Contributions of Muslim Scholars Attributed to Other Scholars in Optics

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Abstract

IbnSahl, a Muslim scholar during the Golden Age in the history of Islam, had contributed in developing of the Snell's law. He explained the law in his book entitled On the Burning Instrument (Kitab al-Parraqat) which was written in 984 CE. Similarly, the first ever camera was developed by Ibn Al-Haytham, a Muslim scholar. Camera obscura which was one of his famous inventions developed based on the idea that was initiated by observing the dust particles found in a stream of light. In addition, telescope and microscope development also should be credited to Ibn Al-Haytham since he was the first scholar who managed to identify the refraction and reflection of light theory. Based on the theory, concave and convex lenses were developed which later became the basic foundation to construct the telescope and microscope.

Keywords: Snell's law, IbnSahl, Camera, Telescope, Microscope, Ibn Al-Haytham.

1. Introduction

Inthis paper, we identify the inventions of Muslim scholars which were attributed to other scholars. The objective of this paper is to ascertain the contributions of Muslim scholars during the Medieval Age which is accredited to other researchers in the field of optics. The significance of this research is to reveal the efforts done by the Muslim scholars in science and technology especially for knowledge of the new generation. Moreover, they should know that the fundamental technological knowhow were developed by Muslim scholars. The methodology used in doing this research is library based as well as internet based research and most of the data are collected from reliable sources.

2. Snell's Law

Snell's law is a law on a ray occurrence on the interface of two media. The ratio of the sine of the angle of incidence to the sine of the angle of refraction remains constant when a light ray passes from one medium to another (http://www.dictionary.com/browse/snell-s-law). According to Merriam-Webster online dictionary, Snell's law is a law of physics where the ratio of the sines of the angles of incidence and refraction is always constant for all incidences in any given pair of media for electromagnetic waves of a definite frequency (https://www.merriam-webster.com/dictionary/Snell%27s%20law). According to the present generation's literature, it is all thanks to the Willebrord Snell (1591-1626) who was a Dutch scientist known as the founder of the Snell's law (Kim, 2001; Frischknecht et al., 2009; Rahhou et al., 2015; Gotte et al., 2013; Leutz et al., 2001). However, the real founder of the Snell's law is a Muslim scholar who used to work in the Abbasid court in Baghdad known as IbnSahl (Khan, 2015; Wolf, 1992; Wolf and Krotzsch, 1995; Gotte et al., 2013; Kwan et al., 2002).Abu Said Al-AlaIbnSahl also known as IbnSahl (940-1000) was the mentor of Ibn Al-Haytham. He is the actual discoverer of the laws of refraction of light which is now known as the Snell's law. A detail explanation on this Snell's refraction law was written in his book, *On the Burning Instrument* (*Kitab al-Parraqat*) in 984. IbnSahl's book is found to have a detail explanation theoretically as well as experimentally with the supporting diagrams. Figure 1 and 2 are the diagrams that were developed by IbnSahl on the law of refraction. In his book, he did analysis on the burning mirrors (parabolic and ellipsoidal shape) and the lenses (hyperbolic plano-covex lenses and hyperbolic biconvex lenses).

He also developed the geometry of refraction as shown in Figure 2 where he uses abstract lines in his diagram of the biconvex hyperbolic lens to concentrate the light of a near source at a point which describes the law of refraction of light (Snell's law) (Khan, 2016; Khan, 2016a; Khan 2015; Mihas, 2008; Guarnieri, 2016). Besides that, he clarified on how curved mirrors and lenses reflect light. Since he published this book, he is known as the first mathematicians who have treated lenses in a mathematical way as well as actively working on refraction in the early tenth century (Mihas, 2008).

Figure 1 shows the IbnSahl diagram for refraction and plano-convex lens which was reproduced from IbnSahl's book, *On the Burning Instruments* (*Kitab al-Parraqat*). This figure is adopted from: (Khan, 2016a; Khan 2015).

