CHAPTER SIX

Cases from Old Debates: The Size of the Universe and the Fate of the Sun

Al-Ghazālī is an outstanding thinker by any stretch of the imagination.

Oliver Leaman

In the history of Islamic philosophical thought, the arguments which were presented by al-Ghazālī and Ibn Rushd on issues of natural philosophy stand as a remarkable monument that reflects the high intellectual level and standard of discourse that existed in their times. Such a splendid debate is a good original resource for identifying the intellectual themes at the time that al-Ghazālī wrote his book *Tahāfut al-falāsifa* (*The Incoherence of the Philosophers*), in which he tried to refute the philosophical approach to comprehending the relation between God and the world and to present an alternative from the Islamic perspective. He thought that following the philosophical approach would corrupt religion:

> [A] group who, believing themselves in possession of a distinctiveness from companion and peer by virtue of a superior quick wit and intelligence, have rejected the Islamic duties regarding acts of worship, disdained religious rites pertaining to the offices of prayer and the avoidance of prohibited things, belittled the devotions and ordinances prescribed by the divine Law, not halting in the face of its prohibitions and restrictions.[1]

Al-Ghazālī also wrote that:

> the source of their unbelief is their hearing high-sounding names such as "Socrates," "Hippocrates," "Plato," "Aristotle," and their likes, and the exaggeration and mis-guidedness of groups of their followers in describing their minds, the excellence of their principles, the exactitude of their geometrical, logical, natural, and metaphysical sciences, and in [describing these as] being alone

> by reason of excessive intelligence and acumen—[capable] of extracting these hidden things; [also hearing] what [these followers] say about [their masters, namely] that concurrent with the sobriety of their intellect and the abundance of their merit is their denial of revealed laws and religious confessions and their rejection of the details of religious and sectarian [teaching], believing them to be man-made laws and embellished tricks.[2]

Al-Ghazālī claimed to have written his book:

> in refutation of the ancient philosophers, to show the incoherence of their belief and the contradiction of their word in matters relating to metaphysics; to uncover the dangers of their doctrine and its shortcomings, which in truth ascertainable are objects of laughter for the rational and a lesson for the intelligent—I mean the kinds of diverse beliefs and opinions they particularly hold that set them aside from the populace and the common run of men.[3]

In his treatise, al-Ghazālī mostly adopted the views and the approach of *kalām*. It was his intention to expose the failure of the philosophical argument in proposing a truly reconciliatory view of God and the world to which Muslims could subscribe without infringing their beliefs. He brought the conflict between Islamic *kalām* and philosophy to a head by undertaking a refutation of twenty philosophical doctrines, out of which seventeen were condemned as being heretical innovations and three as being totally opposed to Islamic belief. In part, al-Ghazālī targeted two prominent Muslim philosophers, al-Fārābī and Ibn Sīnā, for their views about the emanation of the world and the resurrection of bodies. The philosophers he condemned were not atheists and in fact their philosophies rested upon the affirmation of God and the recognition that all in existence emanate as the necessary consequences of the divine essence. Nevertheless, al-Ghazālī saw this as meaning that God has produced the world by necessity, in the same way that an inanimate object like the Sun was said to produce light by its very nature. For him, the views presented by the philosophers meant the denial of the divine attributes of life, will, power, and knowledge. Al-Ghazālī maintained that, denied these attributes, the god of the philosophers was not the god of the Qur'an.

Despite the fact that his *Tahāfut al-falāsifa* had brought the conflict between philosophy and more traditional Islamic beliefs to the fore, al-Ghazālī had in fact largely contributed this treatise to explain some important philosophical arguments. Owing to its intellectual caliber, his book marks a high point in the history of medieval Islamic thought. Although its motivation was religious, as shown above by his own words, it made its case through closely argued criticisms that were, ultimately, philosophical. It is important to note that al-Ghazālī based his critiques of the philosophical arguments related to

natural philosophy on a consistent body of thought which embedded what I call the "principles of *daqīq al-kalām*" in a most efficient manner. This, as we will see below, is not an isolated argument, but is rather a full range of arguments which encompasses detailed comprehension of fundamental concepts such as space, time, causality, the laws of nature, and several others. And, to a large extent, one can say without any equivocation that al-Ghazālī affirmed Ashʿari causal theory. For him, divine power is pervasive and is the direct cause of each and every created existent and each and every temporal event. The basic principle he adopted is that inanimate things have no causal power, a view which he also asserted in other works, such as *al-Iqtiṣād fi al-iʿtiqād*.

Ibn Rushd, the philosopher of Islamic Spain, adopted the views of Aristotle and provided a great service to Greek philosophy by explaining Aristotle's legacy. He found the work of al-Ghazālī to be a sort of forgery of philosophy; accordingly, he devoted his work *Tahāfut al-tahāfut* (*The Incoherence of the Incoherence*) to refuting al-Ghazālī's presentation, following him paragraph by paragraph, mostly reinstating the position of Aristotle on those questions.

