CHAPTER FIVE

Space, Time, and *Kalām*

The time is originated and created, and before it there was no time at all.

al-Ghazālī

In their views on space and time, Muslim philosophers such as al-Fārābī, Ibn Sīnā, and Ibn Rushd almost followed the Greek philosophers, mainly Plato, Aristotle, and Plotinus. The *mutakallimūn* followed another approach; they constructed their views mainly from the Qur'an, the prime source of Islam. The *kalām* views were different from those of the philosophers in some fundamental aspects. The *mutakallimūn* presented their views about space and time when discussing a number of fundamental issues in religion and natural philosophy, most important of which was the problem of creation. They encountered the concepts of space and time when discussing this problem, and the problem of motion. Most of the *mutakallimūn* considered time to be discrete, composed of non-divisible units called (*ān*), meaning an "instant". In conformity with their atomic theory, the *mutakallimūn* viewed the motion of a particle as composed of finite (discrete) transitions over a trajectory separated by stationary points. This concept was fundamentally different from the conventional Aristotelian concept in which motion was described as the transition from one place to another during a given duration of time.

The interesting point to note is that the *mutakallimūn* described space and time as being an integrated entity that is manifested in the occurrence of the event; moreover, they considered both space and time to be described on relative scales, as they are always to be addressed in comparison with other references, refusing the notion of absolute space and absolute time.

In this chapter, besides describing the views of the *mutakallimūn* about space and time, and, inevitably, motion, I will consider the views of two of the great traditional scholars of Islam, who did not formally subscribe to the schools of *kalām,* but who nonetheless frequently espoused some of the doctrines of *kalām* in their arguments, despite having different views about certain other matters. They are Ibn Ḥazm al-Ẓāhirī and Abū Ḥāmid al-Ghazālī. I have chosen these two thinkers because they represent perhaps the highest level of traditional Muslim intelligentsia and they had expressed *kalām* theories in a theological context as well as theological concepts within the framework of *kalām*.

Ibn Ḥazm (d. 1064), who was born and lived in Córdoba (Spain), expressed most of his philosophical views in his famous book *Kitāb al-fiṣal fī al-milal wa al-ahwāʾ wa al-niḥal*, in which he discussed the philosophical thoughts and views of many religious groups and factions. Primarily, he stressed the importance of sense perception, asserting that human reason can be flawed. This might be contrary to the doctrine of al-Ghazālī. While recognizing the importance of reason, and acknowledging that the Qur'an encourages rational reflection, he believed that this reflection is concerned mainly with revelation and sense data. So, it is a form of sensory reminder to admire the glory of God. Accordingly, he concluded that reason is not to be taken necessarily as a faculty for independent research or discovery, but that sense perception should be used in its place, an idea that sounds like a forerunner for empiricism. Although Ibn Ḥazm did not subscribe to any of the *kalām* schools, despite his critique of the Muʿtazila and Ashʿaris, it is not difficult to see that he used some of their thoughts in his arguments. This obviously stems from having a common base with those arguments, which were, of course, based on Islam.

On the other hand, Al-Ghazālī (d. 1111), the most famous Muslim intellectual and thinker, lived and taught in Baghdad at the Nizāmiyya School during the last two decades of the eleventh century. Al-Ghazālī, too, did not officially subscribe to any of the two main schools of *kalām*, but he certainly used their arguments in his book *Tahāfut al-falāsifa* (*The Incoherence of the Philosophers*). In his arguments, he used the concepts of *kalām* extensively and added much elaboration and ingenuity to those concepts, which were then used in *kalām*. Al-Ghazālī shared some of his views with Ibn Ḥazm and sometimes used the same arguments for the problem under discussion.

In this chapter, I will present the views of both scholars, revealing their most important ideas in an attempt to demonstrate an important part of the Islamic view of space and time. I do not intend to set the discussion in a historical context, nor will I present a history of thought on the concepts of space and time, but I will rather concentrate on presenting the ideas and views of these two Muslim thinkers in the context of *kalām*. However, whenever necessary, I will also discuss the thoughts of other theologians or philosophers in order to briefly cover the basic thinking. In order to provide a full coverage of the concepts and thoughts to date, I will also present the views of the two main theories of the twentieth century, namely Einstein's relativity and quantum mechanics. These are presented as references for comparison and to assess the richness of traditional Muslim scholarship, which I leave the reader to appreciate.

Earlier Views

The earliest of the theological views on time in the West was presented by St. Augustine (d. 430), who was born and lived in what is now Algeria. He expressed his views about time in two works: *The City of God* and *The Confessions*. In these, he presented his arguments about time and eternity and discussed the question of the presence of time before the creation of the universe.

