Islamic Position on Physics with Reference to Ibn al-Haytham

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Abstract

This research contends that the study of the tabi'iyat (physics), in its specific form that we know today, was initially formulated by Muslim scholars. It was the Muslims who engender physics from the Aristotelian general outlines of form and matter. History reveals that Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham was the first scholar to scientifically test the premise of hypothetical questions in research with demonstrable experiments. More than two hundred years later his books were read in Europe. Today he is known in Europe as Alhazen, Alhacen, or Alhazeni. The research at hand is part of explorations of his views on physics.

Keywords: Physics, Muslim Scholars, *Tabi'iyat*, Ibn al-Haytham, Engineering Sciences, Position of Islam, Intellectual Contributions of Muslim Scientists

1. Introduction

In the history of knowledge physics, was known as natural philosophy. Philosophy itself, in fact, is the head of all wisdoms, or as it is called in Arabic "*ra's al-hikmah*". Physics therefore, is the diverse endeavors of thinking mankind in making intelligent comprehension of how things happen in nature, and to discover the causes behind. As physics made various explorations on nature different branches and coherent theoretical structure of it evolved. These branches are broadly divided into two types namely the theoretical physics and experimental physics. Classical mechanics, mathematical physics, classical electrodynamics, quantum mechanics are part of the branches of physics. It is not however the aim of this research to evaluate the development of physics in the general sense of the subject matter.

The objective of this research is to reexamine the position of Islam and Muslim outlook, on one of the oldest academic disciplines but at the same time remains to be a viable scientific and epistemological issue. This is done with rigorous reference to Ibn al-Haytham's explorations on physics. For the last few centuries Muslims seem to be on the defensive in the development of science and technology. This study is a part of the awareness, reexamination, and reassessment on that phenomenon. The research will utilize a library-based evaluative methodology to arrive at comprehensive findings.

The importance of this research lies on the fact that it contributes to revive the debate that Islam and Muslims are the bearers and initiators of science and technology. The data of this research is mainly collected from the available resources in the history of Islamic scientific literature. Physics, one of the oldest academic disciplines, has transformed to significant and influential position in the hierarchy of sciences. Its advancement has translated into new technologies especially associated with electronics and machine developments, etc. The sophisticated contributions of Muslim scientists and the reflection on their intellectual level, despite the limitations in facilities during that era is the focus of this research.

2. Delineations to Physics

Physics can be regarded one of the sciences among the fundamental four, namely, biology, chemistry, mathematics, and of course, physics itself. Though some consider it to be primarily a field that wraps the applications of mathematics, it has evolved into a distinctive field of its own, gaining the attention of many scientist around the world. According to Owadally, there is a natural philosophy in Islamic science known as *tabi'iyat* which includes the life sciences and the earth sciences that is inclusive of physics. (Mohammad Yasin Owadally, 2003) He further asserts that:

> "Muslims classified these as the mathematical sciences. The principles of natural philosophy were in a treatise called *fann al-sama al-tabi'* (section dealing with what is heard concerning natural philosophy) ... Nearly every Muslim philosopher had devoted a section of their writing to physics. In traditional doctrines, physics is an application of metaphysics. The principles of physics are to be found in meta-physics." (Mohammad Yasin Owadally, 2003)

Seyyed Hossein Nasr adds that the study of physics (*tabi'iyat*) in the Islamic world, more than any other science, followed the teachings of Aristotle in its basic outlines. (Seyyed Hossein Nasr, 1984) Most of the problems posed by Muslim philosophers and scientists in this field were set within the frame work of doctrines of form and matter, potentiality and actuality, the four causes, and teleology.