In this chapter, I will present two problems which were originally discussed by al-Ghazālī in the context of his critique of the philosophers: the size of the universe and the degeneration of the Sun. The first problem appeared in the context of discussing the presence of time before the creation of the universe, where al-Ghazālī tried to show that time is not eternal and only existed once the universe existed, alongside space. He treated time on an equal footing with space and accordingly he tried to draw an analogy by which the temporal moments *before* and *after* are similar to the spatial allocations *above* and *below*, designations which can only be defined with respect to a given reference point. Consequently, time has no absolute reference except with respect to the moment of creation. In order to establish this analogy, al-Ghazālī went on to question the theoretical possibility that the universe could have been created larger or smaller than it is. If such a possibility is allowed, then the question arises over whether the universe has an exterior into which it can be extended. This was a challenging question for the philosophers, who denied such a possibility, always asserting the finiteness of the universe within a fixed size and shape. Hence, they had no alternative but to admit that beyond the universe there could be neither a body nor a void. This would mean that the volume of the universe is all which can be recognized to exist. Accordingly, and since time is associated with space and matter, no recognition of time would be possible unless the universe existed. Hence, the question of a time existing before the creation of the universe is deemed to be meaningless. Al-Ghazālī's genius was presented in this argument, which makes one admire the consistency of his argument and the boldness of his suggestion that time

should be treated on equal footing with space. It might be said that the visualization of time existing alongside the creation of the universe had already been mentioned by St. Augustine (see Chapter Five on spacetime). This is true and it might be that al-Ghazālī adopted this visualization; however, it is important to note that he extended the argument of the analogy of space and time into a realm well beyond that of St. Augustine, by recognizing that the universe has no exterior and that the temporal extension is a dimension that has to be treated on an equal footing with spatial dimensions, a concept that we acknowledged in our modern age only after Albert Einstein's discovery of the theory of relativity.

The second problem, the question of the corruption of the Sun, was presented in the *Tahāfut al-falāsifa* in the context of discussing the post-eternity of the world, time, and motion. In this respect, al-Ghazālī did not deny the possibility of the post-eternity of the world on a rational basis, but he suggested that this could only be denied on a religious basis:

> No one maintains that the world should necessarily have an end except Abu al-Hudhayl al-'Allaf. For he said: "Just as an infinite number of past [heavenly] rotations is impossible, the same is true of the future." But this is false because the future does not enter at all into existence, either successively or concomitantly, whereas all of the past has entered into existence successively, even though not concomitantly. And if it has become evident that we do not deem it rationally remote for the world's duration to be everlasting, but regard either its rendering it eternal in the future or annihilating it as [both] possible, then which of the two possibilities becomes fact is only known through the revealed law. Hence the examination of this [question] is not connected with what is rationally apprehended.[4]

This is a good point to recognize indeed within the general view that al-Ghazālī held regarding the fate of the world. It does reflect that his religious belief motivated some of his positions on issues of the old metaphysics. And this is indeed what *kalām* was all about. It would affirm the *kalām* approach which I have outlined in Chapter One of this book, which starts with revelation and, according to which, it goes on to build a worldview.

Al-Ghazālī based his argument for rejecting the post-eternity of the Sun by refuting the argument which had been made to affirm its eternity. That argument took the observational fact that the Sun has continued to look the same, without withering, for a very long period of time as evidence for its eternity. Al-Ghazālī showed that this argument was flawed, since it was based on poor observations that were inadequate for recognizing small mass loss from the body of the Sun that might be taking place at a very slow rate.

Both problems were reconsidered by Ibn Rushd in his defense of the philosophers' arguments. Ibn Rushd had fully adopted Aristotelian cosmology and, accordingly, he tried to show that the universe could not be larger or smaller than its given size, because such a possibility, according to him, would change the universal order. He also tried to affirm Galen's position concerning the eternity of the Sun. In his refutation, Ibn Rushd was mostly apologetic and did not provide enough evidence, other than those which were available within Aristotle's metaphysics. However, at certain points through the discussion, one cannot deny that Ibn Rushd made certain notes and hints that reflected his own genius.

The presentation of these two problems here is intended to provide important historical examples of how the views of *kalām* and those of the philosophers constituted two rival theories in respect of natural events.

In concluding this chapter, I will try to assess the views that al-Ghazālī and Ibn Rushd presented on these two problems from the scientific standpoint which is currently held and based on the discoveries of modern astrophysics and cosmology.

Greek Sciences in Islam

The subjects of the creation of the firmament, including all the celestial objects, and of the design and development of the cosmos are some of the main considerations of many verses of the Qur'an. The main goal in presenting this issue, it seems, is to turn people's attention to the signs that demonstrate the glory of the Creator who designed the cosmos, and to appreciate the need for such a creator and designer. These signs mentioned in the Qur'an encouraged Muslims to contemplate the cosmos and try to understand God's action in the world through pure reason according to the philosophical trend. On the other hand, the transmission of Greek astronomy contributed positively to the scientific movement in the Islamic world to the extent that Muslim astronomers were able to develop their own new techniques for astronomical observations and to criticize Ptolemy's geocentric system, as well as develop an alternative astronomical system to replace that of Ptolemy.[5]

Most Muslim scientists and philosophers were overwhelmed by the Greek sciences and philosophy to the extent that they could not circumvent the main propositions of the Greeks with respect to their views of the cosmos. This applied to philosophical trends as much as to some other scientific trends in Islam. Greek philosophers such as Plato and Aristotle—"men of wisdom", as they were called in the Islamic media—were highly respected by most of the Muslim philosophers and especially by al-Fārābī, Ibn Sīnā, and Ibn Rushd. Some Muslim philosophers admired Plato and Aristotle to the extent that they considered them to be gifted wise men comparable to prophets, a status

which would make it nearly impossible to breach their doctrines. For this reason, it would not be surprising to know that genuine contributions by Muslim philosophers to the philosophical achievements were quite modest and that most of their works echoed the original Greek views, despite their endeavor toward reconciling Islamic belief with philosophy.

On the other hand, Muslim rational theologians, who were rehearsing an independent style of thought based on the Qur'an, were less affected by the philosophical thoughts of the Greeks. This strongly applied to the pioneering practitioners of *kalām*, the *mutakallimūn*, who were active during the eighth and ninth centuries. This is why we see that *kalām* was able to reflect the true value and originality of Islamic creed.