It is very elegant how St. Augustine described the experience we all have about the passage of time, through which he presented his views about eternity. He pointed to the fact that there is a difference between eternity and the presence of time as measures for the rate of passing events. Whereas the extension of time from past to present and the future is something that we appreciate consciously through the occurrence of events, eternity is a fixed moment that contains all the past, the present, and the future:

> Who shall hold it and fix it so that it may come to rest for a little; and then, by degrees, glimpse the glory of that eternity which abides forever; and then, comparing eternity with the temporal process in which nothing abides, they may see that they are incommensurable? They would see that a long time does not become long, except from the many separate events that occur in its passage, which cannot be simultaneous. In the Eternal, on the other hand, nothing passes away, but the whole is simultaneously present. But no temporal process is wholly simultaneous. Therefore, let it see that all time past is forced to move on by the incoming future; that all the future follows from the past; and that all, past and future, is created and issues out of that which is forever present.[1]

By this argument, Augustine has set out the divine presence as being what we call in our modern terminology a space-like state. This is something that I find fascinating indeed. After this, Augustine answered the question: what was God doing before he created the earth and the heavens? His answer was that before creating them there was no time:

> For thou madest that very time itself, and periods could not pass by before thou madest the whole temporal procession. But if there was no time *before* heaven and earth, how, then, can it be asked, "What wast thou doing then?" For there was no "then" when there was no time.[2]

Again, that there was no *real* time[3] before the creation of the universe is indeed the answer that we get from theories in modern cosmology. Augustine then argued:

> Yet I say with confidence that I know that if nothing passed away, there would be no past time; and if nothing were still coming, there would be no future time; and if there were nothing at all, there would be no present time. But, then, how is it that there are the two times, past and future, when even the past is now no longer and the future is now not yet? But if the present were always present, and did not pass into past time, it obviously would not be time but eternity.[4]

Here again, in the last sentence of the above paragraph, Augustine tells us that eternity is a *still* moment that never moves. Eternity is not an infinite extension of time. Eternity is the complete absence of time. We will see later how al-Ghazālī continued this discussion with his elegant style of argumentation. Using the analogy of space and time and the interplay between the *before* and the *after* in analogy with the *above* and the *below*, exchanging space and time dimensions, he successfully challenged the presence of time before creation.

Space and Time According to Aristotle

Aristotle rejected the existence of the void and could not accept the visualization of empty space as an extension without any material content. He identified space as being the envelope which surrounds a body. Without bodies there could be no space. A simple void (vacuum) does not exist. All places are somehow filled, if with nothing other than a hypothetical medium called ether. The celestial spheres in which the Sun, Moon, and the planets are supposed to reside are composed of this hypothetical element. It should be noted here that Aristotle's concept of space is highly local, which is very much associated with the existence of bodies. In this view, the existence of bodies is essential to the existence of space.

John Philoponus (d. 570) criticized Aristotle's concept of space by arguing that, if the place of the stone is to be the adjacent boundary, then a stone held in a current of water would change its place continuously, since the water which envelops it is changing, a result which is self-contradictory. Consequently, Philoponus considered the stone's place to be the inner surface of the first immobile body, in this case the riverbed. That is to say, Philoponus considered the riverbed as a frame of reference for defining the position of the stone.

Aristotle's concept of time is different from his concept of motion, since motion is many and varied, whereas time is always one; nevertheless, time is inseparably connected with motion. He wrote: "It is evident, then, that time is neither movement nor independent of movement".[5] The motion of a body in Aristotle's philosophy is considered to be continuous in accordance with his view of the infinite divisibility of bodies.

The concepts of *before* and *after* are related primarily to place, but these concepts can also be applied to motion. Thus, since time is intimately connected to motion, the concepts of *before* and *after* also apply to time. This led to Aristotle's definition of time as a "number of motion in respect of before and after".[6] To put it differently, time is a sort of counter of motion. Although motion is a continuous process, because magnitudes are continuous one can still distinguish a series of phases in the process, which one can identify as a series of "nows". ("Now" is the moment that links the past with the future.) Since motion is continuous, the division of motion into a series of nows represents the arbitrary division of an infinitely divisible process. Time is that by which change is measured, and there can be no measure without the enumeration of the units of the process of change. Time is also the measure of rest, because what is at rest can be moved. Aristotle points out that, in one sense, there is not a series of nows, but one "now" that is associated with different events and that produces the experience of before and after: it is as if the nows were a substratum that takes on different properties as it becomes associated with different events in the process of motion. He said:

> Hence in these also the "now" as substratum remains the same (for it is what is before and after in movement), but what is predicated of it is different; for it is in so far as the "before and after" is numerable that we get the "now".[7]

It is clear that time is secondary to change or motion and presupposes the occurrence of change; there can be no time without change. He describes the present as the extremity of past and future, the indivisible, shared limit of both.

Many Muslim philosophers and scientists of the Islamic era shared the views of Aristotle about space, time, and motion. Most famous of those were Ibn Sīnā and Ibn Rushd.

Space and Time in Physics

In this section, I will present the concepts of space and time in theories of classical and modern physics, specifically the Newtonian and the Einsteinian concepts. I find this presentation relevant for what will follow later, where I will consider the concepts of space and time according to the *mutakallimūn*, as expressed by Ibn Ḥazm and al-Ghazālī. Of course, we will find that some of the views share common concepts or presentations.

