



# Scientists of the Islamic world

## Ibn Al-Haitham father of modern optics

This is the second of a six-part series of articles on Arab and Muslim scientists written by different professors of the Department of Mathematics and Natural Sciences of Gulf University for Science and Technology — **Editor**

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Long before Europe got its Galileo Galilei, Rene Descartes and Newton, the Muslim world had Ibn Al-Haitham, the inventor of the very foundation of modern scientific thinking, the scientific method.

### Introduction

After the fall of the Roman Empire in AD 476, scientific progress in Europe had come to a standstill. This era between fall of Rome and the Renaissance is commonly known as the dark ages. However, from the 8th till 13th century, scientific and cultural knowledge had flourished in the Islamic world. This period, which began soon after the establishment of the Abbasid Khalifate in Baghdad in the later part of the 8th century, is known as the Golden Period of Islam. While Europe was in the dark ages, the Muslim world was experiencing a rapid progress in all aspects of human knowledge and innovation. During this period, countless contributions were made to the fields of science, philosophy, art, literature and sociology by renowned scholars such as Ibn-Khaldun, Jabir Ibn Hayyan, Al-Khawarizmi, Ibn-Sina, Ibn Al-Haitham and many other prominent scholars and inventors. The documentary films producer Howard R. Turner writes in his book *Science in Medieval Islam*, "Muslim artists and scientists, princes and laborers together made a unique culture that has directly and indirectly influenced societies on every continent." The Abbasid caliph Harun Al-Rashid established an academy called "The House of Wisdom" in Baghdad, where scholars used to gather and translate into Arabic scholarly works from Ancient Rome, Ancient Egypt, Ancient Greece, China, India, Persia, North Africa and Byzantine civilizations.

Among those renowned scholars of the late Abbasid era, Ibn Al-Haitham (Latinized as Alhazen or Alhacen) was one of the most eminent scientist. He was born in Basra in 965 C.E. (354 A.H.) and died in Cairo in 1040 C.E. (430 A.H.). He was educated in Basra and Baghdad, and was the first scientist to formulate and test hypotheses with verifiable experiments. He developed what is now known as the scientific method more than 200 years before European scholars learned of it. For this reason, he was called the First Scientist. He is also considered the father of modern optics and was also nicknamed Ptolemy the Second (Ptolemaeus Secundus) in medieval Europe. Ibn Al-Haitham is most famously known for his writings epitomized by influential works such as *Book of Optics*, *Doubts Concerning Ptolemy*, *The Model of the Motions*, *Treatise on Light*, *Scientific method*, *experimental science* and *visual perception*. His work was certainly influenced by Aristotle, Euclid and Ptolemy and had influenced, among others, Omar Khayyam, Roger Bacon, Alfonso and Johannes Kepler. Professor Robert S. Elliot writes about Ibn Al-Haitham in *Electromagnetics*: "Alhazen was one of the ablest students of optics of all times. His seven-volume treatise published on this subject had strongly influenced western thought, notably that of Roger Bacon and Kepler."

### Contribution to physics

Ibn-Al Haitham made enormous contributions to the field of physics. His famous works in the field of physics include *Book of Optics*, *Mizan al-Hikmah* (Balance of Wisdom), *The Model of the Motions*, *Treatise on Light*, *Treatise on Place*, *Visual perception*, and *Celestial mechanics*. In his *Book on Optics* Ibn Al-Haitham proved that rays of light travel in straight lines, and he carried out variety of experiments with lenses, mirrors, refraction, and reflection. Also, in *Mizan al-Hikmah*, he discussed the theory of attraction between masses and it seems that he was also aware of the magnitude of acceleration due to the action of the force of gravity at a distance. Another treatise, *On the Light of the Moon*, he observed that "[the] moon emits light only from those portions of its surface which the sun's light strikes. Ibn Haitham is also considered the

