Micheal E. Marmura, Introduction, The Incoherence of the Philosophers. Tahāfut al-Falāsifah: a Parallel English-Arabic Text, by Abū Hāmid al-Ghazālī, trans. Micheal E. Marmura (Provo, Utah: Brigham University Press, 1997) xv-xix; Ismail Hakki Izmirli, Islâmda Felsefe Akımları (Istanbul: Istanbul Kitapevi, 1995)177-204.

[2] Some of the books of Ghazali that are read today are *al-Munqidh min al-Dalāl* (Deliverance from error), *Ihyā ulūm al-dīn* (The Revival of Religious sciences), *Kitab al-Jawahir al-Qur'an* (The Jewels of the Qur'an), *Maqāsid al-falāsifa* (The Intentions of Philosophers), *Al-iqtisād fi 'l-itiqād* (Moderation in belief), *Mi'yār al-'ilm* (The Standard for Knowledge), *al-Durra al-Fākhira fi Kashf 'Ulum al-Akhira* (The Precious Pearl), *al-Maksad al-Asnā f i Sharh Asmā' Allah al-Husnā* (The Highest Aim in the Commentary on the Beautiful Names of God). For chronology and full list of Ghazali's works, see, G.F. Hourani, "The

A most unique aspect of al-Ghazālī's thinking is the open-minded spirit of his investigative pursuit and his consistent rejection of dogma. For him, all knowledge was worthy of examination and none was to be avoided. Before al-Ghazālī, dialectically competing fields of inquiry such as classical philosophy and theology were considered intellectually distinct within the academic milieu of Medieval Islam. Philosophical works translated from Greek were beginning to pose threatening questions about the rationality of faith. Al-Ghazālī's intuitive belief that theology would be supported and even affirmed by other fields of knowledge, such as logic, led him to attempt a reconciliation between them.[3] His success in bringing the two together marked a turning point in the history of Islamic thought. With his astounding breadth of background in several fields, al-Ghazālī possessed the rare intellectual capacity to be able to compare and draw parallels between and among such seemingly diverse fields.[4]

Al-Ghazālī's *Tahāfut al-Falāsifa*, (Incoherence of the Philosophers), thought to have been written between 1091 and 1095, is one of the best examples of his dialectical method of discourse. In the work, al-Ghazālī deftly presents his arguments, at times as an Ash'arite, at times as an Aristotelian, and at times as a neo-Platonist. Thus although *Tahāfut al-Falāsifa* is indeed a polemical work, it is nevertheless also

---

Chronology of Ghazali's Writings," JRAS 79 (1959): 225-33; W. Montgomery Watt, The Faith and Practice of al-Ghazālī, (London, 1953).

[3] See for example Micheal Marmura, "al-Ghazālī's Attitude to the Secular Sciences and Logic," Essays on the Islamic Philosophy and Science, ed. George F. Hourani (Albany: State University of New York Press, 1975); Marmura, "al- Ghazālī and Demonstrative Science," Journal of The History of Philosophy 3 (1965): 183-204; Van den Bergh, "al-Ghazālī's Gratitude towards God and its Greek Sources," Studia Islamica 7 (1957): 77-98).

[4] C. A. Qadir, Philosophy and Science in the Islamic World (Kent: Mackays of Chatham LTD., 1988) 96-100; For a complete study of Ghazali's life see for example W. Montgomery Watt, Muslim Intellectual: A Study of al-Ghazālī (Edinburg: Edinburg University Press), 1963; Mustafa Abu-Sway, al-Ghazālī: A Study in Islamic Epistemology (Kuala Lumpur: Dewan Bahasa Pustaka, 1996).

sophisticatedly philosophical, and often accepts the plausible points of its interlocutors in the spirit of intellectual pursuit. In it, al-Ghazālī attacks not philosophy *per se*, but rather lays out the contradictions within the thinking of the philosophers of his time, whom he believed had deviated from the straight path of religion. Al-Ghazālī's proposed aim and method in the book are outlined as follows:

> Let it be known that [our objective] is to alert those who think well of the philosophers and believe that their ways are free from contradiction by showing the [various] aspects of their incoherence. For this reason, I do not enter into [argument] objecting , except as one who demands and denies, not as one who claims [and] affirms. I will render murky what they believe in [by showing] conclusively that they must hold to various consequences [of their theories]. Thus I will force on them at one time necessary adherence to Mu'tazilite doctrine, at times to that of the *Karāmiyya*, at yet another to that of the *Wāqifiyya*. I will not rise to the defense of any one doctrine, but will make all the sects as one group against them. For the rest of the sects may differ from us in matters of detail, whereas these [philosophers] challenge the [very] principles of religion.[5]

Clearly then, *Tahāfut al-Falāsifa* is a work written not to put forward or defend a specific line of reasoning, but rather one which chooses from among the many already available in order to mount a dialectic attack on accepted notions within philosophy.

In his introduction to the book, al-Ghazālī begins by showing how the philosophers of his time were divided into three camps, based on their epistemological approaches to religion: the materialists (*dahrīyyūn*), the naturalists or deists (*tabī'īyyūn)*, and the theists (*Ilahīyyūn*). The first group, the materialists, were the philosophers who according to al-Ghazālī rejected the concept of God as the supreme creator and held that

---

[5] Abū Hāmid al-Ghazālī, The Incoherence of the Philosophers. Tahāfut al-Falāsifa: a Parallel English-Arabic Text, trans. Micheal E. Marmura (Provo, Utah: Brigham University Press, 1997) 7-8. (Here on Tahāfut)

the universe was an eternal, self-subsisting system which had developed and operated on its own, and which could therefore be studied according to its own laws. The second group, the naturalists or deists, who studied the sciences of natural phenomena, held that each entity in the universe, and the universe itself, showed a wondrous purpose and wisdom behind it which evidenced the existence of God as a wise creator. However, they denied theological concepts such as spirituality and the immortality of the human soul, resurrection, the day of judgment, and heaven and hell, all of which seemed to run counter to their logic, proposing that such ideas were simply pious fictions. The third group, the theists, were the philosophers who al-Ghazālī felt examined and refuted the views of the materialists and the naturalists effectively. Such thinkers as Socrates, Hippocrates, Plato, Aristotle and later their followers in the Islamic world, al-Farābī (d. 950) and Ibn Sīnā (Avicenna) (d. 1037),[6] who translated and commented on their works extensively, were for al-Ghazālī the best among this group. However, they too needed to be examined and refuted on their own grounds on several points. [7]

In his introduction, al-Ghazālī further categorizes the philosophical sciences into six fields: mathematics, logic, politics, ethics, physics and metaphysics. He systematically analyzes each in turn in order to test their validity on the basis of factual data and the principles of reason. According to his analysis, the bulk of the errors of the philosophers are contained within their theories on metaphysics. Al-Ghazālī finds metaphysics to be mere conjecture on the part of the philosophers, and does not believe

[6] For a contrary argument see Jules Jannes, "Al-Ghazālī's Tahāfut: Is it really a Rejection of Ibn Sina's Philosophy?" Journal of Islamic Studies 12.1 (2001): 1-17.

[7] Sheikh 592-596.

that in it are contained any truths grounded in reason or positive inquiry. *Tahāfut al-Falāsifa* thus primarily attacks the metaphysical views of the philosophers on the basis of accepted orthodox beliefs. Philosophers like al-Farābī and Ibn Sīnā, who expressed numerous metaphysical speculations, had in al-Ghazālī's view departed from the truth revealed in the Qur'an. He does not refrain from calling them heretics, and blames them for following their whims into the depths of Greek philosophy while ignoring the inconsistencies between their trust in Hellenism and the Qur'an.[8]

At a time when classical philosophy was presenting a severe challenge to Islamic orthodoxy, al-Ghazālī's basic argument was that the positive facts of religion could not be disproved, and for the philosophers to claim otherwise was disingenuous. In *Tahāfut al-Falāsifa* he therefore goes about showing how many of their arguments were logically suspect and contradictory, but more than that, how some of their basic assumptions were unfounded, in this way discrediting the validity of their system as a whole.[9]

Tahāfut al-Falāsifa is divided into two sections. The first part of the book critiques the philosophers' metaphysical propositions in sixteen discussions. In the second part of the book, al-Ghazālī moves on to the natural sciences, critiquing the philosophers' theories on natural phenomena in the final four discussions. In an introduction to this second section of the book, al-Ghazālī explains that he will here examine those of the natural sciences whose discourses he finds run contradictory to accepted ideas within the religious sciences.[10]

---

[8] Sheikh 592-596; Marmura Introduction xv-xix.

[9] Sheikh 592-596

[10] Marmura Introduction xv-xix.

The first of these final four discussions, the Seventeenth Discussion, 'On miracles and causality,' attempts to prove the possibility of the occurrence of miracles in the physical world. In order to accomplish this, al-Ghazālī attacks the sources of knowledge of the philosophers who rejected such a possibility. He calls into question the observations on which they based their opinions and their understanding of the physical principles by which the natural world operated. Using logical and theological reasoning, al-Ghazālī slowly deconstructs the arguments of the philosophers before mounting counter-arguments in support of the possibility of the miraculous.

Until relatively recently, the Newtonian concept of the universe has held as the dominant framework through which the physical world has been understood. Newton's ideas gave rise to the field of classical physics, which has since held sway over the hard sciences. However, in 1900 Max Planck stumbled upon a surprising discovery in the midst of an experiment. What he found was that energy flows not in smooth streams, but in separated and distinct 'packages' which he referred to as quanta. His discovery launched a revolution in the field of physics, and indeed in physicists' conceptions of physical reality. Since then, quantum theory has developed as a competing field of inquiry in its own right; one which has questioned and discredited commonly held notions such as the deterministic nature of the universe and the possibility of objectivity in scientific observation. The new knowledge provided by quantum physics has consequently led to a philosophical reevaluation of the place of human consciousness in the physical realm.

What is perhaps surprising is that the new information provided by quantum physics tends to support the view of the natural world espoused by al-Ghazālī in the 12th century. Although there are clearly gaps between the work of a Medieval Islamic theologian and that of a modern physicist, parallel concepts such as the rejection of causality and the limits of scientific observation run through the thinking of both. This thesis thus attempts a comparative analysis between these two seemingly divergent subjects, with the aim of contemporizing the thinking of al-Ghazālī and universalizing the concepts of quantum theory.

As can be expected, little scholarship has yet been accomplished in bringing together these fields of knowledge. As such, what this thesis attempts is highly original. It finds a predecessor in only one previous scholar, Karen Harding, whose relatively short paper "Causality then and Now: Al-Ghazālī and Quantum Theory,"[11] grasps at only some parallels between the two. In general, however, research for this thesis has had to be conducted along two separate but parallel paths, and this is reflected in its structure.

This thesis follows a comparative method of analyses. For this reason, the examination has been divided into three sections. In the first section a thorough review of the ideas contained in the Seventeenth Discussion is presented. The second section presents a review of the history of and dominant concepts discussed within the field of quantum physics. In the third section, a comparative analysis of the two is undertaken.

[11] Karen Harding, "Causality Then and Now: Al-Ghazālī and Quantum Theory." The American Journal of Islamic Social Sciences 10.2 (1993): 165-177.

The reader may find the logical flow of this structure jarring and counter-intuitive at points, but it should be kept in mind that only following a thorough understanding of both of the main subjects, al-Ghazālī's theology and quantum theory, can an informed connection be made between the two.

I. CHAPTER ONE: THE SEVENTEENTH DISCUSSION

1. 1. Introduction

In the introduction to the second part of the book al-Ghazālī states that he will first examine the concept of necessary causal connection, which the philosophers accepted and which he denies:

> The first is their judgment that this connection between causes and effects that one observes in existence is a connection of necessary concomitance, so that it is within neither [the realm of] power not within [that of] possibility to bring about the cause without the effect or the effect without the cause.[1]

Al-Ghazālī further states that he will attempt to refute the existence of a clear connection between what is considered cause and what is considered effect. This will form the basis of his defense of the miraculous, as he explains below:

> The contention over the first [theory] is necessary, in as much as [on its refutation] rests the affirmation of miracles that disrupt [the] habitual [course of nature], such as changing the staff into a serpent, revival of the dead, the splitting of the moon.[2]

He begins by separating the miracles that the philosophers accepted from those that they refused. According to al-Ghazālī, the philosophers had themselves affirmed three instances of miracles. The first was the ability to foresee future events based on the "imaginative faculty." Whereas ordinary people could have this ability in their dreams,

---

[1] Abū Hāmid al-Ghazālī, The Incoherence of the Philosophers. Tahāfut al-Falāsifa: a Parallel English-Arabic Text, trans. Micheal E. Marmura (Provo, Utah: Brigham University Press, 1997) 166 (Here on Tahāfut).

[2] Tahāfut 166.

al-Ghazālī relates, prophets can achieve this during their normal daily lives. The second was intuitive ability, related to the "theoretical rational faculty." Intuition, according to the philosophers, was the ability of the human mind to move from one object of knowledge to another in a quick transition. For example, when a person is told about a thing that is proved the person quickly realizes the proof that led to that conclusion; and when the person is told the proof, the person quickly realizes what is proved. "It may be the case," al-Ghazālī states, "that the intuition of a holy and pure soul would proceed uninterruptedly [as to grasp] all the intelligibles in the quickest of times." Such a person would be a prophet, who would without instruction miraculously immediately comprehend all of the intelligibles, so much so that it would be as though he learns them all by himself. The third of the accepted miracles relates to "the practical faculty of the soul." The philosophers agreed that the soul had the power of influence over the body, and that in the case of a prophet, it was possible that the soul could reach a point in its strength where it could exert influence not only over the prophet's own body but would also be able to be effective on the objects in the environment. Thus, as it is possible for the parts of his body to obey the prophet's soul, it is not impossible for other bodies to obey his soul also. The philosophers agreed that it was therefore possible for the prophets to perform miracles such as causing a storm, rain, or an earthquake to annihilate a community of people, all of which are contingent on the occurrence of coldness, heat, or motion in the atmosphere. These things then can be generated from the soul of the prophet and without an apparent natural cause. However, the philosophers put a limit to this idea, as they believed that these things could only occur in an atmosphere that was disposed to receive such actions. [3]

Al-Ghazālī openly admits, "we do not deny anything they have mentioned and [agree] that this belongs to the prophets." But he disagrees with their confining themselves to it. The second group of miracles, those which the philosophers had denied outright or accepted in a way inconsistent with what was revealed in the Qur'an, he felt ought to be accepted completely also. These included the possibility of the changing of the staff into a serpent, the revivification of the dead and the splitting of the moon.[4] He therefore prepares the reader for the Seventeenth Discussion of *Tahāfut al-Falasifa*, "On Causality and Miracles," both "to affirm miracles and for something else -- namely, to support what all Muslims agree on, to the effect that God has power over all things."[5]

1.2. The Seventeenth Discussion - On Causality and Miracles

The Seventeenth Discussion of *Tahāfut al-Falāsifa*, "On Causality and Miracles," focuses specifically on proving the possibility of miracles. Al-Ghazālī begins the first part of the discussion with a statement that shows he clearly refuses the concept of necessary connection between cause and effect by saying that "the connection between

---

[3] Tahāfut 167.

[4] However, Ghazālī does not mention the splitting of the moon again.

[5] Tahāfut 168-169; also see George Giacaman and Raja Bahlul, "Ghazālī on Miracles and Necessary Connection," Medieval Philosophy and Theology 9 (2000): 39-50; Barry S. Kogan, "The Philosophers al-Ghazālī, and Averroes on Necessary Connection and the Problem of the Miraculous," Islamic Philosophy and Mysticism, ed. Parviz Morewedge (New York: Caravan Books, 1981) 113-132; Blake D. Dutton, "Al-Ghazālī on Possibility and the Critique of Causality," Medieval Philosophy and Theology 10 (2001): 38; Marmura, Al-Ghazālī's Second Causal Theory 85-87. Alai Alon, "Al-Ghazālī on Causality," Journal of the American Oriental Society 100 (1980): 397-405.

what is habitually believed to be a cause and what is habitually believed an effect is not necessary, according to us." [6]

Al-Ghazālī's basic argument against necessary causation is premised upon the following Aristotelian logical[7] assertion:

> ... [with] any two things where 'this' is not 'that' and 'that' is not 'this,' and where neither the affirmation of the one entails the affirmation of the other nor the negation of the one entails negation of the other, it is not a necessity of the existence of the one that the other should exist, and it is not a necessity of the nonexistence of the one that the other should not exist.[8]

The argument states that a presumed cause and a presumed effect are in fact two separate and unconnected events. In order to explain this point further, al-Ghazālī provides examples of assumed cause-effect pairs, such as "the quenching of thirst and drinking, satiety and eating," as well as "burning and contact with fire" and "death and decapitation," all of which, according to his premise, are in fact separable and unnecessary for one another to exist. For al-Ghazālī, the Ash'ārite theologian, only a single source is responsible for all connections:

> ...all [that is] observable among connected things in medicine, astronomy, arts, and crafts. Their connection is due to the prior decree of God, who creates them side by side, not to its being necessary in itself, incapable of separation. On the contrary, it is within [divine] power to create satiety without eating, to create

---

[6] Tahāfut 170.

[7] Goodman states that "here al-Ghazālī uses no other basis for his argument beyond Aristotle's correspondence theory of truth (in making the transition from events to propositions and back) and the Aristotelian rules of logical conversion in deducing that if two propositions imply one another a contradiction must rise from the affirmation of one and the denial of the other. No reference is made to the atomism of the *Kalām*, or to the *Kalām* occasionalism." Lenn E. Goodman, "Did Al-Ghazālī Deny Causality?" Studia Islamica 47 (1978): 86.

[8] Tahāfut 170.

death without decapitation, to continue life after decapitation, and so on to all connected things. The philosophers denied the possibility of [this] and claimed it to be impossible.[9]

1.3. Fire That Does Not Burn

Al-Ghazālī dwells on one example for much of the remainder of this discussion; the "burning of cotton...when in contact with fire." This he chooses in order to connect it with a miracle, namely the miracle of the prophet Abraham who was thrown into fire by his people and did not burn:

> For we allow the possibility of the occurrence of the contact without the burning, and we allow as possible the occurrence of the cotton's transformation into burnt ashes without contact with the fire. [The philosophers], however, deny the possibility of this.[10]

In order to call into question the philosophers' logic denying the possibility of this miracle, al-Ghazālī first outlines the two positions which they have presented against it.[11] It should be noted here that one of al-Ghazālī's repeated dialectical strategies is to refute the arguments that the philosophers have already made as well as arguments which he anticipates they will make.

The first of the philosophers' positions is that the fire alone is the agent, and that its agency is by nature; therefore, burning happens necessarily and not by choice. In other

---

[9] Tahāfut 170; according to Marmura, what Ghazālī means by saying 'side by side' is not "one following the other" but that they are concomitant to each other. Marmura also gives us the information here that Ghazālī is denying the idea of essential causality of Avicenna. See Tahāfut 242; Marmura, "Ghazālīan Causes and Intermediaries," rev. of Creation and the Cosmic System: Al-Ghazālī and Avicenna, by Richard Frank, Journal of the American Oriental Society 115.1 (1995): 91-92.

[10] Tahāfut 170-171.

[11] Tahāfut 170-171. It should also be noted here that al-Ghazālī proposes three different positions to prove his point but gives only two.

words, fire can not refrain itself from burning an object that is able to receive its effect. Al-Ghazālī completely denies this view, firstly on a basis very similar to Ash'ārite atomism, in which it was widely held that every object and event, atoms and accidents, are due to God's decree. [12]

> ...And this is one of the things we deny. On the contrary, we say:
>
> The one who enacts the burning by creating blackness in the cotton, [causing] separation in its parts, and making it cinder as ashes, is God, either through the mediation of His angels or without mediation. [13]

Further, to respond to the philosophers who defend their opinions based on logic, al-Ghazālī is not at all incapable of producing logical refutations in his argument in a manner that shows that he does not solely argue from the point of belief:

> As for fire, which is inanimate, it has no action. For what proof is there that it is the agent? They have no proof other than observing the occurrence of the burning at the [juncture of] contact with the fire. Observation, however, [only] shows the occurrence [of burning] at [the time of the contact with the fire],

---

[12] Ash'ārites held that everything that God created (matter, time, space and motion) consisted of two basic elements, namely atoms and accidents. Atoms were accepted as indivisible. As a result of atomizing mater, space, time and motion the Ash'ārites saw the universe as consisting of separate and independent entities. They denied the Aristotelian necessary causal connection between bodies. For them things in nature could neither posses any causal power nor could they have any ability to create another thing. All the motion and change in the world is caused by God. Things in the world do not have any permanent nature. Fire, for example, does not have an inherent permanent power or quality of burning. When a substance like cotton touches fire, it is only God who creates burning in the cotton, not fire. The Ash'ārites, thus denied the Aristotelian cause and effect correlation and denied that causes create effects. They held strong on the idea of God's constant intervention with the universe. They wanted to maintain that God has the ultimate power, that God is constantly practicing power and control over creations. Ash'ārites held atomism also for proving miracles as literally true. The earliest atomism of Islamic theology is thought to have derived from Greek sources, such as from *Democritus* and *Epicurus*, however, Indian sources are also acknowledged. For more information on this subject see Sholomo Pines. Studies in Islamic Atomism, trans. Michael Scwarz, ed. Tzvi Langermann (Jerusalem: The Hebrew University, Magness Press, 1997); Majid Fakhry, Islamic Occasionalism. (London: George Allen and Unwin LTD, 1958), 17-48; George Makdisi, "Ash'ari and the Ash'arites in Islamic Religious History," Studia Islamica 17 (1960): 19-39; Andrey Smirnow, "Causality and Islamic Thought," A Companion to World Philosophies, eds. Eliot Deutsch and Ron Bontekoe (Malden, Massachesetts; Oxford: Blackwell Publishers, 1997) 593-503.

[13] Tahāfut 171.

> but does not show the occurrence [of burning] by [the fire] and that there is no other cause for it. [14]

Mere observation is not enough for al-Ghazālī. The concurrence of two events in no way proves that one of them caused the other.

Al-Ghazālī builds on this argument by providing examples of similar situations in which philosophers have agreed upon the idea of God's being the sole agent. One of these examples is of a sperm that is placed in a womb. Al-Ghazālī reminds the philosophers that faculties such as seeing, hearing, the life of the sperm itself, or the infusion of spirit are accepted by them not to be brought about 'by' the parent or 'by' its placement in the womb but by God alone:

> It is known that these [come to] exist with [the placing of the sperm], but no one says that they [come to] exist by it. Rather, they exist from the direction of the First, either directly or through the mediation of the angels entrusted with temporal things.[15]

Al-Ghazālī concludes the argument by showing that to find the cause behind the effect one can not trust observation, because observation may show things other than the causes. The cause of something, therefore should mean that the thing is brought about 'by' it, according to al-Ghazālī; 'with' it, on the other hand, is something quite different.