Space and Time in Newtonian Physics

Newton considered space as an extension that is available to contain objects, and accordingly he understood it as an absolute space that is available everywhere in an infinitely extended universe. In the *Principia* we read:

> Absolute space in its own nature, without relation to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute space; which is commonly taken for immovable space; such is the dimension of a subterraneous, an aerial or celestial space, determined by its position in respect to the earth. Absolute and relative spaces are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the air passes; at another time it will be another part of the same, and so, absolutely understood, it will be continually changed.[8]

This new concept of space replaced the Aristotelian concept associated with the boundaries of bodies. In the Newtonian concept, space exists without the need for bodies, thus is absolute in character, not by being infinitely extended, but by being independent of anything else. No doubt that the works and ideas of Galileo Galilei and René Descartes influenced Newton in one way or another. Newton identified relative spaces by the bodies that are present in the absolute space. But, contrary to the Cartesian concepts of infinite extension, Newton used the concept of "mass-point" to allocate the body. This concept, which is used in present-day textbooks, marks the gap that separates Newton's concept of mass from Descartes' concept of spatial extension.

Absolute space is an epistemological (logical) and ontological necessity to Newton; it is a necessary prerequisite for the first law of motion. Rectilinear uniform motion has to be measured with reference to a fixed coordinate system; the state of rest also presupposes such an absolute space. In his *Principia*, Newton made it clear that absolute motion is a translation from one absolute place into another, and relative motion is the translation from one relative place into another.

Max Jammer noted that Newton, being motivated by his mathematical realism, endowed his concept of absolute space with an independent ontological existence:

> For Newton the introduction of the concept of absolute space into his system of physics did not result from methodological necessity only. Newton was led by his mathematical realism to endow this concept, as yet merely a mathematical structure, with independent ontological existence.[9]

This is an important point in considering the question of mathematical realism, where we sometimes see arguments that respect mathematical structures as having realistic existence. This is what happens nowadays with string theory, a point I briefly discussed in previous chapters.

Newton also introduced the concept of absolute time. In the *Principia*, we read:

> Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration: relative, apparent and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time.[10]

Clearly Newton considered time to be absolute, that is, independent of the existence of bodies or motion. Rather, time is an entity by which we measure durations or intervals with respect to which we measure motion. This was a practical and concise understanding which enabled Newton and all physicists that followed him to shape the laws of physics and the time development of physical systems in measurable quantitative forms.

This understanding of time is very practical, but it does not delve into the deeper meaning of time; therefore, it has little philosophical yield.

Space and Time in the Theory of Relativity

The theory of special relativity, which was proposed by Albert Einstein in 1905, suggested that space and time should be considered as one complex entity by which we can define an event. Instead of dealing with three-dimensional space, or viewing events as occuring in places defined by three coordinates, Einstein added a fourth coordinate to represent time. In order to harmonize this new coordinate with the three-space coordinate, Einstein assumed that the velocity of light in vacuum is a universal constant independent of the state of motion of the observer or the source. Accordingly, spacetime was viewed as being defined by four dimensions, three for space coordinates and one for time. The theory defined the "spacetime interval" as the distance between any two points in this four-dimensional spacetime. This distance was found to be invariant with respect to all inertial observers (coordinate systems). In this visualization, physical quantities should be articulated in terms of four components belonging to more general entities expressed in the four-dimensional spacetime. Consequently, the laws of physics should be expressed in a form that is invariant with respect to all inertial observers. This would preserve the unity of physics at every point in the four-dimensional spacetime.

The theory of special relativity abandoned the notion of absolute space and absolute time and considered all inertial observers to be equivalent. Measurements of spatial separations and temporal intervals became observer-dependent quantities, but always preserved the overall spacetime interval invariant. Consequently, a temporal interval with respect to a given observer might be longer than that measured by another observer, but then the spatial interval as measured by the observer has to be shorter so that the sum of the spatial and temporal intervals is constant and invariant with respect to all inertial observers. This implied the relativity of space and time and resulted in a new definition of simultaneity in the universe. Events which occur simultaneously with respect to one observer might be non-simultaneous with respect to another observer. This was expected to have an impact on the conception of causality, and indeed it did.[11]

Apart from explaining many experiments and phenomena, this new vision of the space and time provided us with a new physics in a relativistic framework. Relativity theory made serious predictions which have had a great impact on our lives, most important of which, perhaps, was the discovery of the equivalence of mass and energy. In short, mass was found to be a sort of compressed energy, therefore mass can be converted into energy, and this is what we now enjoy as electricity produced from nuclear plants.

In the theory of general relativity, the concept of spacetime preserves its original character of being relative, but in this case takes on the new character of being curved. The curvature of spacetime exhibits itself in the force of gravity; masses of bodies create curved spacetime according to which masses move. As John Wheeler put it, "mass tells spacetime how to curve and spacetime tells mass how to move".[12] The curvature of time is manifested by a time dilation so that, when light passes through a medium in which time is dilated, its wavelength gets longer and we say that light is "redshifted". This is the gravitational redshift that takes place near very massive compact celestial objects, such as white dwarfs and neutron stars.