founder of modern experimental methods. The German Scholar Matthias Schramm writes in *Ibn al-Haytham's Weg zur Physik*, "[Ibn Al-Haitham] was the first to make a systematic use of the method of varying the experimental conditions in uniform manner in an experiment showing that the intensity of the light-spot formed by the projection of the moonlight through two small apertures onto a screen diminishes constantly as one of the apertures is gradually blocked up." In his *Treatise on Place*, he explained that a body moves perpetually unless an external force stops it or changes its direction of motion. In this statement Ibn Al-Haitham breaks off with Aristotelian notion that motion requires a force to maintain. This is statement is a forerunner to Newton's first law of motion, also known as the law of inertia. Furthermore, he proposed the first successful theory of vision in which he explained through experimentation the process of vision as resulting of rays of light proceeding from each point on an object to the eye.

### His Optics of Vision

One of greatest Ibn Al-Haitham's achievements is in the field of optics. He is considered the founder of ophthalmology because of the precision with which he was able to identify the layers of the eye. He accurately described the structure of the eye, image formation in the eye and made several improvements to the surgery of the eye. Moreover, the names of the optical components of the eye such as Cornea, Retina, Vitreous humor and Aqueous humor, are all his. Furthermore, Ibn Al-Haitham conducted the first experiments in history showing how to disperse light in its constituent colors. By exposing water-filled glass spheres to sunlight, he discovered that rainbows are due to the refraction, not reflection of sunlight by raindrops, as claimed by Aristotle. With further investigating using water-filled glass spheres, he was able to observe that the beams of light were refracted at measurable angles. He was the first scientist observe bending of light rays when entering from one medium to another, such as air and water, in an angle. He was also able to show that a ray of light arriving perpendicular from air to water was not bent at all. Half a millennium later,

Willebrord Snellius (also known as Snell) would turn these observations into a physical law named after him. His works on how lenses work enabled him to invent the spectacles as he argued that magnification was due to refraction and described the link between magnification and the glass curvature.

Ibn Al-Haitham is considered the inventor of spectacles. According to historians, when he became old, he designed a convex lens to be able to continue reading scientific treatises. Perhaps his most famous invention is the pin hole camera and camera obscura. In the book *The Eye As an Optical Instrument*, Wade and Finger write, "The principles of the camera obscura first began to be correctly analysed in the eleventh century, when they were outlined by Ibn al-Haitham."

### What they said about him

Nobel Prize winning physicist Abdus Salam writes about Ibn-al-Haitham: "[He] was one of the greatest physicists of all time. He enunciated that a ray of light, in passing through a medium, takes the path which is the easier and quicker. In this he was anticipating Fermat's Principle of Least Time by many centuries. He enunciated the law of inertia, later to become Newton's first law of motion."

Belgian chemist George Sarton known as the "Father of the History of Science" wrote in the *Introduction to the History of Science*: "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."

The distinguished scholar Professor Robert S. Elliot wrote following about the *Book of Optics*: "Alhazen was one of the ablest students of optics of all times. His seven-volume treatise published on this subject which strongly influenced Western thought, notably that of Roger Bacon and Kepler."

The *Biographical Dictionary of Scientists* wrote the following on Ibn al-Haitham: "He was probably the greatest scientist of the Middle Ages and his work remained unsurpassed for nearly 600 years until the time of Johannes Kepler."

The noted science historian, David Linderberg, wrote that: "Alhazen was

undoubtedly the most significant figure in the history of optics between antiquity and the seventeenth century."

In the medieval French poem *Roman de la Rose* (Romance of the Rose), Guillaume de Lorris and Jean de Meun say this about Ibn Al-Haitham: "Alhazen, the nephew of Hunain, was neither a fool nor a simpleton, and he wrote the book of "Optics", which anyone who want to know about the rainbow should know about. The student and observer of nature must know it and he must know geometry, the mastery of which is necessary for the proofs in the book of Optics."