Seyyed Hossein Nasr describes physics in medieval times as a study that includes the study of all things that change, or, in Aristotelian terminology, the study of all things in the world of generation and corruption. (Seyyed Hossein Nasr, 1984) According to him:

> "Many of the new ideas regarding time, space, the nature of matter, light, and other basic elements of medieval physics came, not from the philosophers, who were mostly bound by the ideas of their Greek predecessors, but rather from the theologians, who usually opposed the Peripatetics. In the writings of such theologians as Abu'l-Barakat al-Baghdadi, Fakhr al-Din al-Razi, and Muhammad al-Baqillani, who may be regarded as the "philosopher of Nature" of the dominant Ash'arite school of Sunni theology, one finds doctrines of much interest. The theologians departed from the path of the Peripatetics and became the founders of a distinct world view. Although they were bound as theologians to those problems connected with faith, they were not restricted to the premises of the Perpatetics philosophy, and were therefore among the severest critics of Aristotelian physics, much of which they rejected in favor of a different conception of time, space, and causality." (Seyyed Hossein Nasr, 1984)

In the early stages of engineering sciences, physics was sorted into speculative and experimental contrary to today's approach where the two approaches are converged; the speculative approach was also highly regarded. (Abdi. O. Shuriye, 2004)

This is in line with the opinion of Seyyed Hossein Nasr who claimed that the study of physics among both the philosophers and the theologians were based on ratiocination, and was not dependent upon direct observation. (Seyyed Hossein Nasr, 1984) One should not, however, suggest that experimental techniques were not employed or unavailable. Seyyed Hossein Nasr continued his discussion claiming:

> "There was a third group who did observe and perform experiments, and in that way sought to analyze the meaning of the sensible aspects of Nature. There were among this group, several important students of optices, such as Qutb al-Din al-Shirazi, and the most famous of all Muslim physicists, Alhazen, as well as al-Biruni, who measured the specific weights of minerals, and Abu'l Fath Abd al-Rahman al-Khazini, who also dealt with the measurement of densitities and gravity. This sort of physics, which resembles the works of Archimedes-at least in approach, if not always in techniques and results-is of much interest from the point of view of modern science." (Seyyed Hossein Nasr, 1984)

Islamic physics also included the determination of the specific gravity of certain metals and precious stones, and work on meteorology, on tides, and on such problems of applied mechanics as the following: windmills, and water-wheels (which the Muslims were the first to develop), balances, wells, water clocks, agricultural methods, irrigation, canal and road building, the preparation of iron and steel, methods of working metals, constructing scientific equipments, paper-making, leather work, and silk and cotton cloth manufacture. Brummett describes Muslim physicists as highly creative scientists. (Palmira Brummett, et al., 2003) However, according to Artz, in physics, Muslim's most outstanding achievement is to be noted in optics, where they clearly surpassed their Greek masters. (Frederick B. Artz, 1980)

*3. **Al-haytham's Contribution to Physics***

If there is an individual's name that is synonymous with the history of the development of physics, it has to be Al-Haytham's, let it be in the East, or the West. Al-Haytham's involvement and contribution in the science of physics, particularly in the area of optics, can be described as one of the fullest, from the establishment of the science of optics as a field by itself to the development of theories and having made remarkable contributions towards optics, he is also regarded as the father of modern optics. (Muhammad Sa'ud, 1986) Al-Haytham's work in the field of optics is enormous. Conner and Robertson claim that Al-Haytham's writings are too extensive for anyone to cover, even a reasonable amount. (J. J. O' Conner & E. F. Robertson, 1999) He is believed to have written around 92 works of which, over 55 have survived till this date. (J. J. O' Conner & E.

F. Robertson, 1999) Al-Haytham's interest in optics include light theory as well as the human vision theory – both of which, he had greatly delved into and produced many writings on. Perhaps, his greatest and most important work on optics must have been the *Kitab Al-Manazir* – a seven volume work that has also been translated into Latin and known as *Opticae Thesaurus Alhazeni* in 1270.