Al-Ghazālī then presents an example to show further proof that observation does not take one to the truth, and in fact it is prone to error. According to him, it is very easy to mistake the cause of things based on mere observation. This time his example describes a person who is born blind and has never experienced the difference between

---

[14] Tahāfut 171.

[15] Tahāfut 171.

night and day. Al-Ghazālī says that if such a person were to start seeing daylight and colors, the person, based on his observation, would firmly and wrongly hold that sight came to him because of the opening of the eyes; however, when night came and darkness fell, the person would realize that in fact the colors and everything else that he could see were due to the daylight. These, according to al-Ghazālī, are a sequence of wrong impressions of natural events which the person observes and comes to a conclusion based on his observations. The real cause, al-Ghazālī repeats, is God alone.[16]

In order to attack the philosophers on their own grounds, al-Ghazālī presents a proof based on their accepted neo-Platonic notions. He puts forth inferences that would necessarily follow based on principles that the philosophers who supported the idea of emanation[17] would have to accept. Again, his argument is about the fallibility of observation:

> Whence can the opponent safeguard himself against there being among the principles of existence grounds and causes from which these [observable] events emanate when a contact between them takes place-- admitting] that [these principles], however, are permanent, never ceasing exist; that they are not moving bodies that would set; that were they either to cease to exist or to set, we would apprehend the dissociation [between the temporal events] and would understand that there is a cause beyond what we observe? This [conclusion] is inescapable in accordance with the reasoning based on [the

---

[16] Marmura Al-Ghazālī's Second Causal Theory 89.

[17] Theory of emanation in Islamic thought comes from al-Farābi. His theory explains the origin of creation by emanation in a hierarchical order from a Necessary First Cause. The First Cause is both Intelligent and Intelligible, as well as unique and it has no opposites. From the first Cause emanated a second intelligence necessarily when the First Cause realized Itself. The third intelligence emanated necessarily from the second when the second intelligence realized the First and itself, and this continued until the tenth intelligence from which the earthly four material causes emanated. Al-Farābi's theory of cosmos is thought to have its roots in the thoughts of *Plotinus* and the school of *Alexandria*. For more information see Ibrahim Madkour, "Al-Farābi," Islamic Philosophy and Mysticism, ed. Parviz Morewedge (New York: Caravan Books, 1981) 450-468; Muhsin Mahdi, "Al-Farābi and the Foundation of Philosophy," Islamic Philosophy and Mysticism, ed. Parviz Morewedge (New York: Caravan Books, 1981) 3-21; Thérese-Anne Druart, "Al-Farabi's Causation of the Heavenly Bodies," Islamic Philosophy and Mysticism, ed. Parviz Morewedge (New York: Caravan Books, 1981) 35-45, also see bibliography.

philosophers' own] principle. [18]

How is it possible for the philosophers to claim that the idea of causality is completely true, al-Ghazālī seems to be asking, while they simultaneously hold the theory of emanation as true? The contradiction is anchored in the fact that one cannot prove that the causes of temporal events don't actually come from the principles of existence (which were accepted to be angels or celestial bodies). It is possible that the causes and effects observed between objects could all be coming from these principles, but because they do not set or die, we do not see that they are the real causes. Based simply on observation of the objects around us, it is not possible to prove that these causes are not from those principles. Although it is unclear at this point whether al-Ghazālī himself accepts the notion of causality as coming from the principles of existence, it seems that he is only playing the part of a neo-Platonist in order to deliver another proof to the philosophers who accepted the concept of emanation, to show them that his argument against the inherent necessity between causes and effects in the observable world still holds, even according to their own description of nature.[19]

Al-Ghazālī then turns to the philosophers whom he refers to as "the exacting among them." They are those who accepted that the real cause of, for example, sight, or "the imprinting of the form of color in the eye comes from the bestower of the forms" and that "the sun's appearance, the healthy pupil and the colored body" are only "preparers for the receptacle's acceptance of these forms." Those who have made this case for all

[18] Tahāfut 172.

[19] Fray Luciano Rubio, El Occasionalismo de los Teólogos Especulativos del Islam (Ediciones Escurialences, 1987) 188-189; Marmura Al-Ghazālī's Second Causal Theory 85-89.

temporal events show an inconsistency among the philosophers while weakening the case for an inherent necessity between presumed causes and effects:

> With this, the claim of those who proclaim that it is fire that enacts the burning, that it is bread that enacts satiety, that it is medicine that produces health, and so on, becomes false. [20]

Up to this point, al-Ghazālī has been responding to the philosophers' first position against the possibility of the miracle of the prophet Abraham's not burning in the fire, based on the concept of fire being an agent which cannot refrain from burning. Al-Ghazālī's response has included an attack on the inherent necessity of the cause and effect relationship, evidence of the fallibility of observation, and a pointing out of the contradictions within the philosophers' thinking. His attack has incorporated Ash'arite, Aristotelian, and neo-Platonic thinking, as has been strategically useful.

Having thus refuted the philosophers' first position, al-Ghazālī at this point turns his attention to their second position:

> The second position belongs to those who admit that these temporal events emanate from the principles of temporal events, but that the preparation of the reception of the forms comes about through these present, observed causes--except that these principles are also [such that] things proceed from them necessarily and by nature, not by way of deliberation and choice, in the way [that] light proceeds from the sun, receptacles differing in their reception because of the differences [of] disposition. [21]

What al-Ghazālī seems to reject here is not the notion of emanation but the notion of necessity in the actions of the principles of temporal events. The example of sunlight,

---

[20] Tahāfut 172.

[21] Tahāfut 172.

which radiates with an undiscriminating strength over all that it touches, is given to exemplify such natural necessity -- only "the differences of the disposition in the receptacle" can determine whether sunlight illuminates, is reflected or is absorbed. In the same way, the philosophers proposed, the principles of existence are constantly inundating all receptacles to the same degree without withholding any from any. They thus reasoned that if two similar pieces of cotton were brought to fire, which is necessarily undiscriminating, they would both burn equally. Applying these principles, the philosophers denied the possibility of the miracle in which the prophet was cast into fire and did not burn. The only way this could be possible, they argued, is "by taking the heat out of fire -- which makes it no longer fire -- or by changing the essence and body of Abraham into stone or something over which fire has no effect," neither of which they accepted as possible.

Al-Ghazālī's response to this position takes two approaches. The first approach is based on refuting the assumption that God does not act voluntarily. Throughout his arguments below, he reasserts his contention that God's will and actions are not involuntary and necessitated. This point should be kept in mind because as al-Ghazālī pursues his argument he does not clearly express this, building the argument instead around the premise that the agent's actions are voluntary he says he does not "concede that the principles do not act by choice and that God does not act voluntarily." [22]

---

[22] Tahāfut 173. Ghazālī here also refers the reader to the 3rd discussion of Tahāfut in which he rejects and attacks the notions of the philosophers on the act and will of God as necessarily coming from God's Essence or Nature. For more information see Marmura, Al-Ghazālī's Second Causal Theory 86-87. For a more extensive description see Saeed Sheikh, "Al-Ghazālī: Metaphysics," A History of Muslim Philosophy, ed. M. M. Shariff (Karachi: Royal Book Company, 1983) 598-601.

Here al-Ghazālī's position as an Ash'ārite theologian is that God acts voluntarily. Thus God "through His will creates the burning" of cotton when in contact with the fire. This proposition gives way to the next proposition that "it becomes rationally possible [for God] not to create the burning with the existence of fire." Here al-Ghazālī clearly states the agency of God as the ultimate cause of everything, including the perceived as cause and effect relationship. [23]

Anticipating the philosophers' objection that if one accepts the possibility of fire not burning, then one must also allow for other unreasonable possibilities and "repugnant contradictions," al-Ghazālī carefully prepares the way for his response:

> It may be said: ....if one denies the effects follow necessarily from their causes and relates them to the will of their Creator, the will having no specific designated course but [a course that] can vary and change in kind, then let each of us allow the possibility of there being in front of him ferocious beasts, ranging from fires, high mountains, or enemies ready with their weapons [to kill him], but [also the possibility] that he does not see them because God does not create for him [the vision of them]. And if someone leaves a book in the house, let him allow as possible its change on his returning home into a beardless slave boy--intelligent, busy with his tasks--or into an animal; or if he leaves a boy in his house, let him allow the possibility of his changing into a dog; or [again] if he leaves ashes, [let him allow] the possibility of its change into musk; and let him allow the possibility of stone changing into gold and gold into stone. If asked about any of this, he ought to say: 'I do not know what is at the house at the present. All I know is that I have left a book in the house, which is perhaps now a horse....For God is capable of everything, and it is not necessary for the horse to be created from the sperm, nor the tree to be created from the seed--indeed, it is not necessary for either of the two to be created from anything. Perhaps [God] has created things that did not exist previously.' Indeed, if [such as person] looks at a human being he has seen only now and is asked whether such a human is a creature that was born, let him hesitate and let him say that it is not impossible that some fruit in the marketplace has changed into a human, namely this human--for God has power over every possible thing, and this thing is possible--hence, one must hesitate in [this matter]. [24]

---

[23] Marmura, Al-Ghazālī's Second Causal Theory 85-112; Rubio 189-191; Giacaman and Bahlul 45; Alon 401-402.

[24] Tahāfut 173-174.

In response, al-Ghazālī defends the position that God is able to do anything and has power over everything. These seeming impossibilities are thus all possible for God if God chooses to do them.[25] "If it is established that the possible is such that there cannot be created for man knowledge of its nonbeing," he argues, then "these impossibilities would necessarily follow." In other words, if God had not created in human beings the ability to conceive of the possible not occurring, then the philosophers' reasoning would hold. However, as the philosophers themselves acknowledged, it is possible for a prophet to know, for example, "that a certain individual will not arrive from his journey tomorrow when his arrival is possible, the prophet knowing, however, the nonoccurrence of this possible thing." Similarly, one may look at a faithless and ignorant man and yet "one does not deny that the soul and intuition [of this ordinary man] may become stronger so as to apprehend what the prophets apprehend, in accordance with what the philosophers acknowledge--although they know that such a possibility has not taken place." With reference to the possible, then, al-Ghazālī states:

> We did not claim that these things are necessary. On the contrary, they are possibilities that may or may not occur. But the continuous habit of their occurrence repeatedly, one time after another, fixes unshakably in our minds the belief in their occurrence according to past habit. [26]

[25] For different discussions on Ghazālī's possibilities see Eric. L. Ormsby, Theodicy in Islamic Thought: The Dispute over al-Ghazālī's "Best of All Possible Worlds" New Jersey: Princeton University Press, 1984) 182-216; Taneli Kukkonen, "Possible Worlds in the Tahāfut al-Falasifa: Al-Ghazālī on Creation and Contingency," Journal of the History of Philosophy 38.4 (2000): 479-502; Kukkonen, "Plenitude, Possibility, and the Limits of Reason: A Medieval Arabic Debate on Metaphysics of Nature" Journal of History of Ideas 61.4 (2000): 539-560.

[26] Tahāfut 174.

The point being made is similar to al-Ghazālī's previous argument about the fallibility of observation leading to the false notion of a necessary causality. The distinction here is between the possible and the necessary, with a warning that simply because God has chosen to allow us to rationalize that what has tended to occur will continue to occur, that doesn't mean that its non-occurrence is impossible:

> If, then, God, disrupts the habitual [course of nature] by making [the miracle] occur at the time in which disruptions of habitual [events] take place, these cognitions [of the nonoccurrence of such unusual possibilities] slip away from [people's] hearts, and [God] does not create them. There is, therefore, nothing to prevent a thing being possible, within the capabilities of God, [but] that by His prior knowledge He knew that He would not do it at certain times, despite its possibility, and that He creates for us the knowledge that He will not create it at that time. [27]

That is, if God were to first 'disrupt the habitual course of nature' and then produce a miracle, it would become clear that miracles are indeed not impossible. Only because we have grown accustomed to the habitual courses of nature do we see these as connected.

The above constitutes al-Ghazālī's first approach in response to what he terms the philosophers' "vilifications," or their *reductio ad absurdum* argument above. He now embarks on his second approach, which he begins with the following statement:

> The second approach, with which there is deliverance from these vilifications, is for us to admit that fire is created in such a way that if two similar pieces of cotton come into contact with it, it would burn both, making no distinction between them if they are similar in all respects. [28]

Agreeing with the philosophers on this point, al-Ghazālī nevertheless holds fast to his initial position:

---

[27] Tahāfut 175.

[28] Tahāfut 172.

> With all this, however, we allow as possible that a prophet may be cast in the fire without being burned, either by changing the quality of the fire or by changing the quality of the prophet. [29]

He is able to maintain this seemingly contradictory stance by referring to a logic superior to yet not contradictory with that of the rational sciences which he has accepted:

> Thus, either there would come about from God or from angels a quality in the fire which restricts its heat to its own body so as not to transcend it (its heat would thus remain with it, and it would [still] have the form and true nature of fire, it's heat and influence, however, not going beyond it), or else there will occur in the body of the prophet a quality which will not change him from being flesh and bone [but] which will resist the influence of the fire. [30]

In this way, al-Ghazālī is able to defeat the philosophers' argument that the only way for the prophet not to be burned would be for the quality of either the fire or the prophet to be changed. Al-Ghazālī here presents both as retaining their qualities and yet, through divine intercession, the prophet remains unharmed. He provides a tangible example to explain his point: "a person who covers himself with talc and sits in a fiery furnace is not affected by it." One who has not seen such an occasion, al-Ghazālī argues, will not believe this, and the philosophers' denial of the possibility that the prophet who was put in fire did not burn is the same. He concludes this argument by stating that God's power includes all kinds of possibilities and wondrous things that we have not observed, and we cannot deny them as impossible simply on the basis of not being able to observe them.

---

[29] Tahāfut 175.

[30] Tahāfut 175.

1. 4. Transformation and Revivification

Thus satisfied with his defense of the miracle of the prophet who did not burn in fire, Al-Ghazālī moves on to his next aim, to show the possibility of the miracles of the transformation of the staff of the prophet Moses into a snake and the miracle of the prophet Jesus raising the dead. Once again, he finds a way to explain his argument using facts and examples that the philosophers used in their own arguments. He starts with one of the philosophers' axioms, that "Matter is receptive of all things," and continues to explain that the world is in a constant process of change. For example, earth and the elements that are contained in earth change into plants, plants due to being eaten by animals change into blood, then blood changes into several parts of the body as well as the sperm. The fetus in its mother's womb respectively develops in stages slowly. All this, "in accordance with habit, takes place in a lengthy period of time." After listing such naturally occurring progress and stages of development and change as they are accepted by the philosophers, al-Ghazālī again connects the argument to the ability and power of God and asks:

> why, then, should the opponent deem it impossible that it lies within God's power to rotate matter through these stages in a time shorter than has been known? And if it is possible within a shorter time, there is no restriction to its being [yet] shorter. These powers would thus accelerate in their actions, through [this] there would come about what is a miracle for the prophet. [31]

That is, the raising of the dead can be seen as simply a regeneration following natural courses; the only unusual factor is the rapid time within which it occurs. And surely, to

[31] Tahāfut 176.

alter time like this is within the power of God, who has created time itself. Once again anticipating the objections of the philosophers, al-Ghazālī asks their next question for them: "Does this proceed from the prophet's soul or from some other principle at the suggestion of the prophet?" His response takes the form of another question directed back at the philosophers:

> [In] what you have admitted regarding the possibility of the coming down of rain [and] of hurricanes and the occurrence of earthquakes through the power of the prophet's soul, do [such events] come about from him or from another principle? Our statement in [answering your question] is the same as your statement in [answering ours]. [32]

It is unclear what this statement would be, but al-Ghazālī at this point seems to be suggesting that both himself and the philosophers have reached the limits of their human ability to know such things:

> It is, however, more fitting for both you and us to relate this to God, either directly or through the meditation of the angels. The time meriting its appearance, however, is when the prophet's attention is wholly directed to it and the order of the good becomes specifically [dependent] on its appearance so that the order of the revealed law may endure. [33]

For al-Ghazālī, that such an event is possible, and that its principle is "benevolent and generous," give credence to the existence of such miracles. This notion of benevolence is applied further by him in explaining when such miracles can occur:

> But it does not emanate from Him except when the need for its existence becomes preponderant and the order of the good becomes specified therein. And the order of the good becomes specified therein only if a prophet needs it to prove his

---

[32] Tahāfut 176.

[33] Tahāfut 176.

prophethood in order to spread the good. [34]

This explanation, says al-Ghazālī, is consistent with and a necessary consequence of what the philosophers have accepted -- namely, that prophets are given different characteristics which are superior to those of normal human beings. Thus al-Ghazālī asks why and how the philosophers can deny such miracles that have been reported and corroborated by multiple sources and by religious law.

In the discussion which follows, al-Ghazālī prepares the way to prove the miracle of the staff turning into a serpent. Beginning with the philosophers' accepted ideas on "the principles of being," or creation via natural reproduction, al-Ghazālī describes how only a human is created from human sperm and only a horse from the sperm of a horse, "since [to take the latter case] its realization from the horse is the more necessitating of preponderance because of the greater appropriateness of the equine form over all other forms." In other words, each thing that is reproduced takes its form from its parental source because, with the participation of the angels, that specific form is the most appropriate and the most necessary one for it. In this way, "wheat has never sprouted from barley and apples never from the seed of pears." [35]

Although it is unclear whether al-Ghazālī takes this theory of reproduction from the philosophers for the sake of argument or whether he accepts it himself, it should be noted that his argument here seems to imply an acceptance of a type of cause and effect

[34] Tahāfut 176.

[35] Tahāfut 177.

relationship; this appears to contradict his seemingly total rejection of the necessity of causality stated earlier. [36]

Continuing this explanation of generation based on what the philosophers accepted, al-Ghazālī next mentions the creatures that were thought at the time to be generated spontaneously. [37] In doing so he takes another step forward in his aim of explaining the miracle of the staff turning into a serpent:

> Moreover, we have seen genera of animals that are [spontaneously] generated from earth and are never procreated--as, for example, worms--and others like mouse, snake, and the scorpion, that are both [spontaneously] generated and procreated, their generation being from the earth. Their dispositions to receive forms differ due to things unknown to us, it being beyond human power to know them, since, according to [the philosophers], forms do not emanate from the angels by whim or haphazardly. [38]

The possibility of the transformation of the staff of the prophet into a snake, then, seems to be related to the possibility of the naturally spontaneous generation of snake-like creatures. It is clear that al-Ghazālī is aware that this argument is less convincing than the others he has presented, for he cites here the inability of human beings to completely comprehend the machinations of the divine.

According to the philosophers' neo-Platonic theory of emanation, the dispositions of created things vary according to certain principles, such as "the configurations of the stars and the differing relations of the heavenly bodies in their movements." These

[36] Marmura Al-Ghazālī's Second Causal Theory 85-86.

[37] This also is an Aristotelian Thought. For a short description of Aristotle's thoughts on spontaneous generation, see A. I. Oparin, "Theories of Spontaneous Generation of Life," The Mystery of Matter, ed. Louise B. Young. (New York: Oxford University Press, 1965) 277-282; also James Conant, "The Controversy Concerning Spontaneous Generation," The Mystery of Matter, ed. Louise B. Young. (New York: Oxford University Press, 1965) 290- 302.

[38] Tahāfut 177.

principles of dispositions have been applied by those practicing the talismanic arts, al-Ghazālī explains, "to combine the heavenly powers and the special properties of minerals" to achieve almost magical results. If such abilities, as it was believed, are possible, he asks, then how can the philosophers doubt similar abilities in a prophet:

> If, then, the principles of dispositions are beyond enumeration, the depth of their nature is beyond our ken, there being no way to ascertain them, how can we know that it is impossible for a disposition to occur in some bodies that allows their transformation in phase of development in the shortest time so that they become prepared for receiving a form they were never prepared for receiving previously, and that this should not come about as a miracle? [39]

The sources of the denial of this, according to al-Ghazālī, are "our lack of capacity to understand, [our lack of] familiarity with exalted beings, and our unawareness of the secrets of God." He adds, as a final note, that those who study such sciences are able to observe the wondrous and yet not claim that these miracles are beyond the power of God.

1. 5. Possibilities and Impossibilities

As he has based much of his argument on the concepts of the possible and the impossible, al-Ghazālī anticipates the philosophers demand that he define these terms. Indeed, by broadening the meaning of 'possible' and reducing the meaning of 'impossible,' one can propose clearly false and nonsensical postulates leading to contradictory conclusions. For example, there would be no difference between voluntary and involuntary actions; the act on the part of the individual would no longer prove either the knowledge or power of the agent; and God would also be able to change genera:

---

[39] Tahāfut 178.

> [God] would thus change substance into accident, knowledge into power, blackness into whiteness, sound into smell, just as He had been able to change the inanimate into the animate and stone into gold, and there would follow as necessary consequences impossibilities beyond enumeration. [40]

Al-Ghazālī's response to such a call for definitions is as follows:

> The impossible is not within the power [of being enacted]. The impossible consists in affirming a thing conjointly with denying it, affirming the more specific thing while denying the more general, affirming two things while negating one [of them]. What does not reduce to this is not impossible, and what is not impossible is within [divine] power. [41]

Nevertheless, examples for the above statements are provided. According to al-Ghazālī, it is impossible to combine blackness and whiteness, because blackness by definition implies the absence of whiteness, and whiteness negates the presence of blackness. Once one of them is understood as the negation of the other, then it becomes impossible to have the negated with the affirmed. It is also impossible for an individual to be in two places at the same time. If an individual is in a house, then, from this, the individual's being out of the house is negated. Hence it is impossible to suppose that the person is in the house as well as out of the house at the same time. As well, it is impossible to create knowledge in inanimate matter, because an inanimate object is understood not to have apprehension:

> If apprehension is created in it, then to call it inanimate in the sense we have understood becomes impossible. And if it does not apprehend, then to call what has been created "knowledge" when its receptacle does not apprehend anything is [also] impossible. On the other hand, something has apprehension then our calling it inanimate becomes impossible. If matter does not have apprehension,

---

[40] Tahāfut 179.

[41] Tahāfut 179.

> then the 'knowledge' created in that matter can not be called 'knowledge', for to call it 'knowledge' while it can not receive a is not able to receive knowledge is impossible. [42]

Regarding the changing of one genera into another, al-Ghazālī mentions that some of the Islamic dialectical theologians accepted this as one of the possibilities for God. He, however, concurs with the philosophers in saying that blackness, for example, cannot change into a cooking pot. Were this to happen, the blackness would cease to exist and something else, the cooking pot, would come into existence. If a thing stops existing and some other thing comes into existence, then it cannot be said that the first changed into second; rather, there is simply the existence of a new and separate thing. Al-Ghazālī holds that one genera can not change into another genera only because they have no common matter between them. "Between accident and substance, there is no common matter," he argues, and so, "the transformation between one genera into another is impossible." If, however, common matter exists between two objects, it is possible for their forms to be changed. Examples of this are blood changing into sperm or water into steam, and "the same holds when we say the staff has changed into a serpent and earth into animal."[43] Thus for al-Ghazālī the staff and the snake both comprise the same matter, but in different forms.