Apart from some minute details, the picture that Muslims had about the firmament was almost the same as the one that was adopted and developed by the Greeks, in which the five planets, the Sun, the Moon, and the fixed stars were thought to be associated with concentric celestial spheres at the center of which Earth resides. This is the so-called "geocentric model" of the planetary system. In its most sophisticated form, this model, as mentioned above, was devised by Ptolemy and was adopted to calculate the positions of the celestial objects for more than 1,200 years. The fact that the calculations did not accurately fit with the observations required many readjustments of the model through the well-known epicycle assumption, by which astronomers had to suggest new values for the parameters every time they found their calculations did not fit the actual observations.

The Firmament in the Qur'an

The terms heaven (singular) and heavens (plural) are mentioned in the Qur'an 310 times. In so many verses, these terms come in the context of descriptions of divine providence and God's care of mankind. The Qur'an stresses that Allah has created the firmament and that He is developing it. However, the concept of the firmament does not have a definitive meaning in the Qur'an. It could mean the clouds, the atmosphere, the open sky, the solar system, the branch of the galaxy to which we belong, the galaxy, the whole universe, or even other universes that are beyond our comprehension. The meaning of the firmament is so widely presented that one cannot but treat every mention within its given context.[6] What is of interest at this point is the way that the Qur'an has presented the development of the firmament:

> Have not those who disbelieve known that the heavens and the earth were joined together as one united piece, then We parted them? And We have made from water every living thing. Will they not then believe? (21:30)

Despite some contextual similarities, this description for the creation of the firmament is somewhat different from what is given in the Old Testament. Here we understand that the heavens and the earth were one entity and that they were separated. The heavens were not born out on the surface of the water, as is stated in the Old Testament. Nevertheless, creation originated from water in the sense that water is the basic composition of living creatures. This provides a more detailed and accurate picture of the event of creation. Moreover, it seems that this event of creating the firmament is running continuously: "We constructed the firmament with our hands, and we will continue to extend it" (Qur'an 51:47).

This clear statement shows the development of the firmament after its creation to be one of continuous expansion. Such an expansion might entail the continuous creation of space, but it is not clear whether such a creation is accompanied by the creation of matter and energy, or whether it is space only which is expanding. Yet, the Qur'an does not specify where the expansion is taking place, whether within a larger volume of space or whether expanding from within. The word "extending" is different from the word "expanding", which has been used by some translators of the Qur'an. To expand may mean to increase the space between the constituents of a structure, say a city, without adding any new buildings. But to extend a city implies the adding of new buildings and an area to it. In the above verse, the sentence in the Qur'an indicates that the firmament constitutes a block that is being extended by the addition of new structures and spaces. So, one may say that space is being expanded possibly with the addition of new matter.

However, such expansion will not go forever, according to the Qur'an. It has to stop one day and will start to contract, taking the universe back to where it started:

> And (remember) the Day when We shall roll up the heavens like a scroll rolled up for letters, as We began the first creation, We shall repeat it, (it is) a promise binding upon Us. Truly, We shall do it. (21:104)

This clearly indicates that the firmament is going to contract and revert to the state of its first creation. In modern cosmology, this is called the "big crunch". The rolling up of the scroll is an interesting image which indicates a flat universe. Arguably, late discoveries of the accelerating universe may indicate that the universe will go on expanding forever. Nevertheless, this fate might be challenged by introducing other factors affecting the status of the universe, such as the so-called "cosmological constant", and some studies allow for the possibility of a collapsing flat universe.

Al-Ikhwān al-Ṣafāʾ (the Brothers of Purity) was a secret group of the Ismaili sect, which adopted the Aristotelian model of the heavens and tried to integrate it with Islamic belief through interpretations of the relevant verses of the Qur'an. They imagined seven ethereal spheres holding seven celestial bodies as being the seven heavens and the seven earths that the Qur'an has mentioned. So, for them, the world is no more than these objects surrounded by the sphere of the fixed stars and encircled by the Atlas orbit, which they interpreted to be the throne of God.

However, they did not tackle the question of the expanding or extending world mentioned in Sūrat al-Dhāriyāt. For this reason, we can say that their Aristotelian view was not of much help in covering the stipulations of the Qur'an concerning the development and the fate of the universe.

On this point, al-Ghazālī did not use the religious argument for asserting the possibility of an expanding universe; however, he may have been motivated by the stipulations of the Qur'an concerning such a possibility. Contrary to the mainstream philosophical thinking at that time, which considered the universe to be static and eternal, al-Ghazālī believed that the world was temporal, being created out of nothing, ex nihilo, and that its creation marked the beginning of both space and time. This understanding was actually borrowed from the *mutakallimūn*, who earlier in the Islamic history of thought had devised a theory of creation by which the universe came into being by the sheer will of Allah. In our present time, William Craig has made some serious efforts in elaborating on the Kalām Cosmological Argument, which stipulated that the universe must have a cause for its existence since it has a beginning.[7]

The Size of the Universe

In the first discussion of his *Tahāfut al-falāsifa*, al-Ghazālī discussed the problem of the temporality and the eternity of the world. His strategy was based on defying what he considered to be the strongest arguments of the philosophers in claiming that the world should be eternal, raising some challenging questions for the philosophers, discussing their views and showing that their arguments were inconsistent. In this context, al-Ghazālī presented a very deep and thoughtful discussion of space and time, defending the necessity to recognize the fact that space and time allocations should not be taken as absolute, but should always be considered in reference to a given point in space or time. This was indeed a very advanced comprehension of a topic that might well be considered a problem for the modern science of the twentieth century. Al-Ghazālī used the terms "spatial dimension" and "time dimension".[8] He refused the notion of a space that goes beyond the world and refused the existence of time before the creation of the world.[9] And it was through this

comparison between space and time that he introduced the question about the size of the world, allowing for the possibility that the world could have been created larger or smaller than it is. With his sophisticated concept of space and time, and his realization of the analogy between space and time, al-Ghazālī refuted the philosophical claim that an infinite extension of time should have existed before the creation of the world. The most important argument which was placed in this context was the notion that both space and time existed only after the creation of the world, a concept that was established only by the modern theory of cosmology.