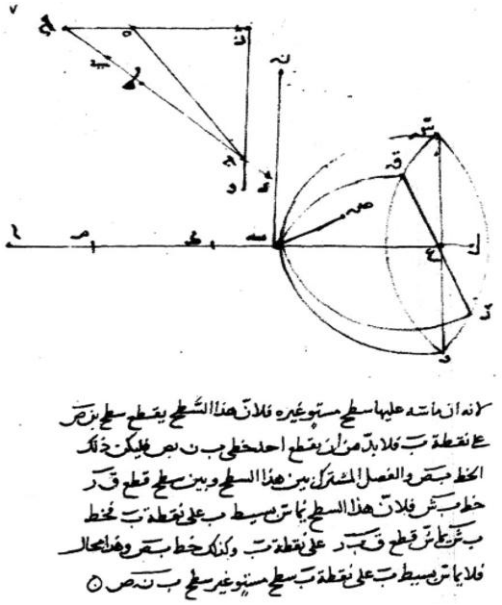
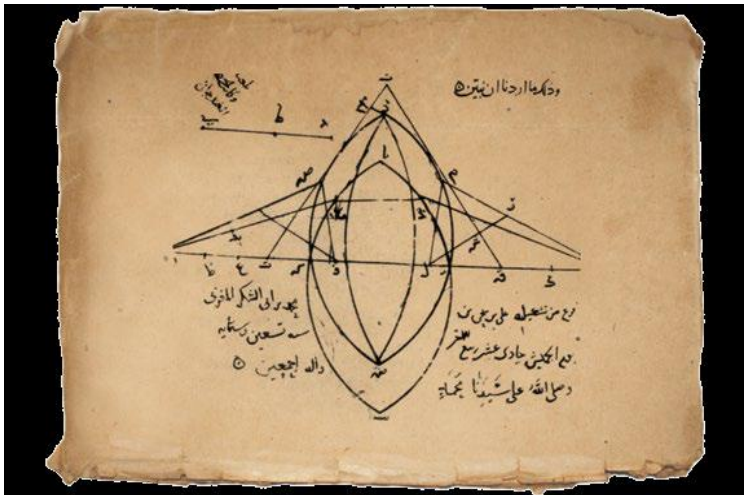


Figure 2 shows the IbnSahl diagram for a biconvex hyperbolic lens from IbnSahl's book, On the Burning Instruments (Kitab al-Parraqat). This figure is adopted from: (Khan, 2015).



Ibn Al-Haytham translated the *On the Burning Instruments* written by IbnSahl and *Optics* written by Ptolemy. Based on these two translation, Ibn Al-Haytham found that IbnSahl made a correct sine law of refraction compared to Ptolemy where he form an incorrect quadratic "law" of refractionsince he was unable to obtain results based on the measurements (Kwan, 2002). In 13th century (1270), Polish scholar, Witelio translated Ibn Al-Haytham's work in Latin which was later expanded by Johannes Kepler (Gorini, 2003; Marshall, 1950). Johannes

Kepler (1571-1630) carried out extensive research on reflecting and refracting surfaces where he discovered the "burning point" which is now known as "focus". Finally, the laws of refraction of light was given the name as Snell's law in order to give credit to Willebrord Snell, a Dutch scientist, who stated the law in a manuscript in 1621.

However, the same law is also known as "*la loi de Descartes*" in French since Rene Descartes (1596-1650) successfully put the law into widespread circulation in his *Discourse on Method* which was published in 1637. Descartes was able to fulfill the perfectly focusing lens or "burning glass" by using the law to derive the hyperbolic form of perfect lenses that focuses the incoming parallel rays to a single point (Kwan, 2002). Hence, there is no doubt that without IbnSahl understanding on sine law of refraction, Descartes would not be able to perfect his theory even though IbnSahl's contribution towards this law is not fully recognized by the present day generation.