In the next argument, he discusses the possibility, posed as a challenge by the philosophers, of God's moving a dead man's hand while the man is in a sitting position, his eyes open and his hand writing. The issue being debated was agency. If, as al-Ghazālī proposed, all things were within the power of God, then human beings possessed

[42] Tahāfut 179.

[43] Tahāfut 180.

no agency, and if human beings possessed no agency, then surely it would be possible for God to animate a dead man as it is for him to know the future actions of a live one. Al-Ghazālī at this point again takes a stand as an Ash'ārite theologian:[44] "[This] in itself is not impossible as long as we turn over [the enactment of] temporal events to the will of a choosing being," he says. This has been accepted as impossible only "because of the continuous habit of its opposite occurring." Al-Ghazālī responds to the idea of the "well designed act" of a human being with the concept that, "the agent is now God, who is the performer of the well-designed act and [the] knower of it."

A related argument regards voluntary and involuntary actions. The Ash'ārite view of human action held that it was only God who created human actions, and that humans acquired these actions as they are being created in the person. This, the philosophers would claim, erased the distinction between voluntary and involuntary actions. According to al-Ghazālī, there exists a difference between involuntary actions (i.e., a tremor) and voluntary actions. "We apprehend [this difference] in ourselves," he states. Voluntary and involuntary actions are different, so much so that we, as humans, have expressed "the difference by the term 'power.'" The two actions happen in two different states. Voluntary actions happen by "bringing the existence of a motion with the power over it" and involuntary actions happen in the state in which the motion comes into existence without the power. Al-Ghazālī further explains that involuntary actions are from God:

If however, when we look at another person and see that there are many ordered

---

[44] Tahāfut 180.

> motions, we apprehend this as if all these are within the power of the individual. For, these are cognition's which God creates according to the habitual course [of events], by which we know the existence of one of the two possible alternatives [but] by which the impossibility of the other alternative is not shown as has been previously said. [45]

Here al-Ghazālī refers to his definition of impossibility, in which he explained, for example, that the existence of blackness shows the nonexistence of whiteness; when the existence of blackness is affirmed, it is impossible to also affirm the existence of whiteness. By using the same logic, he explains that in voluntary actions humans hold power over their motions, and in involuntary actions human power is lacking. Therefore, it can not be said that when an individual has power over her actions, it is possible to call those movements involuntary, and that when the human does not have power over her actions, it is possible to call them voluntary. Al-Ghazālī concludes that the difference between voluntary and involuntary actions persists even when it is held possible that God can move a dead man's hand and thereby writing is produced.

1. 6. Conclusion

The above has been a more or less uncritical presentation of al-Ghazālī's ideas in the Seventeenth Discussion of *Tahāfut al-Falāsifa*, the purpose of which is simply to give the reader a sense of his thinking on the nature of physical reality through an examination of his arguments. The Seventeenth Discussion has attracted many scholars, who have produced invaluable works on al-Ghazālī's opinions on causality, the nature and sources

---

[45] Tahāfut 180

of knowledge and possibilities and impossibilities, as well as whether his arguments can be considered Ash'ārite or Aristotelian. [46]

The above has been presented within these perspectives, particularly with an eye to the commentary of Marmura. For the purposes of this thesis, however, al-Ghazālī's statements themselves have been given more weight than the scholars' ideas regarding the nature or sources of his statements.

The reader is invited to keep in mind the general tenor of al-Ghazālī's thinking on the nature of the universe as he or she moves on to the next chapter, which will deal with the quantum physics conception of the universe. Although intuitive links may be made at this point, it is only in the final chapter that a comparative analysis between the two will be attempted.

---

[46] For example, according to Türkler, Ghazālī shows that the connection between cause and effect is not a necessary one as it is in mathematics. Türkler, Üc Tehafüt Bakimindan Felsefe ve Din Münaseleti (Ankara: Türk Tarih Kurumu Basimevi, 1956) 67-68; Izmirli states that Ghazālī denies causality and asserts God's ultimate sovereignty over everything. Ismail Hakki Izmirli, Islâmda Felsefe Akımları (Istanbul: Istanbul Kitapevi, 1995) 195-196. Fakhry analyzes Ghazālī's views of ontological and logical necessity. He concludes that Ghazālī sees causality as a part of nature and that nature holds a consistency in showing cause and effect relationship, however, this is only based on observation. Majid Fakhry, A History of Islamic Philosophy, New York: Colombia University Press, 1970) 61; Goodman believes that Ghazālī's discussion is made against the notion of causality that the philosophers held and not against causality *per se*. He also explains that this discussion is based on Aristotelian logic and not on theological or atomistic perspectives of nature. Goodman 83-120; Alon holds that Ghazālī is an Ash'ārite and reconciles the two views: theology and philosophy. Alon 397-405; Marmura focuses on whether Ghazālī sees the connection between cause and effect as a necessary one and concludes that Ghazālī argues as an Ash'ārite and does not hold a necessary connection between causes and effects. Marmura, Al-Ghazālī's Second Causal Theory 99; Rubio informs us that Ghazālī denies necessary causality and he is even a betterAsh'āritethan his theological teacher *al-Juwayni*; Rubio 161-197. Riker, states that Ghazālī philosophically defends that natural events are in succession of each other but this is not an enough proof for causality. He further states that "perhaps best solution is to grant that Ghazālī himself may have preferred the first more occasionalist view," but also that he accepted natural causality "while still remaining religiously orthodox." Stephen Riker. "Al-Ghazālī on Necessary Causality." The Monist 79.3 (1996): 321-322 Giacaman and Bahlul, see that Ghazālī's holds occasionalism and refuses necessary connection between causes and effects. Giacaman and Bahlul 30-50; Abrahamov's conclusion shows that Ghazālī combines divine causality with secondary causality and that he holds that secondary causes have inherent natures created and maintained by God. Binyamin Abrahamov, "Al-Ghazālī's Theory of Causality,". Studia Islamica (1988): 75-98.

II. CHAPTER TWO: QUANTUM PHYSICS

As many physicists suggest, the world of quantum mechanics can best be understood within the context of its development. This section will present a brief history of this fascinating field of physical science, outlining the most important dates, figures as well as experiments and results.

2.1. Classical Theory

In our everyday contemporary reality, our observances and expectations provide us the ideas of nature as a continuous, logical and predictable whole. Thus, for example, if a bullet hits its target, we say that it was aimed correctly -- we know that the bullet went through a definite path from the gun to its target and we know that the path was determined by the magnitude, direction and velocity of the muzzle. This knowledge we possess comes from classical physics, inspired by Galileo Galilei and Isaac Newton in the late seventeenth century. Newton discovered the laws of motion and gravity. His book the *Philosophiae Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy, published in 1687), explained the laws of motion of material bodies, which the following generation of scientists used and developed. Newton accepted that the motion of a body was determined by the forces that act on that body, but the initial position and velocity had to be fixed. Newton also described the motion of the planets as moving according to these universal laws of motion. Although Newton himself did not attribute an inherent necessity of cause and effect -- or determinism -- to the natural world, these notions eventually followed as a result of his discoveries.[1] In a letter to his friend Bentley in 1693, Newton wrote the following:

> It is inconceivable that inanimate brute matter should, without mediation of some else which is not material, operate upon and effect other matter without mutual contact....That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance and through a vacuum without the mediation of anything else by and through which their action or force maybe conveyed from one to another is to me so great an absurdity that I believe no man who has in philosophical matters any competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent be material or immaterial is a question I have left to the consideration of my readers. [2]

As Newton's laws proved accurate under many conditions, they were thought to be universally applicable. This acceptance of the laws of motion, in the following century, brought with it the implication of the concept of determinism as the new paradigm for the interpretation of the universe. Every event, that is, occurred by necessity as a result of the action of applied forces. The universe was thus seen as a great clockwork set at the beginning of time and left to tick forward with no intervention. In this universe all macro- and micro-particles worked with absolute accuracy. Once scientific data were gathered about an event, predictions could easily be made about past

---

[1] Paul Davies, The Cosmic Blueprint (London: Heinemann, 1987) 9; Heinz R. Pagels, The Cosmic Code (New York: Simon and Schuster, 1982) 18-20; Ernan McMullin, "The Explanation of Distant Action," Philosophical Consequences of Quantum Theory, eds. Cushing, James T. and Ernan McMullin (Notre Dame: University of Notre Dame Press, 1989) 289-302; Ronald Omnés, Quantum Philosophy: Understanding and Interpreting Contemporary Science, trans. Arturo Sangalli (New Jersey:Princeton University Press, 1999) 31-35.

[2] McMullin 290.

and future events. The idea of determinism that was grounded in Newton's explanations thus became the basis for all scientific testing. [3]

The Newtonian theory of nature, today accepted as classical theory, meant that nature could be understood by reason and logic, and that the changes in nature could accordingly be predicted. For three centuries after the publication of Newton's *Principia*, the mechanical view of nature provided the basis of the science of physics. More recently, however, this mechanical view of nature has undergone major convulsions, and has developed to give rise to a theory that seems to contradict Newton's initial notion of a clockwork universe. This theory has come to be known as quantum theory.

2.2. Quantum Theory

Quantum theory was born by the end of the nineteenth century and the beginning of the twentieth century (1900-1926), when experimental physicists contacted the atomic structure of matter. The first findings showed that it was randomness and uncontrollability, rather than the determinism of Newtonian physics, which modulated the entire micro-world.

Although numerous physicists working on quantum mechanics have explained matter's behaviors in mathematical terms, their interpretations could not be gathered under one heading, and therefore, several different interpretations by different scientists currently exist. Some of these are known as the Copenhagen interpretation, the Many-Worlds interpretation, the Bohmian interpretation, the Rational interpretations, the

[3] Davies 9; Pagels 18-20; Werner Heisenberg, The Physicists Conception of Nature, trans. Arnold J. Pomerans. Wesport (Connecticut: Greenwood Press, Publishers, 1970) 121-151; Nick Herbert, Quantum Reality: Beyond the New Physics (New York: Anchor Press, 1985)1-29; Roberto Torretti, The Philosophy of Physics (Cambridge: Cambridge University Press, 1999) 20-84.

Collapse theories of quantum mechanics, Everett's relative-state formulation of quantum mechanics, modal interpretations of quantum mechanics, and the Kochen-Specker theorem of quantum mechanics.

2.3. Max Planck

Although the laws of classical physics were used by all physicists and accepted as valid and credible, several problems arose regarding experiments and their results. Many physicists were working on these dilemmas, conducting repeated experiments in the hopes of finding results that they could accept. The initial quantum theory grew out of the results that could not be explained by the accepted classical concepts.

It was Max Planck, a German physicist, who brought the first important idea of quantum theory in 1900. Before Plank's theory, the classical view of nature as a logical continuum was widely accepted. It was believed that forms of matter smoothly blended into one another. That is, the physical qualities of the elementary particles of matter, such as momentum, position, energy and spin were considered continuous and free of any irregularities, or so it was thought. Planck, while working on black bodies,[4] derived some surprising findings. According to the concepts of classical physics, when high temperatures were applied to a black body, the energy emitted, which was measured as electromagnetic radiation, was expected to rise steadily. Mathematically speaking, the energy inside the heated black body was expected to increase in proportion to the square of the frequency of the radiation that was produced. This should have eventually resulted

[4] A black body is a sealed container with a small hole that can absorb heat in high temperature. A perfect black body is able to absorb all the radiation that is given to it and as a function of its energy. It emits radiant energy in the most efficient way. Menas Kafatos, and Robert Nadeau, The Conscious Universe: Parts and Holes in Physical Reality (New York: Springer, 2000) 20; Amrtin Ernst-Wolfgang Luther, The Infinite Voyage: A Metaphysical Odyssey (Minnesota: Marwolf Publishing, 1996) 26.

in the emission of extreme amounts of energy, termed the 'catastrophe in the ultra-violet.' However, Planck's measurements of energy emission in the experiments done on black bodies showed a bell-shaped curve. That is, the energy emitted rose to a certain point and then began to recede, eventually falling to a point where no measurable radiation was any longer emitted. This was very different from the predictions, as explained above. Thus, Plank's findings caused a dilemma within classical physics, for the results of the experiments contradicted the deterministic notion of a natural continuum, which would have predicted a continuous rise of the emitted radiation as a factor of the continuing increase of the application of heat. Plank, who worked on this question for years, eventually came up with a hypothesis that shook the foundation of physics. He visualized radiation as an enormous collection of tiny "vibrating oscillators." He came to the conclusion, which he later described as "an act of sheer desperation," that the radiation of energy from the vibrating charges was not as it had always been formulated. By using mathematical argumentation in which he used a new concept (later called 'Planck's constant'), he theorized that the absorption and emission of energy were not continuous but discrete. That is, the exchange of energy was not in a single stream but in tiny "lumps or energy packages," which were discrete and quantized. He concluded that "the hypothesis of quanta has led to the idea that there are changes in nature which do not occur continuously but in an explosive manner." [5]

[5] Gary Zukav, The Dancing Wu Li Masters: An Overview of the New Physics (New York: William Morrow and Company) 55; Herbert 34-35; Fritjof Capra, The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism, 3rd ed. (Boston: Shambhala, 1991) 67-68; Victor J. Stenger, The Unconscious Quantum: Metaphysics in Modern Physics and Cosmology (New York: Prometheus Books, 1995) 37-37.

These energy packages have since been called "quanta," a term denoting their discrete quantity. According to Planck, these quanta had various sizes, depending on the frequency of the emitted radiation. All the energy packets of frequencies of red light, for example, are the same size, and so are all the energy packets of frequencies of violet light. However, the energy packets of violet light are larger than the energy packets of red light. Therefore, Plank discovered that the size of the low energy frequency light. [6]

Plank himself was uncomfortable with his findings as they so clearly challenged accepted notions in classical physics, and he knew he would have to face strong opposition against his new hypothesis. His trepidation is evident in his writing recounting the moment:

> By nature I am peacefully inclined and reject all doubtful adventures. But a theoretical interpretation had to be found at all costs, no matter how high....I was ready to sacrifice every one of my previous convictions about physical laws. [7]

Victor Guillemin, professor of physics at Harvard, explains Planck's dilemma as follows:

> [Plank] had to make a radical and seemingly absurd assumption, for according to classical laws, and common sense as well, it had been presumed that an electronic oscillator, once set in motion by a jolt, radiates its energy smoothly and gradually while its oscillatory motion subsides to rest. Plank had to assume that the oscillator ejects its radiation in sudden spurts, dropping to lesser amplitudes of oscillation with each spurt. He had to postulate that the energy of motion of each oscillator can neither be built up nor subside smoothly and gradually but may change only in sudden jumps. In a situation where energy is being transferred to and fro between the oscillators and the light waves, the oscillators must not only emit but also absorb radiant energy in discrete "packets"....He coined the name "quanta" for the packets of energy, and he spoke of the oscillators as being "quantized." Thus, the trenchant concept of the quantum entered physical science. [8]

---

[6] Zukav 52-57.

[7] Herbert 93.

[8] Zukav 55-56.

Although Plank was surprised by his own discovery, it was he, on December 14, 1900 at the Physikalisch-Technishe Reichsantalt in Berlin, that took the first step in the direction of a quantum theory which was going to be shaped within the next 25 years. After Plank's discovery physics was to change. The idea of an outrageous -- because classical physics simply had no place for it -- discontinuity had entered physics. It was not only Planck, but many physicists who felt that the new discovery gave new messages that they did not understand yet, but the impact of the results were huge.[9] So huge that, for example, Louis de Broglie, a well-known physicist at the time, characterized the importance of Planck's discovery as "On the day when quanta, surreptitiously, were introduced, the vast and grandiose edifice of physics found itself shaken to its very foundation." [10]

2.4. Einstein and the Photoelectric Effect

The second important step in quantum theory, five years later in 1905, came from Albert Einstein. Einstein was working on photoelectric effect. The concept of photoelectric effect can be described simply as an experiment in which a beam of light is sent to a photosensitive metal plate. When the light travels and hits the plate, the results showed that several electrons departed from the sensitive surface of the plate. As light, in classical physics, was thought to be like a wave, this departure of electrons was not possible. Thus, the photoelectric effect, just like black body radiation, was another

---

[9] Pagels 20-39; Zukav 55-57.

[10] Luther 28.

enigma of classical physics. The first guess was that a bright source of light would eject more electrons than a weak source of light. However, soon what was seen was the opposite. A weak beam of ultraviolet light would eject more electrons from the photosensitive plate than a very bright beam of red light. This dilemma would be similar if we compare light to ocean waves and photosensitive plate to pebbles on the shore. The results then, were showing that a very weak wave was moving more pebbles on the shore than a stronger wave. [11]

Einstein solved the problem by applying Planck's theory of quanta. He postulated light not as waves but as particles. If light was also a bundle of electrons than the photoelectric effect could be explained. Einstein hypothesized that the reason why one weak beam of ultraviolet light would eject more electrons from the plate than a strong beam of red light was because the energy of these quanta is proportional to the frequency of light. In other words, it was not the brightness or the weakness of the light that effected the electrons, but rather the rate or frequency of the light. Red light then, no matter how bright, because of its low frequency, does not have sufficient energy to knock the electrons off the plate, but ultraviolet light does. [12]

As a result, by using Planck's constant in his explanation of the photoelectric effect, Einstein explained that light waves also consisted of quanta, which he later called "photons" meaning little packets of energy that constitutes light. Einstein won a Nobel Prize for his theory of light as a bundle of particles and not waves. With his results, Plank's idea was reemphasized and gained more support.

---

[11] Robert Nadeau and Menas Kafatos The Non-Local Universe (Oxford: Oxford University Press, 1999) 30-31; Luther 29-30; Zukav 57-70; Jennifer Trusted, The Mystery of Matter (London: MacMillan Press, Ltd.; New York: St. Martin's Press, 1999) 119-121.

[12] Nadeau and Kafatos Non-Local Universe 30-31; Luther 29-30; Zukav 56-57.

With Planck's and Einstein's findings, a new particle-wave dichotomy entered physics. Up to that point the concept of light, in accordance with the idea of nature as a continuum, had been understood and accepted as waves. However, for a while, Einstein was alone and not supported in his discovery. The majority of physicists found these new notions hard to accept because they were all against the classical notions of nature. This skepticism can be seen in a letter of recommendation written for Einstein's membership into the prestigious Prussian Academy of Sciences in 1913:

> In sum, one can hardly say that there is not one among the great problems, in which modern physics is so rich, to which Einstein has not made a remarkable contribution. That he may have missed the target in his speculations, as for example, in his hypothesis of the light quanta, cannot really be held too much against him, for it is not possible to introduce really new ideas even in the exact sciences without taking a risk. [13]

At the beginning of twentieth century, first with Planck's idea of the quantum, and later with Einstein's photons of light, the view of the nature of light as continuum could not be maintained, and so although not accepted, a new vision and transformation in physics started. What was found showed that the behavior of atoms were incompatible with the classical physics notion of a clockwork universe. The discreteness of light was a big departure from classical physics and the determinacy principle. Because discreteness broke the accepted notion of continuation it also broke the notion of absolute determinism. Discreteness meant that nature was not in a continuum; the behavior of nature, then, could not be predicted, measured and tested. Once the continuum and determinacy were challenged the whole concept of physics was challenged. For that reason, many physicists tried to reconcile these new discoveries with the idea of

[13] Pagels 30.

determinism within the domain of classical physics. Einstein was one of them. For them, there was still a hope of showing that the construction of atoms as the smallest constituents of the big clockwork universe also followed Newtonian determinism. [14]

Nevertheless, it was unavoidable to see that as these new discoveries were applied in different areas in physics, they did not only challenge the old classical Newtonian physics in some ways, but they also gave rise to new insights and new solutions to the problems that were posed within classical physics. Another one of these problems was the circulation of electrons around a heavy nucleus. [15]

2.5. Bohr and Quantum Jumps

Ernest Rutherford, in 1911, set up a model of the atom whose nucleus was suggested to have a heavy positive charge orbited by negatively charged electrons, in a structure similar to that of the solar system. This was inconsistent with the classical physics concept of electromagnetic theory, in which it was believed that opposite charges would attract each other. In this way, according to classical physics, electrons would circuit the heavy nucleus in ever smaller orbits until a certain time and then they would have to collapse into the nucleus. In such a universe, how planets could circle the sun and not collapse into it, for example, was one of the questions that had been puzzling the

[14] Pagels 28-30; Nadeau and Kafatos Non-Local Universe 30-31; Luther 29-30; P.C.W. Davies and J.R. Brown, eds. The Ghost in the Atom: A Discussion of the Mysteries of Quantum Physics (Cambridge: Cambridge University Press, 1986) 2-3.

[15] Davies and Brown 2.

physicists until another step in quantum mechanics came from the Danish physicist Niels Bohr. [16]

When Niels Bohr, in 1913, entered the scene to solve the problem of atomic structure with his experiments and theories on atoms and electrons, he abandoned classical physics and applied the quantum theory that had started with Planck and Einstein. He explained that electrons could only leave their orbits by either giving or taking energy, and that they moved in spectral lines or colored lines. Bohr also used Planck's constant and quantization in his explanations, which resulted in the further acceptance of quantum energy packets and discontinuity theory. He explained that electrons were also quantized and they could reside without a loss of energy at certain energy levels. There was a lowest orbit beyond which the electrons could not fall. He further explained that when electrons jumped between orbits, they released or absorbed electromagnetic energy in discrete quantities. Because only certain electron orbits are possible only certain jumps took place. When the electrons jumped from one orbit to another, the atom emitted light and that light was quantized. Bohr concluded that these energy packets were photons. As the energy of light is related to its color (or frequency), Bohr explained that atoms emitted only specific colors of light, and the fact that each atom emitted light with distinct and unique colors showed the quantum structure of atoms. In other words, it was found that the transmission of energy was discontinuous, unlike a line but discrete; electrons jumped from one orbit to another suddenly, without

[16] Davies and Brown 2-3; Karl R. Popper, Quantum Theory and the and the Schism in Physics (New Jersey: Rowman and Littlefield, 1982) 135-138; Fred A. Wolf, Star Wave: Mind, Consciousness, and Quantum Physics (New York: Macmillan Publishing Company, 1984) 72-79.

appearing at any place in-between, and that this movement happened with no obvious reason in ascending or descending order with the atom. [17]

When the structure of atoms was exposed by such experiments, a new and unfamiliar world started to reveal itself. The usual rules that the physicists had accepted no longer seemed to be trustable. Bohr, perhaps before any other physicist, was ready to accept this new world with its new rules, as his words make clear below:

> One must be prepared for the fact that the required generalization of the classical electrodynamics theory demands a profound revolution in the concepts on which the description of nature has until now been founded. [18]

This new world was the atomic world in which the rules of determinism, supported by centuries of experiments and theories, was about to fall.