One of the arguments of al-Ghazālī concerned the size of the universe, where he posed the question of whether the universe could be larger or smaller than it is. This he posed in order to challenge the philosophers, trying to force them to admit one thing or another in their views concerning the existence of time before the creation of the universe. The philosophers used to argue that, if the universe were not eternal but had been created in time with a well-defined beginning, then why did the Creator wait so long before creating it? Obviously, this question implicitly assumes that the Creator lives in time.

Al-Ghazālī first questioned the philosophers over whether the world could have been created by God larger than its known size: "Did it lie within God's power to create the highest heaven greater in thickness by one cubit than the one He had created?".[10] Then he commented: "If they say, 'No,' this would be [the attribution to Him of] impotence. If they say, 'Yes,' then [it follows that God could have created it] greater by two cubits, three cubits, and so on, ascending ad infinitum".[11]

Consequently, al-Ghazālī concluded that, if the answer was "yes", then this would imply the affirmation of a space beyond the world that has a measure and quantity, since that which is greater by two cubits does not occupy the equivalent space as the one greater by one cubit. Accordingly, he said:

> Then, beyond the world there is quantity, requiring thus that which is quantified—namely, either body or the void. Hence, beyond the world there is either void or filled space.[12]

By setting this argument, al-Ghazālī posited a fundamental paradox that the philosophers were required to solve. The paradox had two faces: they could have said that beyond the world there is a void into which the world could be expanded. But the existence of such a void went against the doctrines of the philosophers, who refused the existence of voids anywhere in the world. Alternatively, they could have said that beyond the world there is a matter-filled space. In this case, there would be no reason why such a filled space should

not be part of the world itself, since it would then be no more than an extension of the world itself.

Similarly, al-Ghazālī posed the other question of whether God is able to create the world's sphere smaller by one cubit, then by two? Accordingly, if one could accept that the measure of the world is reducible in size then, according to al-Ghazālī, this would imply that the void which is left when we reduce the size of the world is measurable, while being nothing. The other side of the paradox was to challenge the philosopher about the limit of God's authority with respect to creating and sustaining the world, a challenge that Muslim philosophers certainly would not have been able to stand.

In fact, the aim behind posing these questions concerning the size of the world was tactical rather than strategic. Al-Ghazālī had no intention of showing that the universe could be expanded or contracted, he intended to show only that we must consider the temporal designations in respect of the *before* and the *after* on an equal footing with the spatial assignments of the *above* and the *below*. That is to say, the temporal assignments of events should be done with respect to a given reference rather than being absolute. Therefore, here al-Ghazālī's argument served a dual purpose: one by which he intended to show that there is no basic natural objection to having a universe larger or smaller than the existing one, and the other that such a possibility would certainly reassure the conceptual integrity of space and time. Consequently, he made an effort to use these results to refute the claim that a temporal world necessitates the existence of a time duration *before* creation had taken place. For this reason, it could be said that al-Ghazālī would be quite happy with the contemporary argument put forward by Adolf Grünbaum,[13] which says that the moment of creation does not qualify as a physical event, since there was no physical moment *before* the initial moment of the big bang. Indeed, according to al-Ghazālī, the creation of the world did not happen *in* time but happened *with* time, as he put it. For this reason, it is legitimate to argue that there is no well-defined moment of creation, since real time only started *with* that moment. This would indeed be quite consistent with an earlier argument of al-Ghazālī:

> Similarly, if we are asked: does the world have a "before"? we answer: If by this is meant does the world's existence have a beginning, that is, a limit in which it began, then the world has a "before" in this sense, just as the world has an outside on the interpretation that this is its exposed limit and surface end. If you mean by it anything else, then the world has no "before," just as when one means by "outside the world" [something] other than its surface, then one would say: there is no exterior to the world. Should you say that a beginning of an existence that has no "before" is incomprehensible, it would then be said: a

> finite bodily existence that has no outside is incomprehensible: If you say that its "outside" is its surface with which it terminates, [and] nothing more, we will say that its "before" is the beginning of its existence which is its limit, [and] nothing more.[14]

So it is here that the moment of creation is considered unique, in that it has no similarity to any other subsequent moment. To confirm this, al-Ghazālī further emphasized the premise that God is timeless and, therefore, the question of what God was doing before the creation of the universe becomes meaningless, a position similar to that put forward by St. Augustine.

Ibn Rushd Responding

In *Tahāfut al-tahāfut*, Ibn Rushd tried to refute the claims of al-Ghazālī by criticizing his arguments and presenting counterarguments. As far as the question of the size of the universe is concerned, Ibn Rushd at first denied that the philosophers had said that God could not change the size of the universe, and rejected the accusation that their position on this matter implied that God is impotent:

> This is the answer to the objection of the Ash'arites that to admit that God could not have made the world bigger or smaller is to charge Him with impotence, but they have thereby compromised themselves, for impotence is not inability to do the impossible, but inability to do what can be done.[15]

Clearly, to say that impotence is not the inability to do the impossible but the inability to do what can be done is true with respect to human acts, but not to divine acts, for we are not sure whether anything is impossible for God. Ibn Rushd confirmed this attitude by saying:

> This consequence is true against the theory which regards an infinite increase in the size of the world as possible, for it follows from this theory that a finite thing proceeds from God which is preceded by infinite quantitative possibilities. And if this is [an] allowed for possibility in space, it must also be allowed in regard to the possibility in time, and we should have a time limited in both directions, although it would be preceded by infinite temporal possibilities.[16]

He then concluded:

> The answer is, however, that to imagine the world to be bigger or smaller does not conform to truth but is impossible. But the impossibility of this does not imply that to imagine the possibility of a world before this world is to imagine an impossibility, except in case the nature of the possible were already realized and there existed before the existence of the world only two natures, the nature of the

> necessary and the nature of the impossible? But it is evident that the judgment of reason concerning the being of these three natures is eternal, like its judgment concerning the necessary and the impossible.[17]

This means that it is not contingent at all for the size of the universe to be smaller or larger than it is, but is something which falls between being either necessary or impossible. With this digression, Ibn Rushd shifted the argument from the arena of metaphysics to the arena of physics. By such a designation, Ibn Rushd thought he could refute al-Ghazālī's conclusions and win the argument. From his point of view, it is impossible for the universe to be larger or smaller than its natural size, since the specified size of the universe is a necessity. Accordingly, a larger or a smaller universe would be rather impossible. As for the designation of the necessity and the impossibility, it is clear that Ibn Rushd was adopting the naturalistic dogma which assumes that whatever happens in the world has to be effected through purely natural causes and that it should take place in accordance with the laws of nature. However, this can be validated only if we have full knowledge of the laws of nature; but, since we now know that our knowledge of the laws of nature is incomplete (see Chapter Two), it would be rather more humble to allow for the possibility of the event happening rather than to deny it. This is, in fact, the contemporary approach adopted by the modern science that we have developed through the ages, and according to which new discoveries are made.

Ibn Rushd further embraced his denial of a possibility for the universe to be larger or smaller than its known size, trying to substantiate his views with more arguments which stemmed, perhaps, from his inability to visualize time on an equal footing with space. Thus, he was unable to accept the notion of spacetime integrity and the absence of absolute space and absolute time, such points which were very essential to the argument used by al-Ghazālī. In fact, Ibn Rushd suggested that, if the universe were allowed to expand, then there is no reason why it should not do so forever:

> Therefore, he who believes in the temporal creation of the world and affirms that all body is in space, is bound to admit that before the creation of the world there was [a] space, either occupied by body, in which the production of the world could occur, or empty, for it is necessary that space should precede what is produced.[18]

Again, it is clear that Ibn Rushd had missed the point made by al-Ghazālī that space itself was non-existent before the creation of the world. This is because he thought of space and time as two independent entities. From the point of view of al-Ghazālī, the existence of an empty space into which the universe

could be extended would be unnecessary, as space was born along with the creation of the universe. The same argument applies to time, since space and time are integrated and should be treated on an equal footing, at least on the conceptual level.[19]

Clearly, al-Ghazālī had allowed for two possibilities for the universe to be larger or smaller than it is. He could foresee no rational reason to prevent such a possibility. It might be true that his argument stemmed from his submission to the belief in the unlimited power of Allah to do whatever was contingent. On the other hand, Ibn Rushd had based his argument on the Aristotelian proposition that the size of the universe is fixed and no other possibility is allowed. His argument that, once the universe is "allowed" to be bigger, there would be nothing to stop it from expanding further was unacceptable, since this would lead to an infinite universe once we assume that it had no beginning, a result which would be in contradiction with the Aristotelian doctrine of a finite universe. Aristotle argued that the universe is spherical and finite. Spherical, because that is the most perfect shape; finite, because it has a center, namely, the center of the earth, and a body with a center cannot be infinite. Therefore, based on the arguments presented by al-Ghazālī which implied that the universe could have been created larger or smaller than its known size, we conclude now that the philosophers should either have abandoned their assumption of the eternity of the world or their doctrine of a geocentric universe. It would be fascinating to see how this conclusion echoes in the modern understanding of the cosmos, a question which I leave for further research.

Scientific Assessment

By the beginning of the twentieth century, some astronomers had started a program of observations aimed at studying the motion of nearby galaxies. It was found that most of these galaxies, which are called "the local group", are descending away from us. Through patient observations that were made during the first two decades of the last century, it was established by the works of Vesto Slipher and Edwin Hubble that the universe is in fact expanding. Hubble deduced that the further away a galaxy is from us, the faster it is descending.[20] Using this discovery, George Gamow and collaborators suggested a scenario to explain the natural abundance of elements, that is the average percentage of each of the ninety-two natural elements found in the universe. This scenario was later called the "big bang theory". A continuously expanding universe was already an option suggested by the theory of general relativity. This theory was proposed by Albert Einstein in 1915 and, having been confirmed by many observations, it was adopted to be the standard theory of

space, time, and gravity. The theory replaced Newton's law of gravity, which had served the astronomical calculation of the solar system for about 300 years. Almost all models of modern cosmology are based on this theory, according to which the universe is being driven to expansion by its own internal energy. Indeed, modern cosmology allows for an infinite universe as a possible solution to the Einstein field equations, although the universal model which was proposed by Einstein himself was static, finite, but unbound. The Einstein static model was a sort of artifact that was designed by Einstein after modifying his field equations. Einstein was driven by the prevailing belief that the universe is finite and static, a belief that might be a relic of Aristotle's universe. The Einstein universe cannot expand nor can it collapse, for once it starts to expand it will do so forever and once it shrinks it will go on shrinking to a point. This critical behavior makes Einstein's universe extremely unstable, like a pencil standing on its tip. It is interesting to note that Ibn Rushd's conjecture concerning the ever-expanding universe echoes in Einstein's model. However, since the discoveries made by Hubble and others have confirmed an expanding universe, the Einstein static universe became redundant. Other dynamic models were alternatively proposed, which were deduced by solutions of the original (unmodified) Einstein field equations. These provided us with three options: a universe which expands forever at an ever-accelerating rate, and this was called the "open universe"; a universe which expands forever but with less acceleration, to reach an ultimate terminal speed at later times, and this was called the "flat universe"; and the third model is a universe that expands until reaching a maximum size within a finite duration of time and then starts a collapse, at the end of which phase it returns to its original state, and this was called the "closed universe". It is this third model here that may correspond with what the Qur'an points to in verse 21:104.