The Foundation for Science Technology and Civilization Limited asserts that this Latin translation of his work exerted a great deal of influence upon Western Science, particularly in the works of Roger Bacon and Kepler. (Ibn Al-Haytham, 2002) This is further supported by Muhammad Sa'ud when he wrote:

> "His *Kitab al-Manazir* (the optical theseurus), is one of the leading classics which influenced scientific thought for more than six centuries. The Latin, Muslim and Hebrew writers such as Roger Bacon, John Peckham, Witelo, Ahmad Ibn Idris al-Qarafi, Qutb al-Din al-Shirazi, Levi Ben Gerson based their works on this great book." (Muhammad Saud, 1986)

The *Kitab Al-Manazir* is more of an experimental and mathematical investigation on the properties of light that is related to vision, rather than a philosophical dissertation. (Mohaini Mohamed, 2000) Kamal Al-Din, student of Qutb Al-Din, the prominent Muslim scholar, later revised Al-Haytham's *Kitab Al-Manazir* and wrote the most important commentary of Al-Haytham entitled *Tanqih Al-Manazir* (The Revision of the Optics), and brought the study of optics to its last brilliant period in the Muslim world. (Seyyed Hossein Nasr, 1984)

Before Al-Haitham, there were two intromission theories of vision that were well received by all. The first was Aristotle's mediumistic theory and the second being the atomists' theory of eidola. (David C. Lindberg, 1983) These theories, however, were inadequate in terms of clarification of the communication of the visible qualities of the object in sight, to the eye. According to Lindberg:

> "The common premise of all ancient theories of vision was that there must be some form of contact between the object of vision and the visual organ, for only thus could an object stimulate or influence the visual power and be perceived. Now in general there appeared to be three ways in which contact could be established. The object could send its image or ray through the intervening space to the eye; the eye could send forth a ray or power to the object; or contact could be established through a medium (usually air) that intervened between the object and the eye. (David C. Lindberg, 1983)

The first theory as mentioned by Lindberg was developed by the atomists stated earlier who argued that thin films of atom depart from visible objects in all directions, maintaining a fixed configuration as they proceed, and enter the eye of the observer (intromission). The next theory was actually proposed by Euclid and later, developed by Ptolemy. The radiation issued from the observer's eye, if fallen on an opaque object, enables the object to be perceived by the sensing organ. The third theory mentioned by Lindberg refers to Aristotle's mediumistic theory of vision. Aristotle proposed that the visible object sends its visible qualities through the intervening air (or other transparent medium) to the observer's eye. Colored bodies produced qualitative changes in the transparent medium, and these changes are instantaneously propagated to the transparent humors of the observer's eye. The eye does not receive the visible object, as in atomistic theory, but become the visible object called 'mediumistic'.

In volume one and two of Al-Haytham's *Kitab Al-Manazir,* Al-Haytham reported his findings on the study of light as well as on visual perception respectively with experimental evidences rather than on abstract theory. (J. J. O' Conner & E. F. Robertson, 1999) Al-Haytham made an important contribution to visual theory. He had developed an intromission theory which was capable of explaining the principal facts of visual perception including the physical contact between an object in sight and the observer through intromitted rays - an important discussion that have been often taken for granted by his predecessors. (David C. Lindberg, 1983)

Al-Haytham broke the limitations of the Aristotelian, Galenic and Euclidian theories by simultaneously satisfying mathematical, physical and physiological criteria in his theory. He had developed the intromission theory to a remarkable degree and challenged the theory of Ptolemy and Euclid. (Palmira Brummett, et al., 2003) According to Mohaini Mohamed:

> "The *Optics* of Ibn al-Haytham is the first authoritative work opposing the theory of Euclid, Ptolemy and other ancients that the eye sends out rays of light and impinges on external things to view objects. According to Ibn al-Haytham it is actually the reverse; object is seen because each point of it receives a ray of light and then reflects that ray into the eye." (Mohaini Mohamed, 2000)

This is further supported by Artz:

> "Alhazen (d. 965) of Cairo opposed the theory of Euclid and Ptolemy that the eye sends out visual rays to the object of vision. Rather, the form of the perceived object passes into the eye and is transmuted by its lens. He found the relation between the positions of a source of light and its image formed by a lens." (Frederick B. Artz, 1980)

Al-Haytham's intromission theory incorporated the physical as well as the causal aspects of the communication between the observer and the visible qualities of the object in sight. Lindberg describes it as the 'forms' that emanate form each individual point in the visual field that communicate with the observer through a modification of the medium intervening between them. (David C. Lindberg, 1983) Al-Haytham also emphasizes greatly on the properties of light in his discussion of visual theory. He had combined both mathematical analysis with well-conceived physical models and careful experimentation in his discussions. According to Conner and Robertson:

> "He notes that light is the same irrespective of the source and gives the examples of sunlight, light from a fire, or light reflected from a mirror which are all of the same nature." (J. J. O' Conner & E. F. Robertson, 1999)

Al-Haytham's discussion of light was based on the theory of direct vision. Having confined himself to the definition of light as self-luminous objects, according to Lindberg, Al-Haytham stated that objects are seen by the emission of their own light. (David C. Lindberg, 1983) Therefore, the visible object that we are able to perceive with our naked eye, when illuminated by a light source of any kind, is actually the light of the visible object itself. Lindberg quotes Al-Haytham's words form the *Kitab Al-Manazir* :

> "It has been shown already that the form of color of any colored body, illuminated by any light whatsoever, always accompanies the light emanating from that body to any region opposite the body…Therefore the form of the color of a visible body always accompanies the light coming to the eye from the light of the body. And since light and color come to the surface of the eye simultaneously, the eye perceives the color of the visible object on account of the light coming to it from the object. It is proper, therefore, that the eye should not perceive the color of the visible object except through the form of color accompanying the light to the eye; and the form of color is always mixed with the form of light" (David C. Lindberg, 1983)

According to Al-Haytham, light and color are the primary forces that can be sensed or perceived by the eye without any external support. In line with this, Lindberg states:

> "Light and color, the first of twenty-two visible intensions identified by Al-Hitham, are perceived by sense alone without the support of any process of ratiocination. The remaining twenty visible intensions-including such things as remoteness, position, shape, magnitude, motion, rest and beauty- are perceived visually, but only by the processes of recognition, distinction, and argumentation performed by the virtus distinctiva. Light and color remain the primary visible intentions, and the others are perceived through their mediation." (David C. Lindberg, 1983)

Al-Haytham had investigated on the conditions for the light and color to enter the naked eye of an observer. He discovered that for the light and color of an object to enter the eye, there must be a certain distance between the eyes and the object of sight within the range of the visual field. Also, the object must be either self-luminous of illuminated by an external source.

The medium between the object and the observer also plays a significant role – in order for the light to enter the eyes, the medium must be transparent so that it can travel through it to the eye. The object in sight must be dense and solid and also possess a magnitude. Lindberg describes this magnitude as the lines drawn from extremities of the lens. (David C. Lindberg, 1983) Al-Haytham noted the effects of bright lights on the eye. Lindberg quotes the words of Al-Haytham from the *Kitab Al-Manazir* :

> "when the eye looks into exceedingly bright lights, it suffers greatly because of them and injured. For when an observer looks at the body of the sun, he cannot see it well since his eye suffers pain because of the light." Clearly this implies an action of bright bodies on the eye, for injury is something inflicted by an agent on a recipient and could not, in the case of the eye, result from emission of the eye's own ray … All these things indicate that light produce some effect in the eye." (David C. Lindberg, 1983)

Al-Haytham's great interest in the study of optics let him to the discovery of the principle of *camera obscura*, a theory, which is also known as point-aperture. He is believed to be the first scholar who had correctly analyzed the principle behind the mechanism of *camera obscura* mathematically. (Seyyed Hossein Nasr, 1984) He claimed that the size of the aperture plays a significant role in the casting of the image that is similar to the source itself.