As for the question of the finiteness of the universe and the existence of a space or time beyond the universe, the theory of general relativity stipulates that there can be no space or time beyond the universe, since the universe occupies all space and time. Using the language of mathematics, we say that the spacetime manifold is itself the whole universe. The observed universe is described by the theory of general relativity as a three-dimensional surface embodied in a four-dimensional spacetime. The three-dimensional surface is the three-dimensional space that we are living in. It is called a "surface", rather than a volume, because it is envisioned geometrically as a cross-section of the four-dimensional spacetime. At any moment, this cross-section constitutes a three-dimensional surface (hypersurface). The universe, therefore, has no center; any point on this hypersurface can be considered a center.

The spacetime in the theory of relativity is bound by the light barrier, which constitutes the physical boundaries of our time-like world in which events are deemed to be causally connected. Beyond this region of spacetime, we have a space-like region in which events are non-causally connected. This has been shown by the Minkowski diagram, which was discussed in some detail in Chapter Three.

Despite not giving details about the nature of time itself, the theory of relativity, through its description of space and time as an interwoven entity and with the speed of light being the "signature" of spacetime, has partly uncovered the nature of time. As it passes, space light follows curved lines called "spacetime geodesics". These geodesics mark the topology (the shape) of the spacetime. When light rays curve spatially, this indicates that the spacetime is curved spatially and, once light is redshifted, it means that time is becoming warped. This is the beautiful connection between space, time, and light. At the event horizon of a black hole, light is bent so drastically that it is forced to have a circular orbit around the singularity which is at the center of the black hole. The space curves so much that it becomes a spherical top. Time becomes so warped at the event horizon that light is frozen. Since the passage of time defines the past and the future through a moving moment—the "now"—frozen time stands as a still moment, at which point all pasts and all futures are in congruence. This is what I would call the "divine moment", which St. Augustine tried to express in his definition of eternity. It is something beyond our time-like comprehension. It is the same moment through which, while writing these words, I believe that I have deeply shared in the inner feelings of St. Augustine as he wrote his words describing eternity. This is a great moment for human consciousness indeed, by which we can appreciate the value of this consciousness that goes beyond spacetime and light to ride on the inner light of our souls and surf through eternity.

It is this perspective which gives us the imagination to envisage a pathway to our destiny. A giant black hole is the most expected destiny of a closed universe, and a closed universe is the destiny for our universe according to the Qur'an.

> The Day when We shall roll up the heavens as a recorder rolleth up a written scroll. As We began the first creation, We shall repeat it. (It is) a promise (binding) upon Us. Lo! We are to perform it. (21:104)

Therefore, it might be sound to think, as a Muslim, that the day after the "rolling up" of the heavens might be understood in terms of the world passing through the inner region of a black hole. Incidentally, all black holes that exist in our present universe are connected through their identical singularities. All our souls in the form of projected holographic presentation will rotate one day around a black hole and finally return to the giant black hole. This will take our souls with all the information contained therein, including all of our past time-like curves, to live the "divine moment", meeting Allah:

> And guard yourselves against a day in which ye will be brought back to Allah. Then every soul will be paid in full that which it hath earned, and they will not be wronged. (2:281)

What I say above might sound like unscientific speculations, but surely they are simply reflections of what the holy scriptures of all the monotheistic religions stipulate, but put into a scientific context? Nobody can claim with any certainty what will happen, but, given the well-organized structure and delicate formation of this universe we are living in, it would be reasonable to talk about a purpose and destiny for such a highly talented creature as the human being. It just cannot be true to say that this universe is purposeless. For that would mean that all space, all time, and therefore all of our science and whatever we know about the universe, are nothing but meaningless illusions. Would such a tragic result be acceptable to Steve Weinberg and Richard Dawkins, and to those who share in their views?

Space and Time in Quantum Mechanics

Quantum theory was originally developed as a theory of matter and energy. Space and time had nothing to do with matter, and energy content was taken as it is in the Newtonian sense. However, as quantum mechanics was further developed, it was inevitable to consider space and time. Physical systems such as particles and so forth, represented now as mathematical functions of space and time, would need a well-defined space and a well-defined time coordinate system to be an arena in which these functions could play out. The Newtonian concept of space and time remains suitable for such a role, but soon it was found that the position of a particle in space is closely connected with its momentum and that time is closely connected with its energy through the different representations of the wave function in different spaces. Moreover, it was found that such relations are bound by a minimum uncertainty imposed on the product of complementary variables, such as momentum and position, time and energy. The concepts of space and time became more complicated once quantum mechanics was presented with the more accurate form of "operators". Energy and momentum are represented as mathematical differential operators, while space and time have preserved their status as parameters that are necessary to describe the physical system in the form of wave functions or the more abstract form of "state vectors".

In quantum mechanics, space and time have a different role from the one they play in classical mechanics. The basic difference between the two is that, whereas in classical mechanics space and time provide the background for the physical arena in which events are taking place and absolute physical values are being measured, in quantum mechanics the wave functions describe the states of the particles and space and time take a more modest role. Alternative spaces such as the "phase space" are good replacements for the formal space. It should also be remembered that space and time are independent of each other in non-relativistic quantum mechanics.