However, if the universe is expanding now, then this means that in the immediate past it must have been smaller in size. Therefore, one might ask where the universe is expanding to. Is it that beyond the universe there is a void into which the universe is expanding? Modern cosmology, which is based on the theory of general relativity, assumes that the universe is four-dimensional, three dimensions are for space and the fourth dimension is time, into which the universe is expanding. Accordingly, the universe has no outside and if we have to talk about the universal volume in space then we have to accept the fact that we can only see the surface of the universe from within. This is realized in the cosmological model for the universe set forth by the theory of general relativity, by saying that the volume of three-dimensional space that we see is actually a three-dimensional surface embodied in

a four-dimensional spacetime, hence time is the axis along which space is expanding. For this reason, cosmological expansion is understood as being the growth of space in between large cosmological structures. This allows us to view the situation in analogy with the expansion of a two-dimensional balloon surface, where we see dots separated by larger and larger distances as the balloon is inflated.

It might be astonishing to know that al-Ghazālī had realized the fact that the universe has no outside. He expressed his understanding by saying:

> If you mean by it anything else, then the world has no "before," just as when one means by "outside the world" [something] other than its surface, then one would say, there is no exterior to the world.[21]

This sentence came in the context of describing that the world has a beginning but no moment before that beginning, stressing the notion that space and time existed with the creation of the world but not before. Furthermore, al-Ghazālī treated space and time on an equal footing:

> It is thus established that beyond the world there is neither void nor filled space, even though the estimation does not acquiesce to accepting [this]. Similarly, it will be said that just as spatial extension is a concomitant of body, temporal extension is a concomitant of motion . . . There is no difference between temporal extension that in relation [to us] divides verbally into "before" and "after" and spatial extension that in relation [to us] divides into "above" and "below". If, then, it is legitimate to affirm an "above" that has no above, it is legitimate to affirm a "before" that has no real before, except an estimative imaginary [one] as with the "above".[22]

This is surely an advanced conceptual understanding that is in agreement with the current understanding of modern cosmology and the theory of general relativity.

The Degeneration of the Sun

The Sun, which is the brightest object in the sky with all its influence on terrestrial life on Earth, has attracted the attention of man since the very early times of his existence. Some nations worshiped the Sun and on many occasions the Sun was taken to symbolize power and life.

According to al-Ghazālī, the Greek philosopher Galen proposed that the Sun is an eternal heavenly body that should not corrupt or diminish. The fact that heavenly bodies were believed to be non-corruptible is one basic doctrine of the philosophy of Aristotle and his followers.[23] The Sun, the planets, and all the stars were believed to be formed of a fifth element called "ether". It

was the sub-lunar world only, the air and the Earth, which was believed to be corruptible.

In the second discussion of the *Tahāfut al-falāsifa*, al-Ghazālī tried to refute the proposition put forward by the Greek philosophers that the world, space, and time are eternal. Post-eternity of the world was the main issue in this discussion and for this reason he considered the example of the fate of the Sun and he first discussed whether the corruption of the Sun could only take place through withering. The argument put forward by the philosophers (which al-Ghazālī attributes to Galen) said that, should the Sun diminish, it would suffer from withering, something which has not been seen despite the long time of observing the Sun. Al-Ghazālī tried to refute this implicit pre-condition on the corruption of the Sun by suggesting that such a pre-condition is unnecessary: "But we do not concede that a thing is corrupted only by way of withering. Rather, withering is but one way of [a thing's] corruption".[24]

Then al-Ghazālī argued that, even if the argument of withering is conceded for, how then would one know about withering except through astronomical observations? But, since astronomical observations are not so reliable, we cannot detect a small diminishing in the size of the Sun. Al-Ghazālī stated that, as the Sun is a very large object, a loss of a small part of it might go unnoticed:

> Should the Sun, which is said to be a hundred and seventy times larger than the Earth, or close to this, be diminished by the size of mountains, for example, this would not be apparent to the senses . . . The senses, however, would have been unable to apprehend this because estimating [such an amount] is known in the science of optics only by approximation.[25]

He then made an analogy of the assimilation of a ruby, where it loses a very small amount of its mass over a long period of time:

> This is similar to the case of rubies and gold that, according to [the philosophers], are composed of elements and are subject to corruption. If then a ruby is placed [somewhere] for a hundred years, what diminished of it would be imperceptible. Perhaps the ratio of what diminishes from the sun during the period of the history of astronomical observations is the same as what diminishes of the ruby in a hundred years, this being something imperceptible.[26]

So, as we see here, al-Ghazālī not only believed in a corruptible Sun, but had conjectured that the Sun might actually be diminishing at a very slow rate that would go unnoticed by the optical techniques available at his time, even by observations extending over a large period of time. This is what our current knowledge would certainly endorse.