2.6. Compton Scattering

Another similar step towards quantum theory was taken by Arthur Holly Compton in 1923. Compton was working on x-rays (high-frequency light). His discovery, known as 'Compton scattering,' involved experiments in which collisions of x-ray photons with electrons were engineered. Compton shone a beam of x-rays onto electrons and found that the x-rays bounced off the electrons. This showed that x-ray photons were also particles. Compton further found that just as light had particle-like properties, electrons could also have wave-like properties. As a result, it came to be

---

[17] Luther 32; Erol Kurt, "Kuantum Teorisi ve Temel Ilkeleri." Populer Bilim Dergisi (1997); 30-34; Pagels, Cosmic Code 70-71; Davies and Brown 2-3; Victor Weisskopf, "Atomic Structure and Quantum Theory," The Mystery of Matter, ed. Louise B. Young (New York: Oxford University Press, 1965) 95-120; Barry Parker, Quantum Legacy: The Discovery that Changed our Universe (New York: Prometheus Books, 2002) 27-28.

[18] Pagels 72.

accepted that light had a nature that behaved like waves or particles, depending on the experiments performed. [19]

2.7. De Broglie and Matter Waves

Soon Clinton Davidson, experimentally, and Luis de Broglie, theoretically, arrived at a new understanding of matter. De Broglie, in his doctoral thesis, explained that all subatomic matter possessed waves that corresponded to them. He called these waves 'matter waves.' The wavelength of these waves corresponded to the nature of the particle. He used Planck's constant and formulated a new equation in which he showed that as the momentum of a particle gets bigger, the corresponding wavelength gets shorter. Experiments performed by Clinton Davidson at the Bell Telephone Laboratories confirmed his thesis, and both scientists received the Nobel Prize for this new discovery. Thus, in this new understanding, electrons as well as photons were shown to be both particles and waves. Depending on particular circumstances, they behaved either as waves or as particles. Soon this theory was accepted for all subatomic particles. That is, it was not only photons and electrons but all subatomic particles that behaved as both particles and waves. In the micro-world of atoms and subatomic particles, therefore, it became evident that the traditional laws of mechanics that were proposed by Newton were completely to be doubted. [20]

---

[19] Zukav 103-105; Nadeau and Kafatos Non-Local Universe 34; Herbert 38-39; Parker 27-28.

[20] Davies and Brown 4; Zukav 106-110; Herbert 39-41; Weisskopf 95-120; Robert P. Crease and Charles C. Mann, The Second Creation: Makers of the Revolution in the Twentieth-Century Physics (New York: Macmillan Publishing Company, 1986) 53-55.

2.8. Schrödinger and Wave Mechanics

Erwin Schrödinger was also working on electrons; however, his approach was more concerned with the visualization of the atomic world. He was attracted to the waves notion of particles of deBroglie's, as well as to classical physics. Schrödinger did not accept Bohr's idea that electrons could jump from one orbit to another with no obvious reason. These jumps were inconsistent with classical physics, in which the notion of continuum is very important. Schrödinger wanted to find a theory that would settle this problem in classical physics. He posited a theory that electrons were not spherical objects but were instead patterns of standing waves. His solution was arrived at by using a mathematical formula, later termed Schrödinger's equation. He explained that these standing waves are also quantized just as atomic phenomena are, and that each standing wave was an electron. He further proposed that electrons were the segments of vibrations of these waves, bounded into nodes. Each atom, Schrödinger explained, had a multitude of differently shaped standing waves. In other words, one atom has several different shapes of standing waves but they are all three-dimensional. This idea of different shapes came to Schrödinger from Wolfgang Pauli, who put forth a principle called the "principle of exclusion," which stated that there can not be any two electrons that are exactly alike in one atom.[21] Schrödinger commented on his extrapolation as follows:

> The ingenious but nevertheless somewhat artificial assumptions of [Bohr's model of the atom]...are placed by much more natural assumption in de Broglie's wave phenomena. The wave phenomenon forms the real 'body' of the atom. It replaces the individual punctiform [pointlike] electrons,

[21] Zukav 110-116; Luther 45-48; Parker 85-101.

which in Bohr's model swarm around the nucleus. [22]

Max Born, another physicist, interpreted Schrödinger's standing waves as unreal and purely mathematical constructions, which he therefore termed "waves of probability." His explanation follows:

> … the whole course of events is determined by the laws of probability; to a state in space there corresponds a definite probability, which is given by the de Broglie wave associated with the state. [23]
>
> We have two possibilities. Either we use waves in spaces of more than three dimensions…or we remain in three-dimensional space, but give up the simple picture of the wave amplitude as an ordinary physical magnitude, and replace it by a purely abstract mathematical concept…into which we can not enter. [24]

From this he concluded the following that "physics is in the nature of the case indeterminate, and therefore it is the affair of statistics." [25]

2.9. Heisenberg and the Uncertainty Principle

Soon after Max Born's explanation of probability waves, Werner Heisenberg, made another big step in quantum theory by explaining the indeterminacy of subatomic events. Heisenberg laid out a principle called the "uncertainty principle" in 1927. Heisenberg's uncertainty principle, sometimes referred as "quantum mechanical indeterminacy" states that one can not precisely know the momentum and the position of a given electron together at the same time. This is not due to the invalidity of the

---

[22] Zukav 114.

[23] Zukav 117.

[24] Zukav 118.

[25] Zukav 118.

measurement tools used or the scientists' observations, but because it is inherent in nature. As a result, it was concluded that an electron (or any other subatomic particle) does not posses both a position and a momentum simultaneously. In order for any particle to traverse a path in the universe, the particle must have a location at a point on the path. If we return to the example of a gun being fired, for example, we can know the position of the bullet as it leaves the barrel and we can also know its momentum. Using classical physics, by knowing the bullet's initial position and momentum, its future trajectory can be determined and predicted precisely. However, if we look at this example from the subatomic perspective, a different conclusion must be arrived at. The Heisenberg uncertainty principle implies that the particle's position and momentum at the instant of its leaving the barrel can not be established at the same time. Since these initial measurements are uncertain, the future trajectory of the bullet is also undetermined. As a result, only a statistical and probabilistic future trajectory of the bullet can be given, with no certainty as to how it will actually move. This uncertainty, it must be kept in mind, is only valid in the micro-world of atoms and particles. Therefore, in the world of electrons we can only have a probabilistic description of future motion. [26]

According to the results of the experiments done on the observation of atoms and subatomic particles, it was seen that their behavior was not identical even among identical atoms whose energies are identical. This gave rise to an understanding that observation does not give a clue for the examiner on their behavior. Their behavior is random, or if there is a cause (or causes), it is not known yet. As a result, no prediction of future events of electron behavior can be given. This of course shows that in the

[26] Davies and Brown 6; Pagels 91; Trusted 138- 150; Parker 116-119; Richard Morris, The Big Questions: Probing the Promise and Limits of Science (New York: Henry Holt and Company, 2002) 54-57.

micro-world of atoms, electrons and photons, as well as other particles, there is a strong element of uncertainty. [27]

The significance of determinacy implies that in order to predict the future, we should have a complete and accurate picture of the present, but quantum indeterminacy shows that we can not do that. Heisenberg not only thought that such prediction was impossible, but he also thought accurate knowledge of the present was impossible, as is clear in his statement below:

> In the statement , 'if we knew the present in all its details we could predict the future with accuracy' it is the premise rather than the conclusion which is wrong, [because we can not] know the present in all its details. [28]

Such indeterminacy, for Neils Bohr, required "the necessity of a final renunciation of the classical ideal of causality and a radical revision of our attitude toward the problem of physical reality." [29]

2.10. The Double-slit Experiment

One of the experiments performed on electrons was called 'the double-slit experiment.' In this experiment a beam of electrons was sent forward from a small source towards a plate punctured by two slits. A detector was placed behind the double-slit plate to record the electrons' positions of impact, which registered as little specks. What was

---

[27] Davies and Brown 6; Omnés 140-144; Werner Heisenberg, "Remarks on the Origin of the Relations of Uncertainty," Quantum Implications: Essays in Honour of David Bohm, eds. B.J. Hiley and F. David Peat (New York: Routledge & Kegan Paul Ltd. , 1991) 3-6; Gordon Reece, "In Praise of Uncertainty," Quantum Implications: Essays in Honour of David Bohm, eds. B.J. Hiley and F. David Peat. (New York: Routledge & Kegan Paul Ltd. , 1991) 7-12; David Bohm Causality and Chance in Modern Physics (New York: Harper and Brothers, 1957) 81-89; Peter Kosso, Appearance and Reality: An Introduction to the Philosophy of Physics (Oxford: Oxford University Press, 1998) 110-116; Parker 116-119; Trusted 138- 150.

[28] Brackets mine. Luther 43.

[29] Zukav 126.

found was that when the multiple electrons were released simultaneously, the specks formed a clearly discernible pattern, called an interference pattern, such as would be created when water when passed though two slits. When the beam was arranged so that only one electron was released at a time, each electron passed through one of the slits, seemingly at random, and registered as an individual speck on the detector plate. When numerous individual electrons had passed through the slits in this way, however, the collective result on the plate began to form the interference pattern again. That is, each individual electron had somehow behaved according to a law of averages, acting as if in cooperation with all the other individually released electrons. Even more surprisingly, when one of the slits was closed off, no such pattern emerged. Nor did the superimposition of the registered specks of two individually opened slits indicate the interference pattern. The electrons somehow knew that one of the slits was closed. It seemed, therefore, as though each electron had somehow 'chosen' which hole to pass through in concert with other individual electrons only when there was such a choice to be made. What's more, if the physicists were to position two detectors in front of the holes to ascertain in advance towards which hole a particular electron was heading, the electron's pattern was so disturbed by the act of measurement that the interference pattern disappeared altogether. That is, only if the physicists did not attempt to trace the route of the electron would the electron's 'knowledge' of both routes be displayed. [30]

One way of looking at this as proposed by some scientists is to remember that quantum particles do not have definite pathways in space, and then to suppose that each electron somehow posses an infinity of different pathways in space in which it has the

[30] Zukav 63-73; Luther 45-53; Nadeau and Kafatos Non-Local Universe 46-51; Richard Feynman, The Character of Physical Law (Massachusetts: The M.I.T. Press, 1965) 127-148; Popper 151-156.

ability to traverse. In this way, it can be explained that some of their pathways pass through the slits and encode information about each pathway and this is how each electron can keep track of what is happening throughout a large area of space. This idea also shows itself when the observer were to put a detector in front of the holes to detect which electron will choose which hole and then immediately blocks the other hole without altering the motion of the electron. In this case, it is seen that the electron's motion is so disturbed that the interference pattern defiantly vanishes. It is apparent that what the observer decides now in a sense influences how the quantum particle shall have behaved in the past. [31]

This experiment with its mysterious results is explained by the physicist John Gribben as follows:

> In the experiment with two holes the interference can be interpreted as if the electron that leaves the gun vanishes once it is out of sight and is replaced by an array of ghost electrons each of which follows a different path to the detector screen. The ghosts interfere with one another, and when we look at the way electrons are detected by the screen we then find the traces of this interference, even if we deal with only one 'real' electron at a time. However, this array of ghost electrons only describes what happens when we are not looking; when we look, all of the ghosts except one vanish, and one of the ghosts solidifies as a real electron... each of the 'ghosts' corresponds to a wave, or rather, a packet of waves, the waves that Born interpreted as a measure of probability. The observation that crystallizes one ghost out of the array of potential electrons is equivalent, in terms of wave mechanics, to the disappearance of all the array of probability waves except for one packet of waves that describes one real electron. This is called the 'collapse of the wave function,' and bizarre though it is, it is at the heart of the Copenhagen Interpretation...[which] depends explicitly on the assumption that myriad ghost particles interfere with each other all the time and only coalesce into a single real particle as the wave function collapses during an observation. What's worse, as soon as we stop looking at the electron, or whatever we are looking at, it immediately splits into a new array of ghost particles, each pursuing its own path of probabilities through the quantum world. Nothing is real unless we look at it,

[31] Davies and Brown 6-9; Pagels 135- 147; Nadeau and Kafatos Non-Local Universe 46-51; Feynman 127-148; Capra 132-139; Tony Rothman and George Sudarshan, Doubt and Certainty (Reading, Massachusetts: Perseus Books, 1998) 163-166; Kafatos and Nadeau Non-Local Universe 38-42.

and it ceases to be real as soon as we stop looking. [32]

This and similar experiments are explained in different ways according to different interpretations of quantum mechanics. The developments of the differing explanations divided the physicists into two camps. Such physicists as Plank, Schrödinger and de Broglie joined ranks with Einstein, who resisted the implications of quantum theory; other physicists such as Dirac, Pauli, Jordan, Born and Heisenberg were in another group, which was led by Bohr, advocating the Copenhagen interpretation of quantum mechanics. The Copenhagen interpretation eventually became one of the most widely accepted and discussed views, according to which, the outcomes of the above experiment show at least three different results. [33]

The first of these is that the measurement results are completely indeterministic and therefore purely statistical. In the quantum world there are no hidden variables that could support the determinism of classical theory, in which probabilities are used to give an accurate prediction of the future act of an object. Therefore, according to the Copenhagen interpretation, no future momentum or position of a particular quantum particle can ever be given. Because individual precise measurements are meaningless, one experiment must be repeated several times to get what can only be seen as general statistical measurements.

Another result derived from these experiments is that the observed object is affected by the observer or by the observing tool. It is impossible to remove the effect of

---

[32] Luther 49-50.

[33] Kafatos and Nadeau, Conscious Universe 30. Heisenberg, Physicists Conception 32-41; Robert Forrest, Quantum Mechanics (Basil Blackwell, 1988) 57-63; Pagels 94-95; Bohm, Causality and Change 84-103; Popper 104-106; Morris 54-57.

the observer on the result. Therefore, what is observed is not nature *per se*, but nature that has been influenced by the examiner. The objectivity of the experiment is lost. Quantum reality is an observer-created reality. The physical world is influenced by the physical world. Heisenberg stated this point as follows:

> What we observe is not nature itself, but nature exposed to our method of questioning. [34]
>
> Some physicists would prefer to come back to the idea of an objective real world whose smallest parts exist objectively in the same sense as stones or trees exist independently of whether we observe them. This however is impossible. [35]
>
> The hope that new experiments will lead us back to the objective events in time and space is about as well founded as the hope of discovering the end of the world in the unexplored regions of the Antarctic. [36]

Bohr further stated that it was meaningless to ascribe attributes to quantum objects before they were observed and measured. It was impossible, for example, to speak about the past of a particle and say that it was a particle or a wave before the measurement. He explained that if the observation is set up to measure the particle's position, what will be seen is a particle at a place; however, if it is set up to measure momentum, the particle will be seen as a motion.

At this point, when several physicists discussed these conclusions, several thought experiments were contrived. One of them, for example, suggested by the Copenhagenists, was that when an electron is put in a box it can be imagined that it can be anywhere in the box while its wave fills the totality of the box. When a screen is

---

[34] Zukav 126.

[35] Herbert 32.

[36] Herbert 17.

placed in the middle of the box, dividing it into two, the electron's waves are still in both places in the box and they will keep existing this way until someone looks at one of the chambers. The Copenhagenists explained that at the point of observation, the particle will be seen only in the chamber that was observed, and the wave in the other chamber will consequently disappear. [37]

This experiment, for the Copenhagenists, explained the three notions that they held -- the collapse of the wave function, superposition and non-locality -- at the same time. The observation collapses the particle's wave, which up to that point is in a state of superposition. In the Copenhagen interpretation it is accepted that atomic phenomena are in a quantum state, meaning that they are in a state that contains a gathering of different quantum states. These quantum states are superimposed over the actual event. Only at the time of observation is one of these states seen, and the others vanish. The idea of non-locality can be understood as two microscopic objects being still connected even if they are in a large distance from each other. For example, in the electron in the box experiment, when the two chambers of the divided box are moved quite a long distance apart from each other, the superposition continues to operate over both chambers. The Copenhagenists held that the electron existed in both chambers although it was only one electron; the electron vanished from one chamber only when the other was observed. Until that point, they were somehow still together but in a wave form. [38]

A lot of physicists and philosophers have criticized the Copenhagen interpretation of quantum mechanics due to its indeterministic and bizarre explanations of nature and

---

[37] Davies and Brown 15-22.

[38] Davies and Brown 15-22; Popper 86-88; Morris 68-69; Euan Squires, The Mystery of the Quantum World, 2nd ed. (Bristol; Philadelphia: Institute of Physics Publishing, 1994) 56-69.

also because it violated the principle of local causality. The principle of local causality asserts that whenever an object is affected, it is either due to local changes in the state of the object itself or due to energy that has been transmitted through the surface of the object. This principle, accepted by all physicists, is the center argument of causality. Einstein explains this concept of local causality as follows:

> If one asks, what, irrespective of quantum mechanics, is characteristic of the world of the ideas of physics, one is first of all struck by the following: The concepts of physics relate to a real outside world....It is further characteristic of these physical objects that they are thought of as arranged in a space-time continuum. An essential aspect of this arrangement of things in physics is that they lay claim, at a certain time, to an existence independent of one another, provided these objects "are situated in different parts of space. [39]

2.11. The Einstein-Podolsky-Rosen (EPR) Paper

A critical attack of the Copenhagen interpretation of quantum physics was launched in 1930 by Einstein, Podolsky and Rosen, who published a famous paper known as the EPR paper in which they described a thought experiment showing that quantum mechanics was either incomplete or that it violated the principle of local causality. Einstein explains the condition of completeness below:

> If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity.[40]

In this thought experiment the three scientists proposed that if, for example, a particle is imagined as exploded into two equal fragments, *A* and *B*, by using the law of

---

[39] Pagels 162-163.

[40] Davies and Brown 14.

action and reaction, observation of *B*'s momentum could be deduced to predict *A*'s momentum. By the law of symmetry, *B*'s distance from the point of the explosion would also show the distance of *A* from the same point, since they are equal. In this way, the momentum or the position of *A* could be predicted, counter to the indeterminacy principle.

Further, Einstein also opposed the whole macro-effect idea of the quantum particles. He argued that if *A* and *B* had flown a very long distance apart, the experiments done on *B* could not influence *A*, as the Copenhagenists had claimed with their electron in the box experiment, because according to the special theory of relativity, no physical signal or effect could traverse space faster than speed of light. According to Einstein, these two systems could not still be affected by each other because they were too far apart. Related to this issue, eleven years later in his autobiography Einstein wrote:

> ...on one supposition we should, in my opinion, absolutely hold fast; the real factual situation of the system *S2* [the particle in area *B*] is independent of what is done with the system *S1* [the particle in area *A*], which is spatially separated from the former. [41]

According to Einstein, there were ways to accept the possibility of quantum mechanics as the Copenhagen interpretation explained it, as complete, but he admittedly refused them. He explained this as follows:

> One can escape from this conclusion [that quantum theory is incomplete] only by either assuming that the measurement of *S1* ((telepathically)) changes the real situation of *S2* or by denying independent real situations as such to things which are spatially separated from each other. Both alternatives appear to me entirely unacceptable. [42]

---

[41] Zukav 320.

[42] Zukav 321.

According to Bohr, however, although no signal or influence travels faster than the speed of light, and although there seems to be no physical force between *A* and *B*, the idea that they cooperate in their behavior cannot be ignored. Furthermore, for Bohr, this did not imply an incompleteness of the theory. After the EPR paper, Bohr explained that matter acted in complementary ways and that depended on the experiment that was being performed:

> ...in the phenomena concerned we are not dealing with an incomplete description characterized by the arbitrary picking out of different elements of physical reality at the cost of sacrificing other such elements, but with a rational discrimination between essentially different experimental arrangements and procedures which are suited either for unambiguous use of the idea of space location, or for a legitimate application of the conservation theorem of momentum. Any remaining appearance of arbitrariness concerns merely our freedom of handling the measuring instruments, characteristic of the very idea of experiment. In fact, the renunciation in each experimental arrangement of the one or the other of two aspects of the description of physical phenomena -- the combination of which characterizes the method of classical physics, and which therefore in this sense may be considered complementary to one another -- depends essentially on the impossibility, in the field of quantum theory, of accurately controlling the reaction of the object on the measuring instruments, *i.e.* the transfer of momentum in the case of position measurements and the displacement in case of momentum measurements.... [43]

> ...we are, in the "freedom of choice" offered by the...[EPR] arrangement, just concerned with the discrimination between different experimental procedures which allow of the unambiguous use of complementary classical physics. [44]

Bohr refused Einstein's thought experiment results, holding the view that the momentum and the position of *A* have no objective meaning until they are directly measured. He held fast to his belief that the whole microscopic behavior of quantum particles must be regarded within the totality of the macroscopic world. In this view, the

[43] Henry J. Folse, The Philosophy of Neils Bohr: The Framework of Complementarity (New York: Sole Distibutions for the USA, 1985) 149.

[44] Folse 149.

experimental method chosen in the macro-world itself affected the outcomes of the experiments conducted on the micro-world. Bohr explains this below:

> ...the very fact that in quantum phenomena no sharp separation can be made between an independent behavior of the objects and their interaction with the measurement instruments, lends itself to any such phenomenon a novel feature of individuality which evades all attempts at analysis on classical lines, because every imaginable experimental arrangement aiming at the subdivision of the phenomenon will be incompatible with its appearance and give rise, within the latitude indicated by the uncertainty relations, to other phenomena of similar individual character. [45]
>
> The discussion...thus emphasized once more the necessity of distinguishing, in study of atomic phenomena, between the proper measuring instruments which serve to define the reference and those parts which are to be regarded as objects under investigation and in the account of which quantum effects cannot be disregarded. [46]

The opposing views of the defenders of the EPR paradox and the orthodox interpretation of quantum mechanics are summarized by Peter Gibbins below:

> Einstein showed that if it is admitted, as it is by the Copenhagen interpretation in one of its forms, that the act of making a measurement on a quantum system disturbs it, then this disturbance can be transmitted over large distances. Einstein rejected action-at-a-distance on principle and so considered that he had demonstrated the incompleteness of quantum mechanics... [However], a deeper analysis of EPR...shows, so most philosophers of physics would say, that quantum mechanics is inconsistent with any hidden-variables theory that rejects action-at-a-distance, and further that quantum mechanics is itself a non-local theory. Experiments, though difficult ones to perform, can decide between quantum mechanics and any local hidden-variables theory. The consensus is that experiment has vindicated quantum mechanics and also refuted locality. [47]

Many physicists and philosophers pondered the philosophical problems of the idea of superposition that was seen in the quantum world, and whether and how it could

---

[45] Folse, 50-151.