Al-Haytham also discovered that the image produced by the *camera obscura* is a composite - that is, it is formed by the superimposition of numerous overlapping images cast by points of the source. (David C. Lindberg, 1983) Al-Haytham concluded that the shape and clarity of the image are determined by the triangularity of the image cast by individual points of the luminous body, arising from the shape of the aperture and the circular pattern in which these triangular images are superimposed, arising from the shape of the luminous object. (David C. Lindberg, 1983)

Volume three of Al-Haytham's *Kitab Al-Manazir* focuses on the conditions that are necessary for good vision as well as how errors in vision are caused. Volume 4 on the other hand, gives a mathematical interpretation of the theory of reflection. Volume 5 discusses Alhazen's problems, a problem that is related to the catoptrics. In catoptrics, Al-Haytham studied spherical irregularity and realized that in a parabolical mirror, all the rays are concentrated at one point and therefore, parabolical mirrors are the best type of burning mirror. (Seyyed Hossein Nasr, 1984) Al-Haytham's problem in optics is in fact connected with the reflection from a spherical surface that is "from two points in a plane of a circle to draw lines meeting at a point at the circumference and making equal angles with the normal at that point". This leads to fourth-degree equation, which he solved by the intersection of hyperbola and circle (Seyyed Hossein Nasr, 1984) and set out to provide a proof of a fact which the ancient had recognized but not demonstrated. (Al-Haytham, 1990)

Volume 6 of the *Kitab Al-Manazir* examines errors in vision due to reflection where as in the final volume, Volume 7, Al-Haytham delved into the theory of refraction. In his study of refraction, Al-Haytham preferred geometrical methods more than algebraic ones. (Mohaini Mohamed, 2000) Mohaini Mohamed adds:

> "He adhered to them closely and was very much influenced by the conics of Apollonius, so much so that, although he had probably heard of the use of sines by the mathematician al-Battani, he preferred to work with chords. Otherwise, he would most likely have discovered the full Snell's Law. He did discover the law for small angles where the angle itself can be substituted approximately for the sine." (Mohaini Mohamed, 2000)

The Foundation for Science Technology and Civilization Limited asserted that Al-Haytham propounded the famous Snell's Law about 600 years before Snell himself. (Ibn Al-Haytham, 2002) Seyyed Hossein Nasr describes Al-Haytham's contribution to the study of refraction as one of the most outstanding ones. In order to prove his theory of refraction, he made careful experiments by placing a graduated cylinder in water to measure the angle of refraction. (Seyyed Hossein Nasr, 1984)

What happens in the real world when this happens is that, the light incident to the surface is refracted towards the perpendicular of the interface when it enters a denser medium from a less dense medium such as from the air into water. According to Winter:

> "When a ray of light reaches the surface of separation of two different media, the velocity along the normal to the surface is assumed to remain constant and the velocity along the surface to be reduced when the second medium is denser and increased when it is rarer. This accords with experiment, and gives a satisfactory explanation of the path assumed by the refracted ray. This path according Ibn al-Haytham is always the one which is 'the easier and quicker'. It is interesting to notice how this conception is a forerunner of Fermat's Principle of Least Time, and also to see how Ibn al-Haytham applied the rectangle of velocities to the movement of light nearly seven centuries before Sir Isaac Newton." (Winter H. J. J., 1954)

Al-Haytham explained the phenomena of refraction by the means of mechanical approach. Lindberg quotes Al-Haytham's words from his *Kitab Al-Manazir*:

> "Every moved object, Alhazen argues, "must have its motion altered if it encounters resistance". Presumably, the same will be true of an object, already resisted, that encounters a greater resistance. If this second resistance is strong, the motion of the object will be reversed in direction and this is called reflection; this is a case of reflection. If, on the other hand, the resistance is weak, the motion will neither be reversed nor be able to continue in its original direction, but will be partially deviated from its original path; this is refraction." (David C. Lindberg, 1983)

Al-Haytham discovered that even though light would be able to pass through any transparent medium, not all of them are equally receptive to light. (David C. Lindberg, 1983) This is because a denser material imposes more resistance to the route of the light and thus, the result, the light moves with reduced velocity in the denser material. Al-Haitham also demonstrated that light passing from denser medium to less dense medium will be deviated away from the perpendicular to the surface of the medium. Al-Haytham's interest in the theory of refraction had also led him to other discoveries. According to Connor and Robertson:

> "Ibn al-Haytham's study of refraction led him to propose that the atmosphere had a finite depth of about 15 km. He explained twilight by refraction of sunlight once the Sun was less than 19° below the horizon." J. J. O' Conner & E. F. Robertson, 1999)

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