Ibn Rushd Defending Galen's View

Ibn Rushd tried to defend Galen's view, claiming that "Galen's statement is only of dialectical value".[27] Then he argued that if the heavens were to suffer such a major change as celestial objects becoming corrupt, then such a corruption would produce a sixth element:

> Should heaven, however, lose its form and receive another, there would exist a sixth element opposed to all the others, being neither heaven, nor earth, nor water, nor air, nor fire. And all this is impossible.[28]

This he said because the fifth, heavenly, element (ether) is supposed to be non-corruptible according to Greek philosophy, so, if it were to suffer corruption, then the element of which it is composed would have to change. As no such element had been identified in the composition of the world, thus for him such an element did not exist. Ibn Rushd then questioned further the possibility of the decay of the Sun by wondering about the secondary effects produced by the decay, which, he thought, would affect the sub-lunar world:

> If the Sun had decayed and the parts of it which had disintegrated during the period of its observation were imperceptible because of the size of its body, still the effect of its decay on bodies in the sublunary world would be perceptible in a definite degree.[29]

This was a reasonable expectation, since a decaying object would certainly produce some output that could be traced in the world through their secondary effects. The reason why such secondary effects are expected to happen is because:

> For everything that decays does so only through the corruption and disintegration of its parts, and those parts which disconnect themselves from the decaying mass must necessarily remain in the world in their totality or change into other parts, and in either case an appreciable change must occur in the world, either in the number or in the character of its parts.[30]

In this statement, Ibn Rushd is expressing the law of conservation of matter,[31] a notion which is so clear and bold here that it does make one admire his genius. However, for him such an effect had not been observed and this therefore supported the proposition that the Sun does not corrupt. Furthermore, Ibn Rushd concluded his response to al-Ghazālī by resorting to a metaphysical argument:

> To imagine, therefore, a dissipation of the heavenly bodies is to admit disarrangement in the divine order which, according to the philosopher, prevails in this world.[32]

This was not much of an argument, since we cannot see how the divine order would become disarranged unless we believe that the metaphysical order requires the heavens to be immune to corruption or change. This was what Ibn Rushd believed, that literally any change could cause such a disarrangement and may cause a change to the divine order.

Scientific Assessment

Modern astrophysics has shown that the Sun, and indeed all other stars in the universe, generates a tremendous amount of energy through the process of nuclear fusion. This happens when four protons (hydrogen nuclei) fuse at a high temperature and pressure, producing one helium nuclei. Consequently, a large amount of energy is released from the core of the Sun in the form of heat, light, and other radiation. According to the law of mass–energy equivalence, which was discovered by Albert Einstein, the amount of energy radiated by the Sun in every second, in the form of heat, light, and other radiations, is equivalent to 4.2 million tons of mass. But this amount of radiation is only a small portion of the Sun's immense mass. At this rate, the Sun loses only about 0.001% of its mass every 150 million years. The Sun is believed to have a sufficient amount of hydrogen to sustain its energy production for the next five billion years or so, by which time the useful percentage of the hydrogen will have been exhausted and the Sun will then undergo a series of changes that will develop by fusing helium nuclei into carbon and oxygen, meanwhile releasing a huge amount of energy during this explosive fusion and causing the Sun to expand tremendously, increasing its size by one hundred and changing it into a "red giant". This late phase constitutes only a relatively short part of the Sun's life and the Sun will end up collapsing into its final fate as a little "white dwarf" that can hardly be seen from Earth. This happens as the red giant cools and the generation of heat and pressure ceases. Consequently, the Sun cannot sustain itself against the gravitational pull of its parts, causing it to collapse in a colossal event to become a white dwarf with a size smaller than that of Earth and to glow with only a faint light. All stars that have approximately the same mass as the Sun will undergo a similar fate. Other stars that are more massive than the Sun will develop into neutron stars, objects mainly composed of a neutron core and with a size of only about 10 km. Stars that are more than 3.4 solar masses will continue the course of their collapse and become black holes, objects with such a strong gravity that even light cannot escape it.

Accordingly, it is reasonable to conclude that the view of al-Ghazālī was more realistic than the one expressed by Ibn Rushd, despite the very interesting objections that the latter had raised against al-Ghazālī's arguments.

Al-Ghazālī's Position on Science and Religion

On many occasions, we read that al-Ghazālī was against science and scientific thinking and recently two well-known physicists[33] claimed that al-Ghazālī was one of the main reasons for the decline in science and scientific thinking in the Islamic world. Here, I will present excerpts from his introduction to *Tahāfut al-falāsifa*, which show that al-Ghazālī actually stood by the exact sciences and proper scientific thinking while opposing philosophers and the atheistic view of the world. There are several other places where al-Ghazālī expressed his respect for the exact sciences, but these can be reported on another occasion.

Al-Ghazālī introduced his book *Tahāfut al-falāsifa* with a prologue in three parts. In the first part, he wrote about the main addressees of his book, who were mainly Aristotle and Plato:

> Let us then restrict ourselves to showing the contradictions in the views of their leader, who is the philosopher par excellence and "the first teacher." For he has, as they claim, organized and refined their sciences, removed the redundant in their views and selected what is closest to the principles of their capricious beliefs, namely, Aristotle.[34]

In the second part, al-Ghazālī differentiated between those subjects of philosophy that he was targeting and those he was not:

> One into the refutation of which we shall not plunge, since this would serve no purpose. Whoever thinks that to engage in a disputation for refuting such a theory is a religious duty harms religion and weakens it. For these matters rest on demonstrations, geometrical and arithmetical, that leave no room for doubt.[35]

At this point, al-Ghazālī went even further to discuss some of the dogmatic suspicions among Muslims about scientific achievements and the possible claims that they might be in contradiction with the stipulations of the Qur'an and the teachings of the Prophet:

> When one studies these demonstrations and ascertains their proofs, deriving thereby information about the time of the two eclipses [and] their extent and duration, is told that this is contrary to religion, [such an individual] will not suspect this [science], only religion. The harm inflicted on religion by those who defend it not by its proper way is greater than [the harm caused by] those who attack it in the way proper to it.[36]