3. Camera

According to the Meriam-Webster online dictionary, camera is define as a device that consists of a light proof of partition with an aperture fitted with a lens and a shutter through which the image of an object is projected onto a surface for recording (as on film) or for conversion into electrical impulses (as for television broadcast) (https://www.merriam-webster.com/dictionary/camera). In a more simplified explanation given by the Oxford Dictionaries, camera is actually a device used for recording visual images in the form of photographs, film, or video signals (https://en.oxforddictionaries.com/definition/camera#camera-Noun-200). According to the present generation, the camera was invented by Johann Zahn (1641-1707) who was a monk of Wurzburg (http://whoinvented.org/?s=who+invented+camera; Jay, n.d.; Lefevre, 2007). However, the first ever camera known as camera obscura, a pinhole camera was invented by a Muslim scholar known as Ibn Al-Haytham (Jay, n.d.; Al-Khalili, 2009; Alley Jr, 1980; Young, 1989; Camuffo, 2011;Fiorentini, 2006; Tbakhi and Amr, 2007). Abu Ali HasanIbn Al-Haitham(965-1039) known as Ibn Al-Haythamor Al-Basri was born in the city of Basra in Southern Iraq. He was known in the West as Alhazenor Alhacen or *Ptolemaeus Secundus* (the Second Ptolemy) because of his achievements were equivalent to Plotemy the Greek astronomer.He was recognized by the world as a pioneer in the field of optics (Guarnieri, 2015; Jay, n.d.; Camuffo, 2011; Alias and Hanapi, 2016; Alley Jr, 1980). According to the Encyclopedia Britannica, he is considered as the important figure in optics after Ptolemy(Zghal et al., 2007). Sir Thomas Arnold stated that:

"The field of optics reached its peak with Ibn Al-Haytham." (Zghal et al., 2007) Besides that, George Sarton also indicated in his *History of Science* (1927):

"Ibn Al-Haitham was the best scientist to have existed in the Islamic world in the middle ages in the field of natural science. He was one of the few most outstanding figures in optics in all times. He was also an astronomer, a mathematician and a doctor." (Zghal et al., 2007; Salih et al., 2005)

Ibn Al-Haytham published more than 200 books which only parts of them survived. One of them would be his famous publication which is *Book of Optics* (*Kitab al-Manazir*), written between the year of 1011 and 1021. The book consists of seven volumes that explained on the evolution between ancient and modern optics and light science (Guarnieri, 2016; Hanapi and Alias, n.d.;Tbakhi and Amr, 2007). In the book, he defined that the light travels in a straight line. The idea wasoriginatedby observing the dust particles found in a stream of light and visibly in a dark room with a hole. Hence, based on the observation and experimental studies, he invented a model called camera obscura (*bayt al-muzlim*) also known as "dark room" in Latin. The model was based on description analysis of the human eye where he developed a theory of vision and how image is formed by the eye. He explained that the vision is a process that takes place in the brain rather than the eyes. He argued on the claimed given by the Greek philosophers where Ibn Al-Haytham firmly stated that seeing happens neither in physical forms that enter the eyes nor by rays emitted from it(Hanapi and Alias, n.d.; Smith, 1992; Belbachir and Gobel, 2009; Young, 1989; Zghal et al., 2007). Ibn Al-Haytham was the first physician who provided correct description of the basic principle of the camera obscura in the tenth century. His descriptions were proven based on the experimental basis (Hanapi and Alias, n.d.; Fiorentini, 2006; Belbachir and Gobel, 2009). He stressed the fact that an image is only projected if the hole is small in size. He experimented the model on the solar eclipse where later it become the crucial use of the camera obscura for centuries (Jay, n.d.). Later in 13th century (1270), Ibn Al-Haytham's *Book of Optics* was translated into Latin by the Polish scholar, Witelio (1230/35-1275 A.D.) (Gorini, 2003).

Further improvement on the camera obscura were done by the scholars after him such as Roger Bacon (1214-1292); Leonardo da Vinci (1471-1519)who gave the accurate description of the camera obscura in the *Codex Atlanticusin*1515;Albercht Durer (1471-1528); Gemma Frisius (1508-1555); Giambattista Della Porta (1535-1615) who improved the camera obscura by replacing the pinhole with a biconvex lens which he compared the device with the human eye, mentioned in his book *Magia Naturalis* (*Natural Magic*, 1558).