In relativistic quantum mechanics, space and time are diffused according to the requirements of the theory of special relativity. However, no fully general relativistic quantum formulation is available till now. Once it becomes available, this could provide us with a theory of quantum gravity. This theory would seem to require quantization of space and time, a requirement which is far from being tenable within the present formulations. Some physicists talk about "spacetime foam" near the Planck scale, which is a very minute scale of space and time by which the unit of distance is 10^{-33} cm and a unit of time is 10^{-44} seconds, but most agree that intervals or durations cannot be infinitely subdivided. At this level, spacetime becomes a parameter defining an entity which characterizes the behavior of other parameters in the universe in such a way as to share their effect instead of only being occupied by it.

In more speculative theories such as string and superstring theories, we encounter other dimensions beyond the four known spacetime dimensions. These presentations are mostly mathematical and are hard to be realized on a common-sense level, as such extra dimensions are said to be compact. However, no one can deny that many formulations which were at first thought to be mathematical in nature gained their physical realization later through actual applications and interpretation of natural phenomena. Likewise, we might become accustomed to dealing with some of the mathematical presentations of string and superstring theories one day, as they become more familiar concepts.

Space and Time According to Islamic *Kalām*

Perhaps the best definition of space according to Islamic *kalām* is the one given by al-Jurjānī: "the conceived empty place which is occupied by the body and in which its dimensions are extended".[13] This implies that space is an envisaged place that does not get its ontology except by being occupied with a body. This is a subtle concept indeed, since it might be understood to mean that space cannot exist unless a body is occupying it. To clarify this position, we need to explain another term which is directly related to the concept of space: "occupancy" (*taḥayyuz*). This means, according to al-Juwaynī, one of the fathers of the late Ashᶜari school, "the place for an envisaged *jawhar* [the indivisible part: the atom]".[14] In this respect, we should remember that, according to most of the *mutakallimūn*, the *jawhar* (see Chapter One) has no size or area. However, as for the other concept of empty space (*khalāʾ*) the *mutakallimūn* considered it to mean "the space which is left behind when the occupying body is removed".[15] So, empty space should exist; without it no motion could be achieved. Ibn Mattawayh, a famous Muᶜtazili, presented an argument in favor of the existence of *khalāʾ*.[16] These concepts were commonly understood by Ashᶜaris and Muᶜtazila, although they had different views on some of the finer details.

The concepts of space and time in Islamic *kalām* are very much connected with the principle of discreteness (atomism) and the principle of re-creation, which was developed by the *mutakallimūn* to apply to all discrete properties.

Space, as well as time, was conceived as being discrete. Al-Jurjānī defines time as "a known renewable by which an envisaged unknown is estimated".[17] Clearly, in this definition, we can spot two features given to time: the first is intrinsic, being renewable, and the second is functional, by which we connect two events. Perhaps one might say that the second feature makes this definition of time include simultaneity, since the adjunction of two events requires defining two times, thus involving simultaneity.

The discreteness of space is another subtle concept, which might not be as clear as in the case of time. However, this discreteness might be clarified first by pointing to the way in which the *mutakallimūn* added two or more *jawhar*s together. In this case, they denied that two *jawhar*s might be diffused into one another, but insisted that they can only touch each other (*tamās*). When two *jawhar*s are attached to each other, a line is formed; to make a two-dimensional surface we would need four *jawhar*s, and to make a three-dimensional volume we would need eight. This describes the fundamental construction of an extension in space according to *kalām*. This exposes an abstract understanding of the basic elements that constitute matter, for example. In this respect, Max Jammer raised the question of whether it was sheer coincidence for Leibniz to suggest monadology, in which he sketched the metaphysics of simple substances, or "monads". Jammer presents an argument pointing to the possibility that Leibniz may have adopted the atomic theory of *kalām*. On the other hand, he says that "consequential thought led the *kalām* to the conclusion that space as well as matter (and time), is of atomistic structure".[18]

Related to the concepts of space and time, we naturally come to the concept of motion. Since space and time were taken to be discrete according to *kalām*, motion becomes a discontinuous process. Motion is viewed as a series or a sequence of momentary leaps; the *jawhar*s occupy different individual places in succession, thus physical motion has to be discontinuous.

Jammer presented a beautiful argument affirming the discreteness of space according to *kalām*, which goes as follows:

> The discrete structure of space according to the theory of kalām, can be inferred from the two premises (1) of the discreteness of time (the third fundamental proposition of kalām, according to the enumeration of Maimonides); (2) of the Aristotelian inference from the continuity of space to that of motion, and from the continuity of motion to that of time. Since the consequent, according to the first premise, is denied, the formal application of the *modus tollens* leads to the conclusion that space is not continuous.[19]

However, the *kalām* theory of motion leads to many complications. First, it would suggest a new concept of velocity by which the faster body is not that which covers larger distances during equal time intervals, but it is that trajectory on which there are fewer moments of rest (*sukūn*). This means that there is one universal speed, but a different number of still points for different trajectories of motion. In a modern description of such a concept, I would say that the *kalām* description of motion resembles the motion as depicted by a digital stream of sequential frames viewed on a cine projector at one speed; a fast object is seen on only a few frames, whereas a slow object would appear on many frames. This *kalām* conception of motion was challenged with the question of the revolving millstone, an example which was put forward by opponents of discreteness. In the words of Maimonides:

> Have you observed a complete revolution of a millstone? Each point in the extreme circumference of the stone describes a large circle in the same time in which a point near the center describes a small circle; the velocity of the outer circle is therefore greater than that of the inner circle. You cannot say that the motion of the latter is interrupted by more moments of rest; for the whole moving body, i.e., the millstone is one coherent body. They [*mutakallimūn*] reply: during the circular motion, the parts of the stone separate from each other, and the moments of rests interrupting the motion of the portions nearer to the center are more than those which interrupt the outer portions.[20]

Maimonides commented further by saying:

> [W]e ask again; how is it that the millstone, which we perceive as one body and which cannot be easily broken even with a hammer, resolves into its atoms when it moves, and becomes once again one coherent body, returning to its previous state as soon as it comes to rest, while no one is able to notice the breaking up of the stone?[21]

We now know that the above argument used by Maimonides was not valid, since, in theory, we can dismantle the millstone into individual parts and consider the motion of each part separately, as we always do in analytical mechanics. As it is clear from the *kalām* description of motion, the speed of the body is trajectory dependent. The more important question is how we can justify the motion of two particles of the same mass on the same trajectory with different speeds. How can a slower particle be at more stationary points than a faster one? Thus, one would think, it is not the trajectory that defines the speed but something else, a problem that is left for further research.[22] Incidentally, as was noted by Landau and Lifshitz,[23] the concept of instant velocity in quantum mechanics is quite obscure. This is because instant velocity is obtained as the first derivative of the distance with respect to time, and this implies the assumption that the duration of time Δt goes to zero. But, according to Heisenberg's uncertainty principle, the energy of the system will then be completely undetermined, a situation which makes the concept of instant velocity in quantum mechanics obscure.

Jammer claims that Galileo's discussion of the problem of discrete motion in his *Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze* (*Discourses and Mathematical Demonstrations Relating to Two New Sciences*), and his treatment of the "infinite and the indivisible", is "reminiscent of the ancient teachings of the *kalām*".[24] Apart from this, very little is known about the influence of the *kalām* conception of space and time on scholastic thought in medieval Europe. But, since it is well established that the works of al-Ghazālī and Maimonides, with their references to the atomistic space theories of *kalām*, were widely read by scholars, Jammer seriously questions the possibility that this atomistic theory of space could have escaped their attention.[25] This is a very important question indeed, taking into consideration the influence of discreteness on Leibniz, which was mentioned above, and the influence on Galileo, also mentioned above. But, to resolve this question, we would need to invest a great deal of impartial effort into analyzing this scholastic legacy. Perhaps this is part of the homework that modern Muslim scholars specializing in the history of science could do.

Space and time are two entities that are essential for our understanding of our physical world. Space seems to be more real than time, as it is objectively present; it is part of what we see around us. Time is not so tangible to our senses, as it seems to be less objectively present. Events need to occur for us to feel the presence of time and our world cannot endure two instances without something changing. It was thought that time exists like a river running independent of any concern for those at its banks; it can only be affected by the topography of the land through which it passes, running quickly as the land slopes and slowly as it climbs a hill. Similarly, time is affected by the topography of space through the mutual play that keeps the path of light intact.

Time seems to have only one direction, regardless of the many mathematical formulae that allow for time reversal. Nature, through the requirements imposed by thermodynamics, prevents time reversal and that is why we have a time arrow. Translation in space can take forward or backward directions; we can retrace back our path as we move, but can never retrace our past time; time reversal is a fiction.

Space and Time According to Ibn Ḥazm

Ibn Ḥazm was born to a rich and influential Córdoban family; he received a distinguished education in religious sciences, literature, and poetry. Profoundly disappointed by his political experiences and offended by the conduct of his contemporaries, Ibn Ḥazm subsequently left public life and devoted his last thirty years to literary activities and produced a reported 400 works, of which only forty still survive. He covered a range of topics, which included Islamic jurisprudence, history, ethics, comparative religion, and theology, as well as producing his famous work, *The Ring of the Dove*, on the art of love. Ibn Ḥazm was a leading proponent and codifier of the Ẓahirī school in Islamic thought. The *Encyclopaedia of Islam* refers to him as having been one of the leading thinkers of the Muslim world and he is widely acknowledged as the father of comparative religious studies.[26]

In his treatise *Kitāb al-fiṣal fī al-milal wa al-ahwāʾ wa al-niḥal* (*al-Fiṣal*) on Islamic science, philosophy, and theology, Ibn Ḥazm stressed the importance of sense perception. While he recognized the importance of reason, since the Qur'an itself invites reflection, he argued that this reflection mainly refers to revelation and sense data, because the principles of reason are themselves derived entirely from sense experience. He concludes that reason is not a faculty for independent inquiry, research, or discovery, but that sense perception should be used in its place, an idea that forms the basis of empiricism.[27] In this argument, perhaps Ibn Ḥazm was criticizing the Greeks, who were known to have stressed the value of reason and mindful works without much need for experimentation. In what follows, I will present Ibn Ḥazm's views on space and time as he has presented them, mainly in *al-Fiṣal*. First of all, we should know that Ibn Ḥazm refused to acknowledge the existence of any physical infinite, including space and time. He tried to refute the infinite extension of time by simple logical arguments. He said: "Everything that exists in reality is confined by number, countable by its own nature, and by [the term] nature we mean the force in the thing by which its properties are run". Then he said: "Everything that is confined by number would be countable by its own nature, therefore it is finite, consequently the world is finite".[28] Accordingly, he refused to accept the existence of anything which has infinite extension:

> An infinite would in no way exist in reality, and whatever might exist but only after an infinite regress could not exist at all, because being "after" necessitates finiteness, and an infinite has no "after". Consequently, nothing can exist after another in infinite regress and, since things do exist one after the other, therefore all things are finite.[29]

So, this is how Ibn Ḥazm thought of the impossibility of infinity. It is this argument by Ibn Ḥazm which makes me think that in fact he was adopting the doctrine of the finite divisibility of things, despite his denial of *kalām* atomism, which was based on his theological argument that Allah is able to divide things infinitely. Otherwise, and as I have found previously, Ibn Ḥazm agreed that a non-divisible part may exist in reality but not in theory.[30]

Ibn Ḥazm defined time as "the duration through which an object stays at rest or in motion, and if the object is to be deprived of this [rest or motion] then that object will cease to exist and time will cease to exist too. Since the object and the time both do exist, therefore they both co-exist".[31]

Clearly, in this definition, Ibn Ḥazm associated the existence of time with the existence of the body, which pointed to the connection between space and time, and then he argued that the time of the world has a finite duration as well as a beginning:

> Any object in the world and every accident associated with an object and every time are all finite and have a beginning. We see this sensibly and objectively because the finiteness of an object is obvious through its size and through the time of its existence.[32]

Therefore objects of the world are finite and in these sentences it is clear that Ibn Ḥazm denied the existence of anything infinite of any sort. But, in the case of time, he went even further to consider time as being composed of finite instances, moments that pass one after the other:

> The finiteness of time happens though what comes after that which has passed, and the exhaustion of every time [period] after its existence, as "now" is the limit of it, and it is this [now] which separates the two times: the past and the future, and it is as such that one time ends and another would start. And every period of time is composed of finite times that have beginnings.[33]

This makes it clear that Ibn Ḥazm considered time to be discrete on the ontological level, despite his general denial of the "indivisible parts". Ibn Ḥazm used these concepts to argue that God existed in neither space nor time:

> Because God is not occupied with time and has no duration or end, because the time is the motion of whatever is timed, its motion from one place to another, or its duration when at rest in one place, and God is neither in motion nor is at rest and [there is] no doubt that He is not timed and has no duration or end, and He is originally not confined to one place.[34]

Consistently, on the same issue in another place, he wrote:

> God is not [confined] to a time and has no duration, because time is the motion of any timely object and its transition from one place to another or the duration of its stay at rest in one place and God neither is movable nor is at rest.[35]

It should be noted from the above quotations that Ibn Ḥazm understood time to run sequentially. He thought that the passage of time occurs in sequential moments, one after the other; as the moment passes, it becomes past. Subsequently, a new moment replaces the old one, and so time passes.

Although Ibn Ḥazm did not seem to accept the principle of discreteness envisaged by the *mutakallimūn*, his sentences above express that time is divided into finite instances, a notion very similar to time discreteness. Indeed, for Ibn Ḥazm to have been consistent in his views about space, time, and the creation of the world, he should certainly have adopted the discreteness and finiteness of parts. Those who claim the contrary should read all the available descriptions and analyze all of his arguments, not only in their expressions but in their consistency, to see that he could not but have adopted discreteness, despite his refusal to accept the notion of a non- divisible part on a theological basis.

Concerning space, it seems that Ibn Ḥazm adopted the Aristotelian view to define space and argue for the absence of voids. In *al-Fiṣal*, he defined space in a similar way to Aristotle: "Because the space that we know is the place surrounding the body localized within".[36] It is also noted that Ibn Ḥazm tried to refute the existence of absolute space (in the Newtonian sense, despite preceding Newton). He referred to a group of people with whom he was engaged in a discussion about space and time, finding them to claim the existence of absolute space and absolute time:

> They say that absolute space and absolute time is not what we have defined previously, because they are changing, and it would suffice to refute their argument of defining an unaccustomed concept of space and an unaccustomed concept of time without having evidence for it.[37]

This absolute space he described as being the void that exists independent of objects or bodies. In order to refute this claim, Ibn Ḥazm used lengthy dialectical arguments, which are not very convincing. A similar discussion was considered by al-Ghazālī, but with more sophisticated arguments.

Space and Time According to al-Ghazālī

Al-Ghazālī was a prominent thinker who produced such a colorful range of thoughts that it is a puzzling task to associate him definitively with any one school of thought, other than to say that he belonged to a special school of his own. He might be considered an Ashᶜari theologian, a philosopher, or a Sufi monk. He expressed a multitude of thoughts in his writings and was experienced in all the possible methodologies of his time.