Al-Ghazālī dwells further on this topic, refuting claims of conflicting views on this matter from religious teachings and proposing that the proper

understanding of those teachings did not to contradict scientific methodologies and results:

> If it is said that God's messenger (God's prayers and peace be upon him) said, "The sun and moon are two of God's signs that are eclipsed neither for the death nor the life of anyone; should you witness such [events], then hasten to the remembrance of God and prayer." How, then, does this agree with what [the philosophers] state? We say: there is nothing in this that contradicts what they have stated since there is nothing in it except the denial of the occurrence of the eclipse for the death or life of anyone and the command to pray when it occurs. Why should it be so remote for the religious law that commands prayer at noon and sunset to command as recommendable prayer at the occurrence of an eclipse?[37]

Clearly, the above examples, which we have presented here at length, reflect al-Ghazālī's positive impression of exact scientific methods and calculations that are not and should never be in conflict with the proper understanding of religious teachings. I hope this will partly refute the infamous claims spread in the West that al-Ghazālī was against science and that he was one important reason for the decline of scientific pursuit in the Islamic world.

Summary Conclusions

In this chapter, I have highlighted the opinions of al-Ghazālī and Ibn Rushd on two problems of the physical sciences: one was the question of the size of the universe and whether it was possible to have been created larger or smaller than it is; the other was the question of whether the Sun might become corrupted over long periods of time. Al-Ghazālī presented arguments which may be summarized by saying that there is no reason why it should not be possible for the universe to have been created smaller or larger in size. It is true that al-Ghazālī brought this question under the auspices of God's ability; however, his main intention was not to question God's ability, but to question the status of the space beyond the world, if any. He actually intended to confuse the philosophers on this question, as they claimed that their approach satisfied the omnipotence of God. For this reason, we find that Ibn Rushd confirmed the philosophers' belief, from the perspective of God's ability to do whatever he wishes within the canonical framework of creation. Al-Ghazālī, it seemed, was aware of such an attitude and for this reason he took the question further to puzzle the philosophers on the question of the designations of the *after* and the *before*. Obviously, al-Ghazālī had no knowledge about the expansion of the universe, nor had he conjectured such an expansion, and for this reason the question that followed in connection with this argument was related to the recognition of a temporal succession of events marking a beginning for time, a point with

which al-Ghazālī wanted to refute the eternity of the world claimed by the philosophers. As far as I know, this problem and the argumentation presented by al-Ghazālī have not yet been studied, and, as is shown in the related arguments and the concluded views here, it does have a sound value in modern cosmology even though al-Ghazālī might not have intended to claim such a target.

The second problem was the question concerning the post-eternity of the world, for which al-Ghazālī took the example of the post-eternity of the Sun. He posed the question of whether the Sun suffers any corruption over time, a point which was pivotal in Greek philosophy. This question was directly related to the classification of the world into corruptible and non-corruptible parts, since it was known that Aristotle had classified the heavenly bodies as being non-corruptible, therefore raising this point was of high importance for al-Ghazālī in order to demolish that classification. In fact, some Muslim theologians and well-known *mutakallimūn* have always suggested that the heavenly bodies are of a different composition from Earth.

Al-Bāqillānī, one of the prominent Ashʿaris and the grand mentor of al-Ghazālī, clearly rejected the notion of ethereal celestial bodies:

> As for those saying that celestial bodies are of a fifth nature, not fire nor earth, air nor water, [I would say that] this is flawed and has no proof.[38]

Moreover, we see that al-Bāqillānī, who rejected the notion of the four basic elements and their intrinsic natures, also rejected astrology on a rational basis and denied any effect of the celestial bodies on Earth and its constituents. We find him in his *Kitāb al-tamhīd al-awāʾil* saying:

> If someone were to say, "why do you deny that the maker of this world and His performer, ruler [. . .] could have been the seven spheres that are the Sun, Moon, Saturn, Mars, Jupiter, Venus and Mercury?", we would say: "we deny that because we know that these stars are created and they are following the course of other objects in the world since it has similar constraints of limits, finiteness, composition, motion, rest and change from one state into another which applies to all other bodies of the world. Thus if it were to be eternal all other objects should be eternal too".[39]

In other places in his discussion of the effects of celestial bodies, al-Bāqillānī tried to refute any claim for astrological effects emerging as a generative effect on the basis that all celestial bodies are of the same quality:

> If it would be acceptable for these effects to be generated then the Sun should generate the same effects as those generated by the Moon and solid rocks should generate the same effects as generated by those celestial spheres, since they are all of the same quality.[40]

Here, again, we find that *mutakallimūn* have presented an advanced view of the world, making the point that the world is one and the same in respect of the basic constituents and in respect of the laws that are in action. The reason why the *mutakallimūn* refused to attribute actions to inanimate matter is the requirement that such actions can only be generated by the presence of a will and reason. They denied that inanimate matter could have any kind of will or reason.

Ibn Rushd discussed the arguments put forward by al-Ghazālī regarding the size of the universe and the corruption of the Sun and tried to show that these arguments were faulty. Obviously, Ibn Rushd relied completely on Aristotelian views and syllogism. He tried in vain, as far as I can see, to convince his readers that the arguments of al-Ghazālī were not valid, since his thinking went outside of the Aristotelian framework. This might be true and might have convinced a limited circle of thinkers, but not those outside it, and surely not the contemporary scientists and philosophers. The views presented by Ibn Rushd concerning these two problems would have been acceptable within the context of pre-Galilean physics, but certainly not in astrophysics and modern cosmology.