[46] Vincent Edward Smith, Science and Philosophy (Milwaukee: Bruce Publications, 1965) 191.

[47] Christopher Norris, Quantum Theory and the Flight from Realism: Philosophical Responses to (New York: Routledge, Taylor and Francis Group, 2000) 74.

apply to the macro-world. In the Copenhagen interpretation, as the act of measurement plays a central role, it is suggested that prior to the measurement it is impossible to know which of the many possibilities implied by the wave function will collapse and which will be materialized. The standard Copenhagen interpretation held that an objective micro-world did not exist, and that the micro-world existed only when one looked at it. Soon the debate took another root. The opponents of the Copenhagen interpretation argued that this was wrong, because the same could not be said for the macroworld.

2.12. Schrödinger's Cat Paradox

In 1935, Schrödinger, who along with Einstein believed that in order for a physical theory to be complete it had to have one-to-one correspondence between every element of the physical theory and the physical reality it described, presented a thought experiment which came to be known as "the Schrödinger's cat paradox." His intent with this experiment was to show that the Copenhagen interpretation of quantum mechanics did not really explain much, and that its credibility should be doubted. He also he wanted to build on his argument for the existence of an objective reality. Schrödinger wanted to show the absolute reality of existing things even in the absence of observation. In this experiment he asked his detractors to imagine the reality of a cat as a multitude of wave functions. [48]

The thought experiment included a cat in a closed box. The idea of the closed box is to show that the events inside the box can not be seen by any observer. This sealed box also contains a random event: the release of poisonous gas determined by the

[48] Nadeau and Kafatos, Non-Local Universe 56-58; Zukav 94-96; T.D. Clark, "Macroscopic Quantum Objects," Quantum Implications: Essays in Honor of David Bohm, eds. B. J. Hiley and F. David Peat (New York: Routledge, 1991) 121-150.

radioactive decay of an atom or by the passage of a photon through a half-silvered mirror. The radioactive decay of the atom determines whether the gas is released or not. If the gas is released it will break a bottle, releasing a poison which the cat will inhale and die. At the same time, according to the concept of indeterminacy, there is an equal chance of the radioactive decay's not taking place. In this case the cat will remain alive. Either trigger is quantum mechanical, and as a result, both are indeterminate or random. If the box is left for an hour one can say with equal certainty that there was a release of the gas leading to the cat's death, or that there was no release of the gas and that the cat thus lives.

According to classical physics, the cat is either dead or alive. To know the result one would only have to open the box and see the result. The result, is not effected or changed by the observation, because the fate of the cat was determined independently during the experiment. However, according to quantum mechanics the situation is more complicated. Quantum mechanics at this point says that there are two systems existing in the box at the same time. These two systems are explained as a superposition of two different states. The cat is explained as a wave function or as in a limbo state in which the possibilities of the cat's being dead or alive are equally existent at the same time. Because the observer is outside the box, the observer can not know if the gas is released or not and therefore can not know if the cat is dead or alive. The question here is what exactly is happening in the box? The Copenhagen interpretation of the experiment suggests that the cat in the box is both alive and dead at the same time prior to the observation and that the cat will die or live only when the observer looks into the box. According to the Copenhagenists, quantum mechanics implies that only when the observer looks into the box will one of the two possibilities will be actualized and the other disappear. The actualization of a possibility, as mentioned, is known as the "collapse of the wave function." Until the wave function collapses by the observer's observation, then, the existence in the box is only accepted as a wave function.[49]

Nevertheless, according to Schrödinger and Einstein, if the Copenhagen interpretation didn't show a one-to-one correspondence between the physical reality and theory, what then was it explaining. They were suggesting that a mathematically real property exists in the physical reality whether or not it is observed.

Different responses came from different physicists about the cat paradox thought experiment. Abner Shimony's explanation of the experiment was as follows:

> There would be nothing paradoxical in this state of affairs if the passage of the photon through the mirror were objectively definite but merely unknown prior to observation. The passage of the photon is, however, objectively indefinite. Hence the breaking of the bottle is objectively indefinite, and so is the aliveness of the cat. In other words, the cat is suspended between life and death until it is observed. [50]

David Bohm's answer to the cat paradox was presented as follows:

> In our approach...the paradox (of Schrödinger's cat) does not arise because we go beyond the assumption that the wave function provides the most complete possible description of reality. [51]

Some physicists say although Schrödinger intended to show the reality of existence of an object prior to the observation of the object, it can be seen that this paradox appears only when it is assumed that there is one-to-one correspondence between

---

[49] Zukav 94-95; Morris 57-59.

[50] Zukav 58.

[51] Luther 60.

the physical theory and reality as Schrödinger and Einstein held. But on the other hand, when this seeming paradox is viewed through the Copenhagen interpretation of quantum physics as Bohr suggests, it ceases to exist. According to Bohr, the state of these systems becomes real only when they are measured and the reality of the potential states can not be assumed in the absence of measurement. [52]

2.13. Bell's Inequality Theorem and Aspect's Experiments

The debate after the EPR paper finally came to an end in 1965. That's when John Steward Bell put forward Bell's inequality theorem, which was basically a mathematical statement predicated on two assumptions: locality and realism. The principle of locality assumes that no signal or energy can travel faster than the speed of light (300.000 kms/sec) and that only objects in the same locality can affect each other. Realism assumes that there exists a physical reality independent of observer, observation or measurement. Bell sympathized with Einstein and supported his EPR debate, and wanted to prove to himself whether it was Bohr or Einstein who was right. For Bell, the issues came down to whether there were certain correlations between quantum particles reflected in a universal reality that was local or non-local in nature. Since Newton, classical physics had accepted the assumption that everything in the universe happens by local actions; by forces that operate in close proximity. These forces were known as the strong force, the weak force, electromagnetism and gravity. All these forces would lose their effect over distance and none operated through space at a speed greater than the velocity of light. The predictions of quantum theory, on the other hand, distinctly

[52] Nadeau and Kafatos Non-Local Universe 59.

implied that a non-locality principle of action existed. Expressing his skepticism of this possibility, Einstein had commented as follows:

> I can not seriously believe in the quantum theory because it can not be reconciled with the idea that physics should represent a reality in time and space, free from spooky actions at a distance. [53]

Bell developed a mathematical formulation that defined the necessary characteristics of every local reality theory. He thought that if events in spatially separated systems were not causally linked then a mathematical proposition could show this. Bell's theorem, as a result, mathematically shows that the principle of local causes (that Einstein held fast to) is incompatible with the statistical predictions that are made by quantum theory. It also shows that not only subatomic phenomena but also the macroscopic domain has aspects that can only be described, for lack of better word, as "irrational."[54] Henry Stapp describes this below:

> The important thing about Bell's theorem is that it puts the dilemma posed by quantum phenomena clearly into realm of macroscopic phenomena…[it] shows that our ordinary ideas about the world are somehow profoundly deficient even on the macroscopic level. [55]

Several experiments, including a famous one in 1982, by Alain Aspect, Philippe Grangier, Jean Dalibard and Gérard.Roger, today known as "Aspect's experiment," were carried out to test the foundations of quantum mechanics and check Bell's inequalities theorem in a manner very similar to that of the EPR thought experiment was postulated by Einstein, Podolsky and Rosen. The results of the experiments showed that the

---

[53] Luther 77.

[54] Luther 75-84; Zukav 314-326.

[55] Zukav 322.

correlations between paired photons over space-like separated regions, do, in fact, hold over any distance instantly, or in "no time."[56] Allan Aspect describes the experiment below:

> It is very difficult to describe. But we can roughly say that first we have a source which emits pairs of correlated photons, and then we have to do some kind of difficult measurements on each of these photons. Now one of the main features of our experiments was to improve the efficiency of this source. Previous attempts to study the EPR correlation led to rather uncertain results....We would excite this atom of calcium in a particular way and then observe the light -- a pair of photons -- emitted by the atom as it gives up its energy and drops back to its unexcited state....In these experiments you have to measure the polarization of photons, the results of which can be either yes or no, either plus one or minus one....[in the third experiment] we have tried to make sure that the two different parts of the system are truly independent of each other. The reason for doing this is that quantum mechanics predicts a very strong correlation between the results of the measurements on the pairs of photons even if the two sets of measuring apparatus are far from each other (15 m in our case). One possibility for understanding this correlation in a naïve picture of reality is to admit that the two sets of measuring apparatus have some mysterious interaction with each other. To eliminate this interpretation, some people argue that if we rapidly change some feature, like the orientation, of one measuring apparatus, then the other apparatus could not respond to this change because no signal can travel faster than the speed of light. So that's what we did.[57]

The results which Aspect found are described below:

> ...we can say that the results violate Bell's inequalities, which means that we cannot keep a simple picture of the world, retaining Einstein's idea of reparability. This is the first feature of the results....I don't think that there can be some signaling, if by signaling you mean that there is some true kind of transfer of information. What these experiments have shown is first that they violate Bell's inequalities, and on the other hand that these results are in very good agreement with the prediction of quantum mechanics. So we assume that quantum mechanics is still a very good theory. Even in this kind of experiment it is not possible to send any messages or useful information faster than light, so I will certainly not conclude that there is faster-than-light signaling. However, if you mean that in some picture of the world that you want to construct, you can include some kind of faster than light mathematical object, then perhaps, yes, it could be a possibility. But you can not use this mathematical construction for practical faster-than-light signaling.... But here we have shown that in this kind of very unusual situation quantum

---

[56] Kafatos and Nadeau, 65-70; Davies and Brown 15-20, 40-57, 149.

[57] Davies and Brown 41-42.

> mechanics works very well, and so this must convince us that truly we must change the old picture of the world....[these experiments] demolish...the possibility of having a hidden variable theory based on Einstein's ideas such as separability. [However] some hidden variable theories still remain possible: the hidden variable theories of David Bohm, for example. But not that these theories are not separable; they are not local. I mean, in these theories (such as Bohm's), there is some kind of faster than light interaction, and so we should not be surprised that these theories cannot be excluded by our experimental results. [58]

Physical reality was not as Einstein had thought. The experiments showed that physical reality in fact operated non-locally. Another physicist, Jim Baggot, described the impact of Aspect's results on our conceptions of physical reality as follows:

> Three centuries of gloriously successful physics have brought us right back to the kind of speculation that it took three centuries of philosophy to reject as meaningless. [59]

> These results provide almost overwhelming evidence in favor of quantum theory against all classes of locally realistic theories...so where does all this leave local reality?...Either we give up reality or we accept that there can be some kind of 'spooky action at a distance,' involving communication between distant parts of the world at speeds faster than that of light...Although the independent reality advocated by the realist does not have to be a local reality, it is clear that the experiments described here leave the realist with a lot of explaining to do.... Whatever the nature of reality, it cannot be as simple as we might have thought at first. [60]

The idea of a non-local nature and universe is completely different from the world view most of us have known. Today, the discovery of non-locality is seen as one of the "most profound discovery in all of science" which causes physicists to revise their understanding of physics, nature and universe at large. According to physicists, non-locality proves that any two particles once connected in any space in the universe are

---

[58] Davies and Brown 42-43.

[59] Luther 77.

[60] Luther 95.

always able to somehow be connected, even if they are billions of light years apart. This result of the experiments, within the theory of Big Bang, shows that all particles that are existent in the universe had interacted with each other at the Big Bang explosion and therefore, today it is believed that all parts of the universe are in immediate connection with each other. The universe, then, is like a web of particles that are in constant contact with each other over any distance, in no time, without the transfer of energy or information. All of physical reality can be seen as a virtual quantum system that reacts together to further interactions.

2.14. The Bohmian Interpretation

Before the advent of quantum mechanics, classical physics had accepted the universe as a gathering of individual and separate objects existing independently. These objects were accepted to be tied together by forces that could only be local. Their effects would diminish with distance between them. The fundamental laws persisting between the objects were understood by their proximity. Very quickly, however, in recent history, the notion of the universe as non-local has been accepted and further developed and explained by some theoretical physicists. One of these physicists is David Bohm's interpretation of quantum mechanics. His comments on non-locality, after Bell's theorem, which are the foundations of his interpretation follow:

> One is led to a new notion of unbroken wholeness which denies the classical idea of the analyzability of the world into separately and independently existing parts ...We have reversed the usual classical notion that the independent 'elementary' parts of the worlds are the fundamental reality and that the various systems are merely particular contingent forms and arrangements of these parts. Rather, we say that inseparable quantum interconnectedness of the whole universe is the fundamental reality, and that relatively independently behaving parts are merely

particular and contingent forms within this whole. [61]

As mentioned at the beginning of this chapter, there are several different interpretations of quantum mechanics. Until this point, the growth of quantum mechanics has been discussed primarily via the Copenhagen interpretation, as it is now accepted as the orthodox one. It is useful at this point to examine the Many-Worlds interpretation, as it has the support of a significant minority of physicists studying quantum physics.

2.15. The Many-Worlds Interpretation

The Many-Worlds interpretation of quantum mechanics was first developed by Hugh Everett in 1957. His basic aim was to explain quantum mechanics without the notions of randomness and action-at-a-distance, notions opposed by Einstein as 'spooky.' One of the criticisms against the Copenhagen interpretation of quantum mechanics was the emphasis on the observer's effect on quantum states, which, if accepted, necessitated the rejection of an objective reality. The dilemma this posed resulted in the rising of different interpretations to challenge this idea. [62] One of these was introduced by Hugh Everett, John Wheeler, and Neil Graham in 1957. This is the Many-Worlds interpretation of quantum mechanics.

The Many-Worlds interpretation responds to the cat in the box paradox by introducing the idea that the limbo state that is represented as a wave function containing the two possibilities (the cat is alive and the cat is dead) does not in fact collapse upon observation. Instead, it explains, at the moment of the photon's decay the world splits

[61] Luther 103-103.

[62] Zukav 83-87, 300-303; Luther 100-106.

into two branches, producing two worlds: one containing a dead cat and the other a live cat. These two worlds proceed on their own, although they coexist in space and time. The Many-Worlds interpretation ignores the idea of the quantum system of a particular experiment, and instead proposes that the whole universe is in state of superposition that is represented as a wave function. Therefore, at the moment of the observation, the observer's world splits into two; one in which the human saw the cat alive, and the other in which the human saw the cat dead. Both of these worlds are as real and as existent. Everett explains this below:

> From the viewpoint of the theory all elements of a superposition ("branches") are "actual," none any more "real" than the rest. It is unnecessary to suppose that all but one are somehow destroyed, since all the separate elements of a superposition individually obey the wave equation with complete indifference to the presence or absence ("actually" or not) of any other elements. This total lack of effect of one branch on another also implies that no observer will ever be aware of any "splitting" process. [63]

The Many-Worlds interpretation proposes that there are many worlds in addition to the one we are aware of. They are all similar and they all exist in the same space and time unaware of one another. This understanding of the universe is not a metaphorical rendering of the realm of the quantum world of atoms and sub-atomic particles, but it directly refers to the macro-world. Byrce DeWitt, who contributed much to the work of Everett explains this as follows:

> One universe must be viewed as constantly splitting into a stupendous number of branches, all resulting from the measurement-like interactions between its myriads of components. Because there exists neither a mechanism within the framework of the formalism, by definition, an entity outside the universe that can designate which branch of the grand superposition is the 'real' world, all branches must be regarded as equally real. To see what this multiworld concept implies one need merely note that because every cause, however microscopic, may ultimately

[63] Torretti 391.

> propagate its effects throughout the universe, it follows that every quantum transition taking place on every star, in every galaxy, in every remote corner of the universe is splitting our local world on earth into myriads of copies of itself. [64]

There are different perspectives of the Many-Worlds view. One, given by David Deutsch, today's best known proponent of the Many-Worlds interpretation, suggests that rather than a constantly branching structure, it is more reasonable to consider that there are in fact an infinite number of universes and that they have always existed side by side. Each one of us is also exists in each of those universes. According to Deutsch, the universes never split but they can sometimes come together. He also believes that with the help of 'quantum computers' (which do not yet exist), we could communicate with the different worlds. [65]

> [w]e exist in multiple versions in universes called 'moments'. Each of us is not directly aware of the others, but has evidence of their existence because physical laws link the content of different universes. It is tempting to suppose that the moment of which we are aware is the only real one, or is at least a little more real than the others.... All moments are physically real. The of the multiverse is physically real. Nothing else is. [66]

David Deutsch's particular explanation about the Many-Worlds interpretation of the quantum mechanics can be applied here. It is presented below:

> [t]he snapshots which we call 'other times in our universe' are distinguished from 'other universes' only from our perspective, and only in that they are especially closely related to ours by the laws of physics. They are therefore the ones of whose existence our own snapshot holds the most evidence. For that reason , we discovered them thousands of years before we discovered them the rest of the multiverse, which impinges on us very weakly by comparison,

---

[64] Torretti 392.

[65] David Deutch. <u>The Fabric of Reality: the Science of Parallel Universes-and its Implications,</u> (London: Allen Lane, 1997) 199-121.

[66] Norris 318.

> though interference-effects. We evolved special language constructs (past and future forms of verbs) for talking about them. We also evolved other constructs (such as 'if....then' statements, and conditional and subjunctive forms of verbs) for talking about other types of snapshot, without even knowing that they exist. We have traditionally placed these two types of snapshot - other times, and other universes - in entirely different conceptual categories. Now we see that this distinction is unnecessary. [67]

Renowned physicist Stephen Hawking, who also accepts the Many-Worlds interpretation, looks at the parallel universes as "histories." He explains this in his book 'Black Holes and Baby Universes' as follows:

> ...we happen to live on one particular history that has certain properties and details. But there are very similar intelligent beings who live on histories that differ in who won the war [referring to World War II] and who is top of the Pops. [68]

What is interesting about the Many-Worlds view is that, while advocating the coexistence of what seem to be multiple times and spaces into a single time and space, it seems to collapse the concepts of time and space themselves into one another.

2.16. Conclusion

Today, with the advent of quantum physics, there exist several new views of the universe and of physical reality which are being discussed by both physicists and philosophers. This chapter briefly outlined the Copenhagen interpretation, which is also known as the orthodox interpretation; the Bohmian interpretation that was first expounded by David Bohm; and also the Many-Worlds interpretation, which accepts several splitting or parallel universes which are all real and continuing. Each of these theories contain their own particularities. The Copenhagen interpretation, for example,

---

[67] Norris 319.

[68] Morris 50.

accepts notions like indeterminism, a non-local universe, no hidden variables and also an observer effect known as the collapse of the wave function. The Bohmian interpretation, on the other hand, accepts a non-local universe with hidden variables (causal laws), and denies notions like indetermism and the collapse of the wave function. Finally, the Many-Worlds interpretation, besides accepting the presence of several worlds existing in the same time and space, accepts determinism and locality while it denies the theory of the collapse of the wave function.

In all cases, with the advent of quantum physics, the notion of the universe as a collection of objectively and independently existing parts which are in relation to one another in any causally unambiguous fashion, as in classical physics, is no longer held as valid. Although this field has revolutionized ways of thinking about physical reality, for many physicists working outside the quantum realm, the arguments of determinism and objective reality still hold.

As stated, the next chapter will attempt a comparative analysis of the current ideas in quantum physics with al-Ghazali's ideas in the Seventeenth Discussion in terms of issues such as causality, the validity of scientific observation and the nature of the physical universe. It is hoped that at that point these seemingly divergent subjects of this study will coalesce into a somewhat coherent whole.

III. CHAPTER THREE:

THE SEVENTEENTH DISCUSSION AND QUANTUM THEORIES: A COMPARATIVE ANALYSIS

3.1. Causality Under Observation

As outlined in Chapter One of this paper, in the first part of the Seventeenth Discussion of *Tahāfut al-Falāsifa*, al-Ghazālī rejects the idea of inherent necessity between cause and effect in his aim to show that God is the ultimate cause of all things. He chides the philosophers for coming to accept this concept, inherent necessity, based on their empirical observations. According to al-Ghazālī, causality can not be asserted simply on the basis of observation because observation is not a tool that can be trusted. For this reason, in the first part of his discussion, his arguments and examples are geared towards revealing how observation is untrustable in apprehending reality.

To review, al-Ghazālī first lists many occurrences in nature that are observable in connected pairs:

> ...the quenching of thirst and drinking, satiety and eating, burning and contact with fire, light and the appearance of the sun, death and decapitation, healing and drinking of medicine...and so on to [include] all [that is] observable among connected things in medicine, astronomy, arts, and crafts. Their connection is due to the prior decree of God, who creates them side by side. [1]

He then chooses a specific example to make his point, that observation itself is insufficient to prove a causal connection between such events:

> They have no proof other than observing the occurrence of the burning at the

[1] Abū Hāmid Muhammad Ibn Muhammad al-Tūsī al-Ghazālī, Incoherence of the Philosophers. Tahāfut al-Falāsifa: a Parallel English-Arabic Text, trans. Micheal E. Marmura (Provo, Utah: Brigham University Press, 1997) 170 (Here on Tahāfut).

> [juncture of] contact with fire. Observation, however, [only] shows the occurrence [of burning] at [the time of the contact with fire], but does not show the occurrence [of burning] by [the fire] and that there is no other cause for it. [2]

Al-Ghazālī states that observation shows only that such events exist 'with' each other, but it does not show that one of them is caused 'by' another: "It has thus become clear that existence 'with' a thing does not prove that it exists 'by' it." [3]

He attacks the philosophers on their own grounds by showing the fallacies in their reasoning. According to al-Ghazālī, there is no proof that the philosophers can produce that shows that what they consider necessary causality does not in fact emanate from the principles of existence. It is possible that this is indeed the case. Since these principles never stop, we can never observe that the causes actually emanate from them and that actually there is no necessary causality between objects on earth:

> Whence can the opponent safeguard himself against there being among the principles of existence grounds and causes from which these [observable] events emanate when a contact between them takes place -- [admitting] that [these principles], however, are permanent, never ceasing exist; that they are not moving bodies that would set; that were they either to cease to exist or to set, we would apprehend the dissociation [between the temporal events] and would understand that there is a cause beyond what we observe? This [conclusion] is inescapable in accordance with the reasoning based on [the philosophers' own] principle. [4]

To summarize, al-Ghazālī at the beginning of the Seventeenth Discussion denies an inherent necessity between presumed causes and presumed effects, stating that such a conclusion is the result of an over-reliance on observation, which is prone to error. All of

---

[2] Tahāfut 171.

[3] Tahāfut 171.

[4] Tahāfut 172.

this he does in order to prove the possibility of the miraculous, a task undertaken in his theological quest to prove that there exists a higher reality beyond what one can see, and that observation does not take one to that higher reality.