Friedrich Risner in 1527, constructed a smaller size of camera obscura where he enhances the optical quality (Guarnieri, 2015; Guarnieri, 2016; Jaliu et al., n.d.).In seventeenth century, Johann Cristoph Sturm, Johann Zahn, and George Friderich Brander successfully developed box-type camera obscura which became the prototype for today's camera (Jaliu, et al., n.d.; Fiorentini, 2006; Lefevre, 2007). As a conclusion, Ibn Al-Haytham was an outstanding scholar during his era. Whenever he came up with a theory, he proved them with the experimental evidences. This attitude should be applied by the modern generation researchers and scientist. However, even though he is fairly known by the world as the pioneer in the field of optics, it is still unfortunate for Ibn Al-Haytham because most of his works are attributed to the other scholars.

4. Telescope

Telescope is an optical instrument that makes the distant objects appear larger and nearer. There are two principal forms of telescope which are refracting telescope and reflecting telescope. Refracting telescope comprises of mainly of an independent lens set into one end of a tube and an adjustable eyepiece or combination of lenses set into the other end of a tube that slides into the first and through which the enlarged object is viewed directly. As for the reflecting telescope, it consists of a concave mirror that gathers light from the object and focuses it into an adjustable eyepiece or combination of lenses through which reflection of the object is enlarged and viewed (http://www.dictionary.com/browse/telescope). The telescope definition can be simplified asatubular optical instrument designed to make distant objects appear nearer. It contains an arrangement of curved mirrors and lenses that collects the rays of light and is focused in order to produce magnified images (https://en.oxforddictionaries.com/definition/telescope; https://www.merriam-webster.com/dictionary/telescope).
According to the modern literature, it is believed that the telescope was invented by Hans Lippershey, who was an eyeglass maker in 1608-1609 (Goehring, 1978; Chapman, 2008; Zewail, 2003).However, this telescope was invented from the combination of concave and convex lenses which were developed based on the refraction and reflection of light theory by a Muslim scholar known as Ibn Al-Haytham (Zewail, 2003; Booth and Van Helden, 2000; Sellers, 2012; Salih et al., 2005). As mention in camera section, Abu Ali HasanIbn Al-Haitham (965-1039) known as Ibn Al-Haytham or Al-Basri was born in the city of Basra in Southern Iraq. He was known in the West as Alhazen or Alhacen or *Ptolemaeus Secundus* (the Second Ptolemy) because of his achievements were equivalent to Plotemy the Greek astronomer. He was recognized by the world as a pioneer in the field of optics as well as the legendary inventor of camera obscura (Guarnieri, 2015; Jay, n.d.; Camuffo, 2011; Alias and Hanapi, 2016; Alley Jr, 1980). According to the Encyclopedia Britannica, he is considered as the important figure in optics after Ptolemy (Zghal et al., 2007).

Ibn Al-Haytham greatest work, *Book of Optics* (*Kitab al-Manazir*), have description on physical light rays and reception by the eye. According to him, luminous bodies emit light rays both directly into the human eyes as well as onto the secondary bodies which brighten themselves in various degrees that allows the human to receive the light in similar manner. He considers this theory for the light of the moon. Besides that, he explained on how is the image of an object is formed in human mind. Based on his knowledge of the eye's interior, he developed a theory of vision in which rays from an object enters the eye and are refracted to a point through the crystalline humour (lens). He also explained that the crystalline humour is an organ which is sensitive to light rays and allows the information to be transmitted to the brain via the optic nerve. But, it was Johannes Kepler who resolved that the retina is a sensory organ that received the image from the lens of the eye (Smith, 1992; Singer, 1920; Marshall, 1950; Goehring, 1978). In addition, Ibn Al-Haytham also observed the power of magnifying spheres and lenses by experimenting with cylindrical, concave, and parabolic metal mirrors where he evaluated the problem of spherical deviation. His geometrical or optical theories were verified by sketches which assisted lens and spectacle makers to produce reasonably precise results (Marshall, 1950).