Al-Ghazālī viewed space and time as being two entities that should be treated on the same footing. His best presentation on this subject can be found in his treatise *Tahāfut al-falāsifa*, where he tried to refute the philosophers' claim about the eternity of the world. Al-Ghazālī presented similar arguments about time to those of St. Augustine, some of which I have mentioned above. However, one can confidently say that, in presenting these arguments, al-Ghazālī was also speaking as a representative of the *mutakallimūn*, since he was using their dialectical method and their concepts about space and time. It would also be fair to say that al-Ghazālī presented these arguments with much originality and thought, for which he deserves the credit. He used an analogy between space and time, the *above* and the *below* versus the *before* and *after*, in order to proclaim an equivalence between spatial and temporal extensions.

Al-Ghazālī considered that time was created alongside the world, and not before it:

> Time is originated and created, and before it there was no time at all. We mean by our statement that God is prior to the world and time, that He was and there was no world and that then He was and with Him was the world.[38]

In response to the question about the time that had passed before the creation of the world, al-Ghazālī replied by presenting an analogy of space, where we are not accustomed to accepting that there is nothing above our heads. But, he said, when we talk about the world as a whole, we should realize that there is nothing beyond the surface of the world:

> Similarly, it will be said that just as spatial extension[39] is a concomitant of body; temporal extension[40] is a concomitant of motion. And just as the proof for the finitude of the dimensions of the body prohibits affirming a spatial dimension

> beyond it, the proof for the finitude of motion at both ends prohibits affirming a temporal extension before it, even though the estimation clings to its imagining it and its supposing it, not desisting from [this]. 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).[41]

The most important piece of information in the above quotation is the reference made by al-Ghazālī to the term "temporal extension" alongside the term "spatial extension". This was something new for the intellectual era in which al-Ghazālī lived and indeed it does reflect a deep understanding of the meaning of space and time in our real world, and the reason for their absence before the creation of the world.

Al-Ghazālī continued arguing on the relativity of the "before" and the "after", responding to criticism that may be directed against his analogy of time with space, where it could be said that space and time cannot be treated on an equal footing:

> This comparison is contorted because the world has neither an "above" nor a "below," being, rather, spherical, and the sphere has neither an "above" nor a "below". Rather, if a direction is called "above" this is inasmuch as it is beyond your head; the other [direction is called] "below" insofar as it extends beyond your foot.[42]

But then al-Ghazālī retaliated by saying:

> This makes no difference. There is no [particular] object in assigning the utterance "above" and "below," but we will shift to the expressions "beyond" and "outside" and say, "The world has an inside and an outside: is there, then, outside the world something which is either filled or empty space?" [The philosophers] will then say, "Beyond the world there is neither a void nor filled space. If by 'outside' you mean its outermost surface, then it would have an outside; but if you mean something else, then it has no outside." 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."[43]

Al-Ghazālī continued his discussion on this issue, presenting and defending persistently his concepts of space and time. The discussion led him to question the size of the universe and whether it could have been created larger or smaller than its known size. This is a challenge that I will discuss in the next chapter.

Therefore, I may conclude that al-Ghazālī, adopting the basic views of *kalām*, considered space and time to be on an equal footing and was able to envisage the relationship between them in a way that perceived their relativity in the sense of how it is accounted for by the observer (obviously, not in the Einsteinian sense). Accordingly, he was able to present the reason for there not being an arrow of time before the creation of the world.

Concluding Remarks

Space and time are entities that our consciousness encounters on two levels: one is through direct sensation, which gives us the feeling of being in a place surrounded by things such as walls, furniture, and the environment, including the changes around us. The other level includes the mental comprehensions by which we try to translate the first level into a more meaningful one, by philosophizing to go beyond the trivial sense. The purpose of this, then, is to be able to understand all phenomena which are related to changes in space and time. At this point, we start doing physics. For this reason, our view of space is a fundamental milestone in understanding the world. The history of knowledge has persistently proved this throughout the different ages of philosophical thinking.

The description of motion in *kalām* resembles the motion depicted by a digital stream of sequential frames, viewed on a cine projector at one speed: a fast object is seen in only a few frames, whereas a slow object would appear in many frames. If our world is predestined, then we have no choice but to believe in the analogy of the film reel, that our life is nothing but a film. On a film reel, events come in discrete frames and time is defined by the number of frames. Our world, if predestined, should be described as "spacelike". I would not say that it is purely spatial, since, when tracing sequential frames, time is also passing, which is to say that the time dimension is realized through moving from one frame into the next. This may provide us with a clearer understanding of eternity, in confirmation of the accurate description given by St. Augustine. Now, if God knows the future of everything, and if we assume that He enjoys the capabilities that Pierre Laplace assumed a supernatural being to have, then the world would surely be deterministic in the eyes of God. Accordingly, it would be true to say that "God does not play dice", but our consciousness does play dice; it is the way the world appears to us rather than how it really is.

As for our present age, we seem to be on the verge of a new era in our vision of space and time; this vision goes beyond the standard picture provided by relativity theory and the standard theory of quantum mechanics. The new vision will challenge our consciousness as well as our mental capabilities and, in order for such a vision to be fruitful, it has to be realized in actual practice through new discoveries. As such, the new understanding could provide us with explanations for many phenomena that might have been considered until now as being so obscure that they do not belong to our physical world. This new vision comes as a compilation of both the old and modern ideas about space and time, and it will elevate our thinking to a new level through our journey to understand this world.