By comparison, in one of the contemporary interpretations of quantum theory, namely in the Copenhagen interpretation, ideas strikingly similar to those of al-Ghazālī can be traced. This is particularly true of some of the arguments of Heisenberg and his uncertainty principle and some of Bohr's ideas on the nature of observation.

Prior to Heisenberg's uncertainty principle, causal laws and determinacy in the quantum world seem to have only been discussed among the physicists. Causal relations of matter had always been derived from scientific observation. After repeated tests and experiments on some subject, results were recorded, statistics were formulated and reports were written. As physicists arrived at the same conclusions time and time again, they accepted that there were causal laws and that these laws did not change. The acceptance of the laws of causality introduced also the acceptance of the notion of determinism. Once the existence of the causal laws were accepted, determinism followed because scientists could predict approximately what was expected and when the expected result would come about. Heisenberg explains this below:

> The concept of causality became narrowed down, finally, to refer to our belief that events in nature are uniquely determined, or, in other words, that an exact knowledge of nature or some part it would suffice, at least in principle, to determine the future. [5]

[5] Werner Heisenberg, The Physicist's Conception of Nature, trans. Arnold J. Pomerans. (Westport, Connecticut: Greenwood Press Publishers, 1970) 34; see also Karen Harding, "Causality Then and Now: Al-Ghazālī and Quantum Theory," The American Journal of Islamic Social Sciences 10.2 (1993): 165-177.

It was accepted that if before an experiment all the conditions (such as position, momentum, time, energy, etc.) of an event were known, then the result would be predicted with near-perfect accuracy. However, as it was never possible to know all the variants of the conditions of an event, this clearly meant that only general predictions could be made. In other words, the accuracy of predictions directly correlated with the accuracy of the knowledge of the initial conditions, and this, of course, were based on observation. Heisenberg explains this below:

> Even in principle we can not know the present in all detail. For that reason everything observed is a selection from plenitude of possibilities and a limitation on what is possible in the future. [6]

In the early years of the advent of quantum theory, several unexpected results were derived from the experiments of microphysics, all pointing to the discontinuity of subatomic nature. This concept of discontinuity came into the open with Heisenberg's formulation of an uncertainty principle. Heisenberg formulated this principle based on the observation of quantum particles under specific microscopes. He found that as the nature of subatomic particles were inherently both waves and particles, it was not possible to make measurements of them that could give precise results. He saw that when an electron's momentum is observed its position is disturbed, and when its position is observed its momentum got blurred. Heisenberg's uncertainty principle shows that to know the initial conditions of matter in the quantum realm is impossible. The immediate result, of course, is that to make predictions in the quantum world is also impossible. This

---

[6] Helge Kargh, Quantum Generations: A History of Physics in the Twentieth Century (Princeton; New Jersey: Princeton University Press, 1999) 209.

is not based on the physicists' inability of measurement or the unavailability of the precise measurement tools but on the inherent nature of matter at the sub-atomic level:

> Nature thus escapes accurate determination, in terms of our commonsense ideas, by an unavoidable disturbance which is part of every observation. It was originally the aim of science to describe nature as far as possible as it is, i.e., without our interference and our observation. We now realize that this is an unattainable goal. In atomic physics it is impossible to neglect the changes produced on the observed object by observation. [7]

Bohr also made similar arguments:

> ...any measurement which aims at an ordering of the elementary particles in time and space requires us to forgo a strict account of the exchange of energy and momentum between the particles and the measuring rods and clocks used as a reference system. Similarly any determination of the energy and momentum of the particles demands that we renounce their exact co-ordination in space and time. In both cases the invocation of classical ideas, necessitated by the very nature of measurement, is, beforehand, tantamount to renunciation of a strictly causal description. [8]

Heisenberg, further thought that if matter was inherently not able to be observed under the most precise tools, and gave results undermining the concept of determinism, then perhaps, the laws of causality which were the ultimate source of determinism were to be undermined as well, since they too were based on observation:

> In view of the intimate connection between statistical character of the quantum theory and the imprecision of all perception, it may be suggested that behind the statistical universe of perception there lies hidden a 'real' world ruled by causality. Such speculations seem to us - and this we stress by emphasis - useless and meaningless... [9]

---

[7] Jennifer Trusted, The Mystery of Matter (London: MacMillan Press, Ltd.; New York: St. Martin's Press, 1999) 144.

[8] Trusted 147.

[9] Franco Selleri, Quantum Paradoxes and Physical Reality, ed. Alwyn van der Merwe (London: Kluwer Academic Publishers, 1990) 111

According to Heisenberg:

> Since all experiments obey quantum laws and, consequently, the uncertainty relations, the incorrectness of the law of causality is definitely established as a consequence of quantum mechanics itself. [10]

Here we see the similarity between Heisenberg's conclusion on the incorrectness of the law of causality in nature, based on the fallacy of determinism, which is based fallacy of observation, and what al-Ghazālī says about the lack of inherent necessity of the cause and effect relationship which is also based on the fallacy of observation. They both agree on mistrusting observation as a precise and ultimate tool to see causality.

The founder Copenhagenists with their conclusions took the matter further and claimed that if observation disturbed the nature of matter, perhaps the nature we know is not the same as the nature that we are now discovering.

Although both al-Ghazālī and the physicists argue about fallacy of observation and fallacy of causality, they do not think on the same lines. Al-Ghazālī's aim is to prove the omnipotence of God and therefore miracles, whereas the physicists' arguments center around how the fallacy of observation effects physics and its view of nature. Heisenberg commented on this latter subject as follows:

> We have had to forgo the description of nature which for centuries was considered the obvious aim of all exact sciences. All we can say at present is that in the realm of modern atomic physics we have accepted this state of affairs because it describes our experience adequately. On the question of the philosophical interpretation of the quantum theory opinions still differ, and occasionally we may hear the view that this new form of natural description is still unsatisfactory, since it fails to satisfy earlier ideals of what scientific truth ought to be and must be considered itself as a symptom of the crisis of our times, and by no means final. [11]

---

[10] Kargh 209.

The meaning of Heisenberg's uncertainty principle is very important for understanding nature. The fact that the ultimate constituents of matter have dual characteristics altered the way physicists and also philosophers conceived of reality.

Although Einstein did not agree with all parts of the Copenhagen interpretation of quantum physics, he, just like most physicists, accepted the duality of matter and the new reality. Einstein and Leopold Infeld explain this below:

> Physics really began with the invention of mass, force, and inertial system. These concepts are all free inventions. They led to the formulation of the mechanical point of view. For the physicist of the early nineteenth century, the reality of our outer world consisted of particles with simple forces acting between them and depending only on the distance. He tried to retain as long as possible his belief that he would succeed in explaining all events in nature by these fundamental concepts of reality.... The quantum theory again created new and essential features of our reality. Discontinuity replaced continuity. Instead of laws governing individuals, probability laws appeared. The reality created by modern physics is, indeed, far removed from the reality of the early days. [12]

The arguments put forth by al-Ghazālī on observation insist that observation is like illusion, we see things but we do not really know if we see a reality or there is another reality behind what we see. Contemporary physics, with quantum mechanics, also came to a point where what al-Ghazālī is saying about observation and reality are now being talked about in a very similar manner. James Jeans discusses the new physics below:

> The new physics suggest that, besides the matter and radiation which can be represented in ordinary space and time, there must be other ingredients which can not be represented. These are just as real as the material ingredients, but they do not happen to make any direct appeal to our senses. Thus the material world...

---

[11] Heisenberg. 25.

[12] Albert Einstein and Leopold Infeld, "Physics and Reality," The Mystery of Matter, ed. Louise B. Young. (New York: Oxford University Press, 1965) 126.

> constitutes the whole world of appearance, but not the whole world of reality; we may think of it as forming only a cross-section of reality. [13]

Al-Ghazālī's arguments regarding causality, observation, and reality are framed by scriptural evidence, background knowledge in both theology and philosophy, and of course, also his intellectual ability, whereas today's arrival to these quite similar conclusions is by way of quite detailed and precise experimentation and scientific theorizing. Nevertheless, it is evident that there are compelling similarities between the two conclusions.

3.2. Possibilities

Before entering into an examination of the similarities and the differences between the Many-Worlds interpretation and al-Ghazālī's Seventeenth Discussion, a brief review of one of the thought experiments explained in Chapter 2 would be useful. This thought experiment involved Schrödinger's cat paradox. The experiment was contrived to show the incorrectness of applying microworld concepts to the macroworld, and also to show that the 'collapse' was not applicable in the real world, where objects exist in reality even when no conscious being was observing.

The thought experiment of a cat in the box whose death and life depended on the quantum action of a decayed or undecayed photon respectively, showed that the cat was neither alive nor dead but both at the same time. This position of both quantum states (although they are opposites) existing at the same time was explained by the notion of the superposition of quantum states in a quantum system (or experiment). To reemphasize

[13] James Jeans, "Some Problems of Philosophy," The Mystery of Matter, ed. Louise B. Young. New York: Oxford University Press, 1965) 127.

the point, it bears repeating that in the Copenhagen interpretation, the two quantum states, (one in which the cat is dead and the other in which the cat is alive) exist together, and only when an observer looks at it does the quantum potential collapse into either one of the states, causing the disappearance of the other state.

The Many-Worlds interpretation explained that there are an infinite number of worlds and universes coexisting in the same space and time. There are variations to this interpretation, one of which was proposed by Deutsch. It is possible to compare one of al-Ghazālī's examples to Deutsch's interpretation of quantum mechanics.

Al-Ghazālī's argument is to prove the omnipotence of God and that God and the principles of existence or celestial bodies, (an expression he uses later in his discussion) are voluntary. God can will freely, and create whatever God wills. Once this is stated, al-Ghazālī accepts the strange possibilities that he believes God can create, which the philosophers call "repugnant contradiction" His first example of these is as follows:

> "...The possibility that there being in front of him ferocious beasts, ranging from fires, high mountains, or enemies ready with their weapons [to kill him], but [also the possibility] that he does not see them because God does not create for him [the vision of them]. [14]

In al-Ghazālī's view, God can create beings which exist unseen near a person. In the Many-Worlds interpretation of quantum mechanics, especially in the one Deutsch proposed, there exist many universes and there exist many beings in these universes, unseen to each another. What al-Ghazālī accepts as possible, Deutsch sees as true and

[14] Tahāfut 173-174.

actual. For Deutsch, they are not just possible imaginations but they are all true and physical beings. However, in Deutsch's view, God is not mentioned.

Furthermore, in al-Ghazālī's view, although a person can not see these beings, they can see the person. This happens because God does not create the vision for the human being to see them. In the Many-Worlds interpretation, as well, the multiverses are not aware of each other. However, Deutsch accepts the possibility of some of them to fuse with each other.

It should be mentioned that the basic reason why the Many-Worlds interpretation was proposed was because scientists wanted to explain quantum mechanics in classical terms, and this was also the reason why the Copenhagen interpretation of quantum mechanics, which spoke against the classical ideas of determinism and causal laws, was refused by some scientists.

Seen from this view, al-Ghazālī's "repugnant contradictions" seem at first similar to the Many-Worlds interpretation, but when analyzed more deeply it is clear that they differ, because the Many-Worlds interpretation accepts the laws of causality and determinism while al-Ghazālī's worlds do not obey those laws. In a way, al-Ghazālī's possibilities represent a Many-Worlds interpretation that should be explained by the Copenhagenists. But such an interpretation does not exist; after all that would be against the aim of the Many-Worlds interpretation. If, on the other hand, those examples were seen from the perspective of the Copenhagen interpretation, the comparison could be easily made.

More of al-Ghazālī's examples are given below:

> And if someone leaves a book in the house, let him allow as possible its change

on his returning home into a beardless slave boy -- intelligent, busy with his tasks -- or into an animal; or if he leaves a boy in his house, let him allow the possibility of his changing into a dog; or [again] if he leaves ashes, [let him allow] the possibility of its change into musk; and let him allow the possibility of stone changing into gold and gold into stone. If asked about any of this, he ought to say: 'I do not know what is at the house at the present. All I know is that I have left a book in the house, which is perhaps now a horse that has defiled the library ...and that I have left in the house a jar of water, which may well have turned into an apple tree. For God is capable of everything... it is not necessary for the horse to be created from the sperm, nor the tree to be created from the seed -- indeed, it is not necessary for either of the two to be created from anything. Perhaps [God] has created things that did not exist previously.' Indeed, if [such as person] looks at a human being he has seen only now and is asked whether such a human is a creature that was born, let him hesitate and let him say that it is not I impossible that some fruit in the marketplace has changed into a human, namely this human -- for God has power over possible things, and this thing is possible -- hence, one must hesitate in [this matter]. [15]

In his description of the event in which the object that is left alone in the house changes into another object, al-Ghazālī approaches a description of the thought experiment of Schrödinger, in which the cat is put in a closed box. In both cases, the object is somewhere beyond observation and speculations are made about the object while the object is not seen. In both cases as well, the observer, with limited information and untrustable natural laws, hesitates in making any predictions about what is occurring inside the unseen area.

In the Copenhagen interpretation, the object is in a superposition of two quantum states, both life and death are present, and when the observer looks, one of the two quantum states collapses into form as the other disappears. In al-Ghazālī's example, the book (or ashes, or stones) is not under the superposition of any (quantum) state but still under observation, because the observer, in al-Ghazālī's case, is not a human but is God who is able see and do anything.

[15] Tahāfut 173-174.

3.3. Impossibilities

Al-Ghazālī finishes his argument on the possibilities that he believes God can create with a warning to "hesitate" in giving more examples of those possibilities. As he returns to the arguments of possibilities and impossibilities at the end section of his argument, we understand that he put limitations on those possibilities. He outlines these impossibilities in the last section of the Seventeenth Discussion.

Al-Ghazālī clearly states what is not possible below:

> The impossible is not within the power [of being enacted]. The impossible consists in affirming a thing conjointly with denying it, affirming the more specific thing while denying the more general, affirming two things while negating one [of them]. What does not reduce to this is not impossible, and what is not impossible is within [divine] power. [16]

From this it is clear that al-Ghazālī thinks in terms of classical physics. He has a definition of objects in his mind, just as we have of the macroworld. When we think of an object, in other words, we have an image of it and we also have some intellectual definition of it. In our mind, the object is distinct from another object, although the two might be quite similar. Here al-Ghazālī is doing the same thing; in order to affirm a thing, he defines it in his mind and he knows what it is. Similarly, when he denies it he knows what he is denying. In this way, he affirms in his mind that he can not affirm a thing while denying it. From most of his examples on the impossibilities, it is evident that al-Ghazālī thinks of a "thing" as matter.

---

[16] Tahāfut 179.

In an earlier part of his discussion, Al-Ghazālī states that "matter is receptive of all things,"[17] However, at the last section of his discussion, where he talks about the impossibilities, he makes it clear that matter is not limitless in its receptivity:

> [Again,] we say that blood has changed into sperm, we mean by this that matter itself took off one form and put another. This, then, amounts to the fact that one form has ceased to exist and one has come into existence, there being a subsistent matter over which the two forms rotated. When we say that water through heating has changed into air, we mean that matter receptive of the form of water took of this form and received another form. Matter thus common, while the quality changes. [18]

Before going into the comparison, it should be noted that al-Ghazālī very clearly contradicts himself in two places. One, when he says, as we shown above, that "matter is receptive of all things" he contradicts himself by saying that this only applies to specific things such as the changing of blood into sperm. Two, this contradiction itself violates what he said above about the impossibilities: that it was not possible to affirm "the more specific thing while denying the more general." This in fact is exactly what al-Ghazālī does. He first gives a general argument that "matter is receptive of *all* things," which he then violates by giving only a specific meaning to it and proposing that change can happen only within the same genera. Thus, al-Ghazālī affirms the specific while denying the general.

A comparison of al-Ghazālī's description of matter with the description of matter proposed by the quantum physicists produces some interesting results. After a long history of experimentation, physicists today have a specific vision of what constitutes

[17] Tahāfut 176.

[18] Tahāfut 180.

matter. Today, matter is understood to consist of several different particles, such as protons, mesons, photons, electrons, etc. These are accepted as the elementary particles, or simply, particles of matter. However, this definition is far too simple, for the description of these so-called particles articulates not, as we might imagine, simply tiny individual dots. For example, Schrödinger tells us:

> Increasing knowledge has in some ways made us not more certain but less certain of the nature of matter...modern wave mechanics implies very clearly that, in fact, they are not identifiable individuals at all. [19]

This new view of elementary particles seems to be very similar to how al-Ghazālī first explains matter. According to al-Ghazālī there is a subsistent matter in nature and this matter can receive all forms. Schrödinger tells us that elementary particles are indistinguishable:

> ...The elementary particle is not an individual; it can not be identified...The implication, far from obvious, is that the unsuspected epithet "this" is not quite properly applicable to, say, a superposition electron, except with causation, in a restricted sense and sometimes not at all. [20]

Heisenberg further explains that recently the number of elementary particles that constitute all matter, and therefore nature, were reduced to three. Recent experiments, however, have showed that there are more. But again it was found that the newly found particles were not always persistent in nature. They appeared and disappeared. This is explained below:

---

[19] Erwin Schrödinger, "What is an Elementary Particle?" Interpreting Bodies: Classical and Quantum Objects in Modern Physics, ed. Elena Castellani (New Jersey: Princeton University Press, 1998) 197.

[20] Schrödinger 197.

> In contrast to the three basic building-stones, these new particles are always unstable and have very short lives...one type...of about a millionth of a second, another lives only one hundredth part of that time...a third...only a hundred billionth of a seconds... [21]

> This state of affairs is best described by saying that all particles are basically nothing but different stationary states of one and the same stuff. Thus even the three basic building-stones have become reduced to a single one. *There is only one kind of matter but it can exist in different discrete stationary conditions*. Some of these conditions, i.e., protons, neutrons and electrons, are stable while many others are unstable. [22]

Thus what al-Ghazālī first says about matter is confirmed by what has been found about the constituents of matter by current quantum mechanics. The fact that there is only one ever-shifting kind of matter that simply takes on new forms is stated by both.

However, as al-Ghazālī changes his description, and also contradicts himself, the similarities turn into differences. Al-Ghazālī makes it clear that only genera within itself can be changed (by God). However, if he continued to hold his first opinion further, he could conclude that if all matter is constituted of basically the same material, which would then not make it possible for him to claim that there are different kinds of genera, he could not conclude that God could not change one genus into another. This would bring his theory more in line with that of quantum physics.

Regarding the changing of matter from one form to another, Heisenberg describes the current capability to actually do so. He explains that especially after "Otto Hann's discovery of the fission of uranium in 1938," elements can be changed into one another even on a large scale. [23] His explanation is presented below:

---

[21] Heisenberg 45.

[22] Heisenberg 45-46.

[23] Heisenberg 43.

...during experiments in the last few years, it has become clear that these elementary particles can change into one another during their collisions, with great changes of energy. When two elementary particles collide with great energy of motion, new elementary particles are created and the original particles, together with their energy, are changed into new matter. [24]

Nevertheless, it is evident that, in general, both contemporary quantum physics and al-Ghazālī give similar views about the changing of one form of matter into another.

Al-Ghazālī also proposes the following as impossible:

As for combining blackness with and whiteness, this is impossible. For by the affirmation of the form of blackness in the receptacle we understand [(a)]the negation of the appearance of whiteness and [(b)] [the affirmation of] the existence of blackness. Once the negation of whiteness becomes understood from the affirmation of blackness, then the affirmation of whiteness, together, becomes impossible. [25]

If we take al-Ghazālī's idea above conceptually, we can see that he believes that opposite things can not exist with each other. Al-Ghazālī's belief is that because opposite things deny the presence of each other they can not be in existence at the same time and place. We also understand that he perceives blackness and whiteness as a kind of characteristic of a matter whose receptacles are able to receive one or the other.

This concept can be compared to the characteristics of matter in quantum physics. That an electron can have different and opposite characteristics at the same time is a proven and accepted concept today. Schrödinger's describes this below:

A vast amount of experimental evidence clinches the conviction that wave characteristics and particle characteristics are never encountered singly, but always in a union; they form different aspects of the same phenomenon, and

---

[24] Heisenberg 45-46.

[25] Tahāfut 179.

> indeed of all physical phenomena. The union is not a loose or superficial one. In the early days of the new theory it was suggested that particles might be singular spots within the waves, actually singularities in the meaning of the mathematician. The idea was very soon abandoned. It seems that both concepts, that of waves and that of particles, have to be modified considerably, so as to attain a true amalgamation. [26]

According to this information about the nature of matter, it is possible to say that matter has two opposite characteristics together. In fact, having two opposite characteristics is *the* nature of matter.

What al-Ghazālī says about a receptacle (of matter) not being able to have both whiteness and blackness, because two opposite qualities can not exist in the same matter, is in direct contradiction with the contemporary interpretations of quantum mechanics. Quantum mechanics, as has been shown, accepts and asserts the idea of matter having two different characteristics at the same time, for this is the nature of matter. Al-Ghazālī states another of the impossibilities below:

> It is [further] impossible for the individual to be in two places, because we understand by his being in the house [for example] he is not being in [a place] other than the house. Hence, it is impossible to suppose him in [a place] other than the house together with his being in the house, [his being in the house] signifying the denial of [his being] elsewhere other than the house. [27]

This above idea of al-Ghazālī is in direct contradiction with the Many-Worlds interpretation of quantum theory. According to many worlds interpretation, there is no contradiction at all in accepting a person as being in the house and outside the house at the same time, for a person's being in the house does not deny his being simultaneously

---

[26] Schrödinger 199.

[27] <u>Tahāfut</u> 179.

outside the house. In fact, according to the Many-Worlds interpretation, a person is in infinite worlds at all times.

One last point of comparison between the ideas of al-Ghazālī and quantum mechanics is the impossibility of knowledge existing in inanimate matter. Al-Ghazālī says:

> It is impossible, moreover, to create knowledge in inanimate matter. For we understand by the inanimate that which does not apprehend. If apprehension is created in it, then to call it inanimate in the sense we have understood becomes impossible. And if it does not apprehend, then to call what has been created "knowledge" when its receptacle does not apprehend anything is [also] impossible. This, then, is the way in which this is impossible. [28]

In contemporary theories of quantum mechanics, discussion on the constituents of matter and nature and the universe involve speculations based on the consciousness of both the elementary particles and also the whole universe. For example, Cochran, who explains the double-slit experiment from a different perspective, accepts that each electron has a degree of consciousness and this is how they find their ways through the holes:

> Each electron passes through one hole, but is aware of the existence and location of the other hole when it is open, and it chooses different angles of diffraction when the second hole is open -- angles that will enable it to form a part of the characteristic diffraction pattern. Instead of being something that has both particle and wave properties, the electron in this concept is a particle that has a degree of consciousness. The consciousness of the electron is a periodic pulsation with characteristic frequency that is determined by the energy of the electron, and it does not involve an extended wave. The electron exhibits its particle aspects in interactions in which it gains or loses energy, and it exhibits its degree of consciousness in interactions in which its energy remains constant, such as diffraction. Since an electron going through a hole can deflect its course in a great many ways, a calculation of its possible angles of diffraction involves a large number of possibilities and takes the form of the quantum mechanical wave function. The wave function describes the choices open to the electron and the relative probabilities that these choices will be realized. [29]

[28] Tahāfut 179.