In 13th century (1270), Ibn Al-Haytham's *Book of Optics* was translated into Latin by the Polish scholar, Witelio (1230/35-1275 A.D.) (Gorini, 2003; Marshall, 1950).Roger Bacon (1214-1292) later conducted experiment with lenses and came up with a conclusion that the lenses are useful for aiding vision which is mention in his book *Opus majus* which was written in 1266-1267 (Bardell, 2004; Sellers, 2012).

"If a man looks at letters or other small objects through the medium of a crystal or of glass or of some other transparent body placed above the letters, and it is the smaller part of a sphere whose convexity is toward the eye, and eye is in the air, he will see the letters much better and they will appear larger to him. For in accordance with the fifth rule regarding a spherical medium beneath which is the object or on this side is its center, and whose convexity is toward the eye, all conditions are favorable for magnification, since the angle is larger under which the object is seen, and the image is larger, and the position of the image is nearer, since the object is between the eye and the center. Therefore this instrument is useful to the aged and those with weak eyes. For they can see a letter, no matter how small, sufficiently enlarged." (Bardell, 2004)

Johannes Kepler (1571-1630) in *Ad Vitellionem Paralipomena* (*Supplement to Witelo*), 1604 introduces the first correct account of image formation where a reversed image both laterally and vertically was formed at the back of the eye (on the retina); Galileo Galilei (1564-1642) was the first to make use of the telescope to visually approach a far distance (Zewail, 2003; Sellers, 2012). In the end of the sixteenth century, Hans Lippershey is credited as the telescope inventor since he applied for a patent in October 1608 (Goehring, 1978).As a conclusion, even though Ibn Al-Haytham theory related to the lenses was corrected by Johannes Kepler, he is still considered as the one who influences the scholars after him to keep on improvising the old ideas into refined ideas in order to live a better life.

5. Microscope

Microscope is an optical device that uses a lens or combination of lenses to produce a magnified image of a small and close object which are difficult or impossible to observe using the naked eye. The concept is similar as telescope where light is reflected from or passed through the sample being observed to form a magnified image of the object by refracting the light with arrangements of lenses and mirrors (http://www.dictionary. com/browse/microscope). According to Cambridge online dictionary and Meriam-Webster online dictionary, microscope can be defined as an optical instrument or device consist of a lens or combination of lenses which have the capability in enlarging images produce from a very small object (http://dictionary.Cambridge.org /dictionary/english/microscope;https://www.merriam-webster.com/dictionary/mi croscope).

According to the present literature, it is believed that the microscope was invented by Zacharias Janssen, who was a spectacles maker (Bardell, 2004; Salih et al., 2006; Schultheiss and Denil, 2002). However, this microscopeis known as a reverse version of telescope, was invented from the combination of concave and convex lenses which were developed based on the refraction and reflection of light theory by a Muslim scholar known as Ibn Al-Haytham (Zewail, 2003; Booth and Van Helden, 2000; Sellers, 2012; Salih et al., 2005; Uluc et al., 2009). As mention in camera and telescope section, Abu Ali HasanIbn Al-Haitham (965-1039) known as Ibn Al-Haytham or Al-Basri was born in the city of Basra in Southern Iraq. He was known in the West as Alhazen or Alhacen or *Ptolemaeus Secundus* (the Second Ptolemy) because of his achievements were equivalent to Plotemy the Greek astronomer. He was recognized by the world as a pioneer in the field of optics as well as the legendary inventor of camera obscura (Guarnieri, 2015; Jay, n.d.; Camuffo, 2011; Alias and Hanapi, 2016; Alley Jr, 1980). According to the Encyclopedia Britannica, he is considered as the important figure in optics after Ptolemy (Zghal et al., 2007).

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