The authors of the book "The Conscious Universe," Kafatos and Nadeau, both accept that the universe as a whole is a conscious being. A part of their view is presented below:

> ...on the most fundamental level the universe evinces an undivided wholeness, and this wholeness in modern physical theory does not appear to be associated with a principle of cosmic order. If this principle were not a property of the whole that exists within the parts, it seems reasonable to conclude that there would be no order or no higher-level organization of matter that allows for complexity. Because the whole, or reality-in-itself, transcends space-time and exists or manifests within all parts or quanta in space-time, the principle of order seems to operate in self-reflective fashion. If the whole were not self-reflectively aware of itself as reality-in-itself, the order that is a precondition for all being would not, in our view, exist. Since human consciousness in its most narrow formulation can be identified as self-reflective awareness founded on a sense of internal consistency or order, we can infer, but not prove, that the universe is, in these terms, conscious. [30]

We can see that in both of the given contemporary views, one derived from the double-slit experiment and the other inspired by the non-locality concept of quantum mechanics, the physicists and scientists look at inanimate things in the universe and also the universe itself as possibly conscious. From this perspective, al-Ghazālī's view of inanimate things as not being able to comprehend and contain knowledge is contradicted by the conclusions of contemporary interpretations of quantum mechanics on inanimate things.

According to al-Ghazālī, an inanimate thing can not have knowledge because it does not apprehend. According to Cochran's interpretation, the elementary particles,

---

[29] Selleri 113.

[30] Menos Kafatos and Robert Nadeau, The Consciouss Universe: Parts and Wholes in Physical Reality (New York; Springer, 2000) 158

which have commonly been seen as inanimate matter, do have a degree of consciousness. They do apprehend their environment and act accordingly.

3.4. Prophets, Humans and the Collapse

Al-Ghazālī first introduces the subject of the souls of the prophets because the philosophers accept the souls of prophets as being special and different from those of ordinary human beings. At the point he first mentions the nature of the souls of the prophets, al-Ghazālī's aim is directed at exposing the incoherence of the philosophers' views in also accepting as possible a normal human being's ability to arrive, with hard work and study, to a point equal in nature to the souls of the prophets. This initial mention, taken together with what al-Ghazālī says later in the discussion about the souls of the prophets, indicates that both the philosophers and al-Ghazālī see the souls of the prophets as being at a higher level of intuition and knowledge:

> Indeed, it is possible for one of the prophets to know through the ways [the philosophers] have mentioned that a certain individual will not arrive from his journey tomorrow when his arrival is possible, the prophet knowing, however, the occurrence of this possible thing. [31]

The discussion goes on to show that, according to the philosophers, the prophets' souls are able not only to know whether a possible future event will occur or not, but that they also have special powers to affect a natural event in a way so as to bring about another event in nature. Al-Ghazālī describes this as follows:

> [In] what you have admitted regarding the possibility of the coming down of rain [and] of hurricanes and occurrence of earthquakes the power of the

[31] Tahāfut 175.

> prophet's soul...Our statement...is the same as your statement. [32]

However, al-Ghazālī quickly ties this ability of the prophets to the omnipotence of God. In explaining why and how such things can occur, he states:

> It is, however, more fitting for both you and us to relate this to God, either directly or through the mediation of the angles. [33]
>
> The time meriting its appearance, however, is when the prophet's attention is wholly directed to it and the order of the good becomes specifically [dependent] on its appearance so that the order of the revealed law may endure. [All] this gives preponderance to the side of [the] existence [of the miracle], the thing in itself being possible [and] the principle [endowing it being] benevolent and generous. But it does not emanate from Him except when the need for its existence becomes preponderant and the order of the good becomes specified therein. And the order of the good becomes specified therein only if a prophet needs to prove his propehthood in order to spread the good. [34]

Does what al-Ghazālī says above have any points in common with contemporary interpretations of the quantum mechanics explain? This is a question dealt with below.

Both in Schrödinger's cat paradox and in the double-slit experiment the presence of the observer effect was accepted by the Copenhagen interpretation. In the cat paradox, the presence of an observer collapsed the wave function from a superposition of two quantum events. The cat either lived or died only after the opening of the box. However, this was only a thought experiment which was constructed after the Copenhagenists explained their view of the quantum world.

---

[32] Tahāfut 176.

[33] Tahāfut 176.

[34] Tahāfut 176.

The double-slit experiment, on the other hand, shows real events happening in the quantum world. To review, when an electron was sent through one hole, the measuring apparatus gave results indicating that a particle had passed, and the same result was achieved when the other hole was closed. However, when both holes were open, one electron's passage created an interference pattern indicating that waves were passing. This and several other experiments in the history of the quantum theory showed that quantum particles have both wave-like and particle-like properties. They can behave like waves, and they can behave like particles. The behavior of the particle was concluded to be both wave-like and particle-like based on the experiment the scientist chose to perform. Bohr soon explained this reality of wave-like/particle-like behavior in the quantum world. He explained them as complementary and related to the type of experiment performed. In order words, for Bohr the position or the momentum of an electron can only be found within the context of an experiment, and so the quantum world could only be defined with respect to the type of observation chosen. Bohr describes this below:

> No photon exists until a detector fires, only a developing potentiality. Particle-like and wave-like behavior are properties we ascribe to light. Without us, light has no properties, no existence. There is no independent reality for phenomena nor agencies of observation....Isolated, material particles are abstractions, their properties being definable and observable only through their interaction with other systems. [35]

Further, according to Bohr:

> There is no quantum world. There is only quantum physical description. It is wrong

[35] Fritjof Capra, The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism, 3rd ed. (Boston: Shambhala, 1991) 137.

to think that the task of physics is to find out how nature is. Physics concerns what we can say about nature. [36]

Furthermore, Schrödinger explained that the elementary particles are in a deterministic quantum system that can only be represented by a mathematical construction known as a wave function. The Copenhagenists explained that when the system is observed by an external observer, the wave function collapses. As a result, the system, at the time of observation is divided into two -- the one that is observed and the one that was before being observed. This explanation led to another result: that there is more than one reality. According to Heisenberg:

> The concept that events are not determined in a peremptory manner, but that the possibility or 'tendency' for an event to take place has a kind of reality -- a certain intermediate layer of reality, halfway between the massive reality of matter and intellectual reality of the idea or image....In modern quantum theory this concept takes on a new form; it is formulated quantitatively as probability and subject to mathematically expressible laws of nature. [37]

According to Eugene Wigner:

> It appears that our theory denies the existence of absolute reality -- a denial which is unacceptable to many....I do not know how one could define operationally the reality of anything. [38]

According to Wheeler:

> No elementary phenomenon is a phenomenon until it is an observed

---

[36] Trusted 258.

[37] Trusted 136.

[38] Tony Rothman and George Sudarshan, Doubt and Certainty (Reading, Massachusetts: Perseus Books, 1998) 167.

> phenomenon....The universe is a self-excited circuit. As it expands, cools, and develops, it gives rise to observer-participancy. Observer-participancy in turn gives what we call 'tangible reality' to the universe. [39]

The collapse of the wave function, as accepted primarily by the Copenhagen interpretation, is very similar to what al-Ghazālī explains above regarding the nature of the souls of the prophets. Both he and the philosophers, as al-Ghazālī explains, believed that the nature of the souls of the prophets could affect the environment around them. They could do so in such a way that earthquakes and hurricanes could come about from their effect. The Copenhagen interpretation also suggests that the observer collapses the wave function that is persistent in the quantum world. The observation affects the quantum state in such a way that the effect somehow creates what we perceive as physical reality.

This can again be shown in the thought experiment that was proposed by Schrödinger, in which the cat in the box is in a superposition of two quantum states. These quantum states exist as one system because they are together and not separated. But from a classical point of view, they can be seen as the quantum state in which the cat is alive, and the quantum state in which the cat is dead. The Copenhagen interpretation explained that this superposition of quantum states can only be separated when the observer looked, and thereby interfered with the system. At the point of observation, the wave function that was persistent collapses into either one or the other of these states. As a result, the cat is seen as either alive or dead. In other words, the observation affected the quantum system and brought about a single reality out of at least two possible

---

[39] Rothman and Sudarshan 167.

realities. From this, it is possible to conclude that, similarly, the interference of the prophets' souls in the physical system was able to bring about a single (unexpected) physical reality from multiple possible realities.

There are, however, as mentioned, several different interpretations of this experiment. Some, for example, explained this point of the experiment not as a wave function collapse but as the coexistence of many realities in different worlds at the same time and space, as in the Many-Worlds interpretation

There are also different views as to what exactly happens at the time of observation. For some theorists, it is the consciousness of the human being, and for others, it is the recording of the observation of the event that collapses the wave function. By the second perspective, the observer does not need to be a conscious being. Any observer, including a robot or a recording instrument, can collapse the wave function. For Wigner, the collapse of the wave function takes place as follows:.

> ...the impression which one gains at an interaction, called *the result of an observation*, modifies the wave function of the system. The modified wave function is, furthermore, in general unpredictable before the impression gained at the interaction has entered our consciousness; it is the entering of an impression into our consciousness which alters the wave function because it modifies our appraisal of the probabilities for different impressions which we expect to receive in the future. It is at this point that the consciousness enters the theory unavoidably and unalterably. [40]

Two physicists, John Barrow and Frank Tipler, explain the observer's role as consciousness:

> We ourselves can bring into existence only very small-scale properties like the spin of the electron. Might it require intelligent beings 'more conscious' than ourselves to bring into existence the electrons and other particles? [41]

[40] Selleri 112.

From this it is possible to conclude that al- Ghazālī and the Copenhagenists have another point in common: they both accept the influence of human consciousness on the physical environment. In al- Ghazālī's view the influence is understood as miracles performed by the prophets at specific times and under specific conditions. As al- Ghazālī explains, it is only when the prophet's attention is directed towards the environment that it can be influenced in a miraculous way.

Al- Ghazālī takes this point further by stating that both he and the philosophers ought to attribute the prophet's ability to influence the natural environment in this way to God.

In the Copenhagen interpretation any observer can, by the act of observing, collapse the wave function into an actual state from a superimposed state. The result in this case is not a miracle but simply a collapse from a wave form into a particle form. As Borrow and Tipler conclude, human consciousness is able to affect the physical world in a relatively small way, but perhaps more intelligent or more conscious beings could do so on a larger scale.

Moreover, some physicists also attribute this influence to God, as al- Ghazālī does. According to these quantum theorists it is also possible to consider the whole universe as being under the observation of its creator. In this view, it is God, as an ultimate observer, who collapses every wave function. [42] This, however, is not (yet) a generally accepted idea within the Copenhagen interpretation of quantum mechanics.

---

[41] Rothman and Sudarshan 167.

[42] For example, see Euan Squires, The Mystery of the Quantum World, 2nd ed. (Bristol; Philadelphia:

3.5. Conclusion

All of the above point to parallels between al-Ghazali's concept of the structure and machinations of the natural world, as outlined in the Seventeenth Discussion of *Tahāfut al-Falāsifa*, and the views of the quantum physicists regarding systems operating within the physical universe. For both, generally speaking, notions of an inherent causality guiding events in the universe are rejected. As well, regarding the place of human consciousness, particularly in terms of the inability of human observation in discovering an objective reality, the views of both are in general agreement. The consequent reevaluation of what is possible and impossible is evident in both as well, although the two views differ in terms of the details. Finally, the work of both points to the need for a reconsideration of preexisting beliefs about the physical world and how it operates, from a human perspective.

Institute of Physics Publishing, 1994) 66-99.

IV. CONCLUSION

Although more than nine centuries separate the thinking of al-Ghazālī in the Seventeenth Discussion of *Tahāfut al-Falāsifa* from the work of the quantum theorists, numerous parallels can be drawn between the conclusions reached by both as to the nature of physical reality and the ability of the human mind to perceive an objective view of its structure.

These parallels can be grouped under four general headings, as follows:

1) The invalidity of the idea of causality as an inherent system consistently operating within the physical/natural realm.

2) The impossibility of human perception to apprehend an objective 'always true' vision of the operating structures of physical matter and the universe.

3) A subsequent reevaluation of what can be confidently asserted to be possible and impossible within the physical realm.

4) A consequent call for a reconsideration of the sources and means of obtaining knowledge about the physical realm.

Clearly, the purposes and objectives of the two in undertaking their respective projects differ. Al-Ghazālī, in his theological Seventeenth Discussion, aims to prove the possibility of the miraculous and thereby underline the omniscience and omnipotence of God; whereas the quantum theorists, in their scientific experimentation and resulting conclusions, aim to arrive at a more comprehensive understanding of the physical world and the place of human consciousness within it. Nevertheless, both projects explicitly call for a reevaluation of the assumptions held by the dominant theories of their times, be they in the fields of physics or philosophy. In this sense, the ideas produced by both projects can be seen to be truly revolutionary within their respective epochs.

Admittedly, the method applied within this comparative analysis has been less than systematic, in the academic and scientific senses. However, the material being compared, as it has been derived from two fields of inquiry considered mutually distinct --theology and physics -- has not lent itself to such systematic analysis. In a somewhat Ghazālīan sense, then, this thesis has not attempted to defend any one line of reasoning, but has chosen from the many available in order to arrive at a more holistic consideration of the nature of the physical universe. In the process, it has attempted to connect the thinking of the Medieval Islamic milieu to that of contemporary Western science.

It is hoped that this will help to pave the way for further such studies, with the aim of redirecting the focus of academia, both within religious studies and the physical sciences, towards a contemplation of the similarities rather than the differences between such seemingly exclusive fields of investigation.

V. BIBLIOGRAPHY

Abrahamov, Binyamin. "Al-Ghazālī's Theory of Causality." Studia Islamica 67 (1988): 75-98.

Abu Shanab, R. E. "The Philosophical Significance of al-Ghazālī." Iqbal Review 13.1 (1972): 51-70.

Achinstein, Peter. Particles and Waves: Historical Essays in the Philosophy of Science. New York; Oxford: Oxford University Press, 1991.

Al-Ghazālī, Abū Hāmid Muhammad Ibn Muhammad al-Tūsī al-Ghazālī. The Incoherence of the Philosophers. Tahāfut al-Falāsifa: a Parallel English-Arabic Text. Trans. Micheal E. Marmura. Provo, Utah: Brigham University Press, 1997.

Alon, Ilai. "Al-Ghazālī on Causality." American Oriental Society Journal 100 (1980): 397-405.

Andersen, Peter B., Claus Emmeche, Niels Ole Finnemann, Peter Voetmann Christiansen, eds. Downward Causation: Minds, Bodies, and Matter. Aarhus University Press, 2000.

Aydin, Mehmet S. Din Felsefesi. 10th ed. Izmir: Ilahiyat Fakultesi yayinlari, 2002.

Baffiony, Carmela. "From Sense Perception to the Vision of God." Arabic Sciences and Philosophy 7 (1998): 213-231.

Benner, William H. "Dialogs on Causality and the Limits of Empiricism." Philosophical Investigations 26 (2003): 1-23.

Bitbol, Michel. "Science as if Situation Mattered." Phenomenology of the Cognitive Sciences 1 (2002): 181-224.

Bohm, David. "A New Theory of the Relationship of Mind and Matter." Philosophical Psychology 3.2 (1990): 271-286.

---. Causality and Chance in Modern Physics. New York: Harper and Brothers, 1957.

---. Wholeness and the Implicate Order. London: Routledge & Kegan Paul, 1980.

Bohr, Niels. "Causality and Complementarity." Philosophy of Science 4.3 (1937): 289-298.

Born, Max. Natural Philosophy of Cause and Change. New York: Dover Publications, Inc., 1964.

---. "Physical Reality." Interpreting Bodies: Classical and Quantum Objects in Modern Physics. Ed. Elena Castellani. New Jersey: Princeton University Press, 1998.

Bostock, David. "Logic and Empiricism." Mind 99.396 (1990): 571- 582.

Brewer. Bill. "Self-Location and Agency." Mind 101.401 (1992): 17-34.

Buks, E., R. Schuster, M. Heiblum, D. Mahalu and V. Umansky. "Dephasing in Electron Interference by a 'Which-Path' Detector." Nature 391 (1998): 871-874.

Bunge, Mario. Causality and Modern Science. 3rd ed. New York: Dover Publication, Inc., 1979.

Burrell, David. "Al-Ghazālī on Created Freedom." American Catholic Philosophical Quarterly 73.1 (1999): 135-179.

Butterfield, Jeremy. "Causal Independence in EPR Arguments." PSA1 (1999): 213-225.

Butterworth, Charles E. "The Sources that Nourishes, Averroes' Decisive Determination." Arabic Sciences and Philosophy 5 (1995): 93-119.

Campbell, Scott. "Could Your Life Have Been Different?" American Philosophical Quarterly 37 (2002): 37-50.

Castellani, Elena, ed. Interpreting Bodies: Classical and Quantum Objects in Modern Physics. Princeton, New Jersey: Princeton University Press, 1998.

Capra, Fritjof. The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism. 3rd ed. Boston: Shambhala, 1991.

James Conant, "The Controversy Concerning Spontaneous Generation," The Mystery of Matter. Ed. Louise B. Young. (New York: Oxford University Press, 1965) 290-302.

Copeland, Jack. "Narrow Versus Wide Mechanism." Journal of Philosophy 97.1 (2000): 5-32.

Copleston, C.H. A history of Medieval Philosophy. London: Methuen and Co. Ltd., 1972.

Copleston, Frederick. A History of Philosophy. Vol. 1. London: Burns and Oates Limited, 1961.

Corbin, Henry. History of Islamic Philosophy. Trans. Liadain Sherrard. London; New York: Kegan Paul International, 1996.

Crease, Robert P. and Charles C. Mann. The Second Creation: Makers of the Revolution in the Twentieth-Century Physics. New York: Macmillan Publishing Company, 1986.

Craig, Edward. Ed. Routledge Encyclopedia of Philosophy. New York: New York 1998.

Çubukçu, İbrahim Agâh. İslâm Düşünürleri, 2nd ed. Ankara: Ankara Üniversitesi İlâhiyat Fakültesi, 1986.

Dag, Mehmet. "The Concept of Acquisition in *Kalam* and Islamic Philosophy." Ankara Universitesi Ilahiyat Fakultesi Dergisi 33 (1992): 221-248.

Davies, Paul. The Cosmic Blue Print. Heinemann: London, 1987.

---. Superforce: The Search for a Grand Unified Theory of Nature. New York: Simon and Schuster, Inc., 1984.

Davies, Paul C. W. and J. R. Brown, The Ghost in the Atom.: A Discussion of the Mysteries of Quantum Mechanics. Cambridge: University Press, 1986.

Deutch, David, The Fabric of Reality: the Science of Parallel Universes-and its Implications. London: Allen Lane, 1997.

Dickson, Michael. "Quantum Logic is Alive [Logical and] (It is True [Logical Or] It is False)" Philosophy of Science 68.3 (2001): S274-S287.

Donaldson, Dwight M. "Mohammad al-Ghazālī." The Muslim World 11 (1921): 377-388.

Doty, Robert W. "Five Mysteries of the Mind and Their Consequences." Neuropsychologia 36 (1998): 1069-176.

Dretske, Fred. "Conscious Experience." Mind 102.406 (1993): 263-283.

Driessen, Alfred and Antoine Suarez, eds. Mathematical Undecidability, Quantum Nonlocality and the Question of the Existence of God. Dordrecht; Boston; London: Kluwer Academiz Publishers, 1997.

Druart, Thérese-Anne. "The Human Soul's Individuation and Its Survival After the Body's Death: Avicenna on the Causal Relation between Body and Soul." Arabic Sciences and Philosophy 10 (2002): 259-273.

Druart, Thérese-Anne. "Al-Farabi's Causation of the Heavenly Bodies," Islamic Philosophy and Mysticism. Ed. Parviz Morewedge. New York: Caravan Books, 1981).

Dutton, Blake D. "Al-Ghazālī on Possibility and the Critique of Causality." Medieval Philosophy and Theology 10.1 (2001): 23-46.

Einstein, Albert and Leopold Infeld. "Continuity and Discontinuity." The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Einstein, Albert and Leopold Infeld. "Physics and Reality." The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Everett, Theodore. "Rationality of Science and the Rationality of Faith." Journal of Philosophy 98.1 (2001): 19-42.

Fakhry, Majid. A History of Islamic Philosophy. New York: Columbia University Press: 1970.

---. Islamic Occasionalism and its Critique by Averroës and Aquinas. London, Allen and Unwin, 1958.

---. Philosophy, Dogma, and the Impact of Greek Thought in Islam. Altershot, Hampshire, Great Britain; Brookfield, Vt, USA: Variorum, 1994.

Fatoorchi, Pirooz. "The Problem of the Beginning: Modern Cosmology and Transcendent Hikmah Perspectives." Islamic Studies 39.4 (2000): 633-656.

Fisher, J. M. and P. Hoffman. "Alternative Possibilities: A Reply to Lamb." Journal of Philosophy 91.5 (1994): 321-6.

Fraassen, Bas C. van. "'World' is not a Count Noun." NOUS 29.2 (1995): 139-157.

Frank, R. M. Al-Ghazālī and the Ash'arīte School. Durham, N.C.: Duke University Press, 1994.

---. "Ambiguities of Understanding." Journal of the American Oriental Society 106.2

(1986): 313-321.

---. "Bodies and Atoms: The Ash'arīte Analyses." Islamic Theology and Philosophy: Studies in Honor of George F. Hourani. Micheal E. Marmura. Ed. Albany: State University of New York Press, 1984.

---. "The Science of Kalam." Arabic Sciences and Philosophy 2 (1992): 7-37.

Frank, R. M. and Norman Calder. "Al-Ghazālī and the Ash'arīte school." Bulletin of the School of Oriental and African Studies University of London. 61.1 (1998): 131-132.

Fank, R. M. and Ess, Josef van. Creation and the Cosmic System: Al-Ghazālī and Avicenna. Heidelberg: C. Winter Universitätsverlag, 1992.

Freeman, Walter, J. "Consciousness, Intentionality, and Causality." Journal of Consciousness Studies 6 (1999): 143-172.

Freudental, Gad. "The Medieval Astrologization of Aristologization of Aristotle's Biology: Averroes on the Role of the Celestial Bodies in the Generation of Animate Beings." Arabic Sciences and Philosophy 12 (2002): 111-137.

Frye, Douglas, David Phillip, and Tibor Palfai Zelago. "Theory of Mind and Rule-Based Reasoning." Cognitive Development 10.4 (1995): 483-527.

Folse, J. Henry. The Philosophy of Neils Bohr: The Framework of Complementarity. (New York: Sole Distributions for the USA, 1985) 149.

Forman, Robert. "What does Mysticism have to Teach us about Consciousness?" Consciousness and Cognition 5 (1998): 185-201.

Giacaman, George and Bahlul, Raja. "Al-Ghazālī on Miracles and Necessary Connection." Medieval Philosophy and Theology 9.1 (2000): 39-50.

Gibbins, Peter. Particles and Paradoxes: The Limits of Quantum Logic. Cambridge; New

York; New Rochelle; Melbourne; Sydney: Cambridge University Press, 1987.

Goldvarg, Eugenia and P. N. Johnson-Laird. "Naive Causality: a Mental Model Theory of Causal Meaning and Reasoning." Cognitive Science 25.4 (2001): 565-610.

Golshani, Mehdi. "Islam and the Sciences of Nature: Some Fundamental Questions." Islamic Studies 39.4 (2000): 597-611.

---. "How to Make Sense of Islamic Science?" American Journal of Islamic Social Sciences 17.3 (2000): 1-21.

Goodman, L.E. "Did Al-Ghazālī Deny Causality?" Studia Islamica 47 (1978): 83-120.

Greenstein, George and Arthur G. Zajonc. The Quantum Challenge: Modern Research on the Foundations of Quantum Mechanics. Boston; Toronto; London; Singapore: Jones and Bartlett Publishers, 1997.

Gutas, Dimitri. Avicenna and the Aristotelian Tradition: Introduction to Reading Avicenna's Philosophical Works. Leiden; New York: E.J. Brill, 1988.

---. "Intuition and Thinking: The Evolving Structure of Avicenna's Epistemology." Interdisciplinary Journal of Middle Eastern Studies IX (2001): 1-37.

Hacking, Ian. "What is Logic?" The Journal of Philosophy 76.6 (1979): 285- 319.

Halevi, Leor. "The Theologian's Doubts: Natural Philosophy and the Skeptical Games of Ghazālī." Journal of the History of Ideas 63.1 (2002): 19-39.

Hammond, Robert. The Philosophy of al-Farabi. New York: Hobson Book Press, 1947.

Harding, Karen. "Causality Then and Now: Al-Ghazālī and Quantum Theory." The American Journal of Islamic Social Sciences 10.2 (1993): 165-177.

Hasse, Dag N. "Avicenna on Abstraction." Interdisciplinary Journal of Middle Eastern Studies IX (2001): 39-73.

Healey, Richard A. "How Many Worlds?" NOUS 18 (1984): 591-616.

---. The Philosophy of Quantum Mechanics: An Interactive Interpretation. Cambridge; New York; Port Chester; Melbourne; Sydney: Cambridge University Press, 1989.

Heisenberg, Werner. Across the Frontiers. Trans. Peter Health. Ed. Ruth Nanda Anshen. New York; Evanston; San Francisco; London: Harper & Row, 1974.

---. "Nature of Elementary Particles." Interpreting Bodies: Classical and Quantum Objects in Modern Physics. Ed. Elena Castellani. New Jersey: Princeton University Press, 1998.

---. Nuclear Physics. New York: Philosophical Library, 1953.

---. "Remarks on the Origin of the Relations of Uncertainty." Quantum Implications: Essays in Honor of David Bohm. B.J. Hiley and F. David Peat. Ed. London; New York: Routledge & Kegan Paul Ltd., 1991.

---. The Physicist's Conception of Nature. Trans. Arnold J. Pomerans. Westport, Connecticut: Greenwood Press, Publishers, 1970.

---. "The Roots of Atomic Science." The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Helrich, Carl. S. "John Polkinghorne: Crossing the Divide between Physics and Metaphysics." Zygon 35 (2002): 963-969.

Herbert, Nick. Quantum Reality: Beyond the New Physics. New York: Anchor Press, 1985.

Hilley, B.J. and David Peat, eds. Quantum Implications: Essays in Honor of David Bohm. London; New York: Routledge and Kegan Paul Ltd., 1991.

Hourani, George Fadlo. "A Revised Chronology of Ghazālī's Writings." American

Oriental Society Journal 104 (1984): 289-302.

---, ed. Essays on Islamic Philosophy and Science. Albany: State University of New York Press, 1975.

---. Reason and Tradition in Islamic Ethics. Cambridge, New York: Cambridge University Press, 1985.

---. "The Chronology of Ghazālī's Writings," JRAS 79 (1959): 225-33.

---. "The Dialogue between al-Ghazālī and the Philosophers on the Origin of the World." Muslim World 48 (1958): 183- 191.

Hooker, C.A., ed. Contemporary Research in the Foundations and Philosophy of Quantum Theory. Vol. 2. Dordrecht; Boston: D. Reidel Publishing Company, 1973.

Hyman, John. "Vision and Power." Journal of Philosophy 91.5 (1994): 236-252.

Izmirli, Ismail Hakki. Islâmda Felsefe Akımları . Istanbul: Istanbul Kitapevi, 1995.

Janssens, Jules. "Al-Ghazālī's Tahafut: Is It Really a Rejection of Ibn Sina's Philosophy?" Journal of Islamic Studies 12.1 (2001): 1-17.

Jeans, James. "Some Problems of Philosophy." The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Kafatos, Menas and Robert Nadeau. The Conscious Universe: Parts and Wholes in Physical Reality. New York; Springer, 2000.

Kargh, Helge. Quantum Generations: A History of Physics in the Twentieth Century. Princeton; New Jersey: Princeton University Press, 1999.

Khan, I. A. "Authenticity and Development of Islamic Thought." International Journal of Islamic and Arabic Studies 4.2 (1987): 31-47.

Kilmister, C. W. and H. Pierre Noyes. The Concept of Object as the Foundation of Physics. By Irvin Stein. New York; Wasington D.C.; Baltimore; San Francisco; Berlin; Frankfurt am Main; Berlin; Vienna; Paris: Peter Lang, 1996.

Klein, Etienne. Conversations with the Sphinx. Trans. David Le Vay. (Souvenir Press, 1996.)

Kogan, Barry S. The Philosophers Al-Ghazālī and Averroes on Necessary Connection and the Problem of the Miracles. Delmar, N.Y.: Caravan Books, 1981

Kojiro, Nakamura. "Was Ghazālī an Ash'arite?" The World of Islam 41 (1993): 3-20.

Kosso, Peter. Appearance and Reality: An Introduction to the Philosophy of Physics. New York; Oxford: Oxford University Press, 1998.

Kretzmann, Norman, ed. Infinity and Continuity in Ancient and Medieval Thought. Ithaca; London: Cornell University Press, 1982.

Kukkonen, Taneli. "Possible Worlds in the Tahafut al-Falasifa: Al-Ghazālī on Creation and Contingency." Journal of the History of Philosophy 38.4 (2000): 479-503.

---. "Plenitude, Possibility, and the Limits of Reason: A Medieval Arabic Debate on the Metaphysics of Nature." Journal of the History of Ideas 61.4 (2000): 539-560.

Lamb, James. "Evaluative Compatibilism and the Principle of Alternate Possibilities." Journal of Philosophy 98.3 (1993): 517-527.

Lange, Marc. An Introduction to the Philosophy of Physics. Oxford: Blackwell Publishers, 2002.

Larmer, Robert. " Is there Anything wrong with 'God of the Gaps' Reasoning?" International Journal for Philosophy of Religion 52 (2002): 129-142.

Laszlo, Ervin. The Whispering Pond: A Personal Guide to the Emerging Vision of

Science. Massachusetts; Dorset; Queenland: Element, 1996.

Laurikainen, Kalervo V. The Message of the Atom: Essays on Wolfgang Pauli and the Unspeakable. Berlin: Heildelberg; New York; Barcelona; Budapest; Hong Kong; London; Milan; Paris; Santa Clara; Singapore; Tokyo: Springer, 1997.

Lazarus-Yafeh, Hava. Studies in al-Ghazālī. Jerusalem: Magnes Press, 1975.

Leaman, Oliver Introduction to Classical Islamic Philosophy. Cambridge: Cambridge University Press, 2002.

---. Introduction to Medieval Islamic Philosophy. Cambridge: Cambridge University Press, 1985.

Lemay, Richard. "Religion vs. Science in Islam." OM XIX.3 (2000): 557-575.

Luther, Martin Ernst-Wolfgang. The Infinite Voyage: A Metaphysical Odyssey. Minneapolis, Minnesota: Marwolf Publish, 1996.

Mabud, Shaikh Abdul. "Reason and Revelation: Conflict or Convergence?" Muslim Education Quarterly 11.4 (1994): 58-71.

Mackie, Penelope. "Causing, Delaying, and Hastening: Do Rains Cause Fires?" Mind 101.403 (1992): 483-500.

Madkour, Ibrahim. "Al-Farabi," Islamic Philosophy and Mysticism, ed. Parviz Morewedge. New York: Caravan Books, 1981.

Mahdi, Muhsin. "Al-Farabi and the Foundation of Philosophy," Islamic Philosophy and Mysticism. ed. Parviz Morewedge New York: Caravan Books, 1981.

Makdisi, George. "Ash'ari and the Ash'arites in Islamic Religious History." Studia Islamica XVII (1962): 37-80,

---. “Ash‘ari and the Ash‘arites in Islamic Religious History.” Studia Islamica XVIII (1963): 19-40.

Marmura, Michael. “Al-Ghazālī and Ash‘arism Revisited.” Arabic Sciences and Philosophy 12.1 (2002): 91-110.

---. “Al-Ghazālī and Demonstrative Science.” Journal of the History of Philosophy 3 (1965): 183-204.

---. “Al-Ghazālī Causes and Intermediaries.” Rev. of “Creation and the Cosmic System. Al-Ghazālī and Avicenna.” Journal of the American Oriental Society 115 (1995): 89-104.

---. “Ghazālī’s Attitude to the Secular Sciences and Logic.” Essays in Islamic Philosophy. Ed. George F. Hourani. Albany: State University of New York Press, 1975.

---. “Al-Ghazālī’s Chapter on Divine Power in the Iqtisad.” Arabic Sciences and Philosophy 4 (1994): 279-315.

---, ed. Islamic Theology and Philosophy: Studies in Honor of George F. Hourani. Albany: State University of New York Press, 1984.

---. “Plotting the Course of Avicenna’s Thought.” Journal of the American Oriental Society 111.1 (1991): 333-343.

---. The conflict over the World's Pre-eternity in the Tahafut of al-Ghazālī and Ibn Rushd. Ann Arbor, Michigan, 1959.

McGrath, James. “ Only if Quanta had Logic.” Proceedings of the Biennial Meeting of The Philosophy of Science Association 1 (1978): 268-276.

Melsen, Andrew G. Van. From Atomos to Atom: The History of the Concept of Atom. Trans. Henry J. Koren. Pittsburgh: Duquesne University Press, 1952.

Menger, Karl. "The New Logic." Trans. H.B. Gottlieb and J.K. Senior. Philosophy of Science 4.3 (1937): 299-336.

Mermer, Yamine Bouguenaya. "Induction, Science and Causation." Islamic Studies 35 (1996): 244-282.

Montada, Joseph Puid. "Ibn Rushd Versus al-Ghazālī: Reconsideration of a Polemic." The Muslim world LXXXII 1 (1992): 113-132.

Morewedge, Perviz. Islamic Philosophical Theology. Albany: State University of New York Press, 1979.

---, ed. Islamic Philosophy and Mysticism. Delmar, N.Y.: Caravan Books, 1981.

Morris, Richard. The Big Questions: Probing the Promise and Limits of Science. New York: Henry Holt and Company, 2002.

Morris, Thomas V., ed. Divine and Human Action: Essays in the Metaphysics of Theism. Ithaca, NY: Cornell University Press, 1988.

Murdoch, Dugald. Niels Bohr's Philosophy of Physics. Cambridge: Cambridge University Press, 1987.

Nadeau, Robert and Menas Kafatos. The Non-Local Universe: The New Physics and the Matters of the Mind. New York: Oxford University Press, 1999.

Nagel, Tilman. The History of Islamic Theology: From Muhammad to the Present. Trans. Thomas Thornton. Princeton: Marcus Wiener Publishers, 2000.

O'Connor, Timoty. "Causality, Mind, and Freewill." Philosophical Perspectives 14 (2000): 1005-117.

Omnés, Ronald. Quantum Philosophy: Understanding and Interpreting Contemporary Science. Trans. Arturo Sangalli. New Jersey:Princeton University Press, 1999.

Oparin, A. I. "Theories of Spontaneous Generation of Life," The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Orman Sabri. Gazali'nin Iktisat Felsefesi. Istanbul: Insan Yayınları, 1984.

Ormsby, Eric. L. Theodicy in Islamic Thought: The Dispute over al-Ghazālī's "Best of All Possible Worlds." New Jersey: Princeton University Press, 1984.

Osman Bakar. Tawhid and Science. The history and philosophy of Islamic Science Cambridge, U.K.: Islamic Texts Society, 1999.

---. Classification of knowledge in Islam: a Study in Islamic Philosophies of Science Cambridge, UK: Islamic Texts Society, 1998.

Othman, Ali. The Concept of Man in Islam, in the writings of al-Ghazālī. Cairo: Dar al-Marref Printing and Publishing House,1960.

Özcan, Hanifi. Human Freedom: From the Point of View of Knowledge-Object Relationship." Journal of Islamic Studies 7.1 (1996): 1-15.

Pagels, Heinz R. The Cosmic Code: Quantum Physics as the Language of Nature. New York: Simon and Schuster, 1982.

Parker, Barry. Quantum Legacy: The Discovery that Changed our Universe. New York: Prometheus Books, 2002.

Pessin, Andrew. "Does Continuous Creation Entail Occasionalism? Malebranche (and Descartes)." Canadian Journal of Philosophy 30.3 (2000): 413-441.

Perlman, James S. Science without Limits: Towards a Theory of Interaction Between Nature and Knowledge. New York: Prometheus Books, 1995.

Pines, Sholomo. Studies in Islamic Atomism, trans. Michael Scwarz, ed. Tzvi Langermann Jerusalem: The Hebrew University, Magness Press, 1997.

Plotnitsky, Arkady. The Knowable and the Unknowable: Modern Science, Nonclassical Thought, and the 'Two Cultures.' Ann Arbor: The University of Michigan Press, 2002.

Poidevin, Robin Le. "Can Beliefs be Caused by Their Truth Makers?" Analysis 59 (1999): 148-156.

Polkinghorne, John. "The Nature of Physical Reality." Zygon 35 (2000): 927-940.

Popper, Karl R. Quantum Theory and the Schism in Physics. Totowa; New Jersey: Rowman and Littlefield, 1982.

Pratt, D. "Consciousness, Causality, and Quantum Physics." NeuroQuantology 1 (2003): 58-67.

Price, Huw. "A Neglected Route to Realism about Quantum Mechanics." Mind 103.441 (1994): 303-336.

Qurashi, M. M. "Basic Concepts of Physics in the Perspective of the Qur'an." Islamic Studies 28.1 (1989): 55-75.

Rahman, Fazlur, ed. Avicenna's Psychology: an English Translation of Kitāb al-Majāt. London: Oxford University Press, 1952. al-Ghazālī

---, ed. Avicenna's De anima: being the Psychological Part of Kitāb al- Shifā'. London, Oxford Univ. Press, 1959.

Rahman, Yusuf. "A Study of the Theories of the Philosophers. Al-Ghazālī and Ibn Rushd." Hamdard Islamicus 21.1 (January 01, 1998): 23-25.

Rashed, Roshdi. "Al-Quhi vs. Aristotle: On Motion." Arabic Sciences and Philosophy 9

(1999): 7-24.

Riker, Stephen. "Al-Ghazālī an Necessary Causality in the Incoherence of the Philosophers." The Monist 79:3 (1996): 315-324.

Rogers, Katherin. "What's Wrong with Occasionalism?" American Catholic Philosophical Quarterly 75.3 (2001): 345-371.

Rosenberg, Alex. Philosophy of Science: A Contemporary Introduction. London; New York: Routledge, Taylor and Francis Group, 2000.

Rostron, Ismail Paul. "An Islamic Perspective on Quantum Mechanics." The Islamic Quarterly XLVI (2002): 79-95.

Rothman, Tony and George Sudarshan. Doubt and Certainty. Reading, Massachusetts: Perseus Books, 1998.

Rubio, Fray Luciano. El Occasionalismo de los Teólogos Especulativos del Islam. Ediciones Escurialenses, 1987.

Saeed, Ahmed M. "Al-Ghazālī." Review of Religions 90.1 (January 1995): 22

Schaffer, Jonathan. "Causes as Probability Raisers of Processes." Journal of Philosophy 98.2 (2001): 75-92.

Scheibe, Erhard. " Popper and Quantum Logic." The British Journal for the Philosophy of Science 25.4. (1974): 319-328.

Scott, David. "Occasionalism and Occasional Causation in Descartes' Philosophy." Journal of the history of philosophy 38.4 (2000): 503-528.

Searl, John R. "Meaning, Mind and Reality." Revue Internationale de Philosophie 2 (2001): 173-179.

Selleri, Franco. Quantum Paradoxes and Physical Reality. Ed. Alwyn van der Merwe. Dordrecht; Boston; London: Kluwer Academic Publishers, 1990.

Shaker, Asaad F. Al-Ghazāli on Intention, Sincerity and Truthfulness. Cambridge: Islamic Texts, 2001.

Schrödinger, Erwin. "What is an Elementary Particle?" Interpreting Bodies: Classical and Quantum Objects in Modern Physics. Ed. Elena Castellani. New Jersey: Princeton University Press, 1998.

---. "The Importance of Form." The Mystery of Matter. Ed. Louise B. Young. New York: Oxford University Press, 1965.

Smith, Margaret. Al-Ghazālī, the Mystic: a Study of the Life and Personality of Abu Hamid Muhammad al-Tusi al-Ghazālī. London: Luzac & co., 1944.

Smirnow, Andrey.. "Causality and Islamic Thought." A Companion to World Philosophies. Eds. Eliot Deutsch and Ron Bontekoe (Malden, Massachesetts; Oxford: Blackwell Publishers, 1997) 593-503.

Smith,Vincent Edward. Science and Philosophy (Milwaukee: Bruce Publications, 1965).

Sorell, Tom. "Descartes, the Divine Will and the Ideal of the Psychological Stability." History of Philosophy Quarterly 17.4 (2000): 361- 379.

Squires, Euan. The Mystery of the Quantum World. 2nd ed. Bristol; Philadelphia: Institute of Physics Publishing, 1994.

Stachel, John. " The 'Logic' of 'Quantum Logic.'" Proceedings of the Biennial Meeting of the Philosophy of Science Association (1974): 515-526.

Stairs, Allen. " Quantum Logic and the Luders Rule." Philosophy of Science 49.3 (1982): 422-436.

Stap, Henry. P. " Quantum Theory and the Role of Mind in Nature." Foundations of Physics 31.10 (2001): 1465-1499.

Stenger, Victor J. The Unconscious Quantum: Metaphysics in Modern Physics and Cosmology. New York: Prometheus Books, 1995.

Sunar, Cavit. "Berguson'da Suur Halleri ve Zaman." Ankara Universitesi Ilahiyat Fakultesi Dergisi 18-19 (1970): 47-66.

---. "Beynimizin Ruhsal Mu'cizeleri." Ankara Universitesi Ilahiyat Fakultesi Dergisi 22-23 (1978): 157-200.

---. "Madde ve Ruh Hakkinda Birkac Söz". Ankara Universitesi Ilahiyat Fakultesi Dergisi 20-21 (1975-76): 21-52.

Talbot, Michael. Beyond the Quantum. New York: Macmillan Publishing Company, 1986.

Taliaferro, Charles. "Saving Our Souls: Hacking's Archeology and Churcland's Neurology." Inquiry 40 (1997): 73-94.

Triver, Howard. The Rhythm of Being: A Study of Temporality. New York: Philosophical Library, 1985.

Trusted, Jennifer. The Mystery of Matter. Houndmills; Basingstoke; Hampshire; London: MacMillan Press, Ltd.; New York: St. Martin's Press, 1999.

Torretti, Roberto. The Philosophy of Physics. Cambridge: Cambridge University Press, 1999.

Tooley, Michael. Causation: A Realist Approach. Oxford: Clarendon Press, 1987.

Turgut, Sadi. "Parcaciklar Telepati Yapar mi?" Bilim ve Teknik (Ekim, 2000): 40-44.

Türkler, Mubahat. Üc Tehafüt Bakimindan Felsefe ve Din Muhasebeti. Ankara: Türk

Tarih Kurumu Basimevi, 1956.

Vallicella, William F. "God, Causation and Occasionalism." Religious Studies 35.1 (1999): 3-18.

Vries, Hent de. " Of Miracles and Special Effects." International Journal for Philosophy of Religion 50 (2001): 41-56.

Walzer, Richard. " Philosophical Surveys, VIII: A Survey of Work on Medieval Philosophy 1945-52." The Philosophical Quarterly 3.11 (1953): 175-181.

Wallace, William A. Causality and Scientific Explanation. Vol. 2. Ann Arbor: The University of Michigan Press, 1972.

Watt, W. Montgomery. "Al-Ghazālī." Encyclopedia of Islam New Edition. (New York: E. J. Brill, 1993).

---. Muslim Intellectual: a Study of al-Ghazālī. Edinburgh, University Press, 1963

---. "The Authentic of the Works Attributed to al-Ghazālī." Journal of the Royal Asiatic Society (1952): 24-45.

---. "The Study of al-Ghazālī." Oriens 13-14 (1961): 121-131.

Weisskopf, Victor. "Atomic Structure and Quantum Theory," The Mystery of Matter. Louise B. Young. New York: Oxford University Press, 1965.

Wolf, Fred A. Star Wave: Mind, Consciousness, and Quantum Physics. New York: Macmillan Publishing Company, 1984.

Yazicioglu, M. S. "Human Acquisition and a Qur'anic Verse." Ankara Universitesi Ilahiyat Fakultesi Dergisi XXVIII (1987): 327-334.

Young, Louise B., ed. The Mystery of Matter. New York: Oxford University Press, 1965.

Zuberi, Masarrat Husain. Aristotle, 384-322 B.C. and al-Ghazālī, 1058-1111 A.D. Karachi: Royal Book Co., 1986.

Zukav, Garry. The Dancing Wu Li Masters: An Overview of the New Physics. New York: HarperCollins Publishers, 2001.