In Ibn al-Haytham's *Weg zur Physik*, Matthias Schramm writes: "Through a closer examination of Ibn al-Haytham's conceptions of mathematical models and of the role they play in his theory of sense perception, it becomes evident that he was the true founder of physics in the modern sense of the word; in fact he anticipated by six centuries the fertile ideas that were to mark the beginning of this new branch of science."

In *Lenses and Waves*, Fokko Jan writes about Ibn Al-Haitham: "Through the influential work of Alhacen the onset of a physico-mathematical conception of optics was established at a much earlier time than would be the case in the other mathematical sciences."

### His Works

Ibn al-Haytham was a pioneer in many areas of science, thus making significant contributions to various fields of science. His optical work influenced many Western scholars such as Roger Bacon, John Pecham, and Johannes Kepler. Moreover, his work on number theory, analytic geometry, and the link between algebra and geometry, also had an influence on Isaac Newton's calculus. In "Contributions of Islamic scholars to the scientific enterprise" Farooqi (2004) mentioned that: "Ibn Al-Haitham's work led in pure mathematics to the harmonious fusion of algebra and geometry that was epitomized by Descartes in geometric analysis and by Newton in the calculus. He was a scientist who made major contributions to the fields of mathematics, physics and astronomy during the latter half of the tenth century. According to medieval biographers, more than 200 works on a wide range of subjects have been written by Ibn Al-

Haitham. Unfortunately, most of his works are now lost. Also, his surviving works have not all been studied. Nearly half of his surviving works is on mathematics, 23 on astronomy, and 14 on optics, with a few on other subjects such as *Book of Optics*, *Balance of Wisdom*, *Finding the Direction of Qibla by Calculation*, *On the Configuration of the World*, *On the Light of Stars*, *On the Light of the Moon*, *The Direction of Mecca*, *Treatise on Light and Influence of Melodies on the Souls of Animals*. Among these massive contributions, Ibn Al-Haitham's Seven-volume work on Optics is considered to be the most important contribution.

In Book 1 of the *Book on Optics*, Ibn Al-Haitham investigates the light, vision, camera obscura and discusses the structure of the eye, while the Book 2 is devoted to the visual perception and Book 3 examines conditions necessary for good vision and the causes of errors in vision. Book 4 focuses on the theory of reflection, and then Book 6 examines error in vision due to reflection. On the contrary, Book 7 discusses refraction. Conclusion with his Achievements

Ibn Al-Haitham is considered as one of the very early founders of the scientific method and the first scientist to test hypotheses with verifiable experiments. He is regarded as the father of modern optics, pioneer of the modern scientific method, and the founder of experimental physics. Also, he was the first to prove the intromission theory of vision and refined it into its modern form. In his book on theology, he described himself as someone who constantly sought knowledge and truth for gaining access to the effulgence and closeness to God as for him there was no better way than that of searching for truth and knowledge. When in Iraq, he was appointed as a minister of Basra and the surrounding area. However, he had to leave that post as he decided to devote himself completely to the study of science. He was a true pioneer whose ideas had to wait centuries to be understood and developed further. It is said Newton to have remarked in a letter to his rival Robert Hooke, "If I have seen further it is by standing on the shoulders of giants." Ibn Al-Haitham was indeed a giant and he may well be one of the giants Newton had in mind when he made that remark.

### 'Reign of terror'

## Qaeda 'targets' citizen journalists

BEIRUT, Nov 7, (AFP) — Al-Qaeda is targeting citizen journalists in Syria's Raqa with a wave of kidnappings, beatings and assassinations aimed at silencing them, in what activists call a reign of terror.

"Is your head still attached to your body? I swear to God your head will be cut off, and that we'll give you a visa to hell," read the threat sent last week to photographer Abd Hakawati.

It came from the al-Qaeda-affiliated Islamic State of Iraq and the Levant (ISIL). Originally from the central province of Hama, Hakawati had worked on and off in the northern city of Raqa in recent months.

The regime has detained him twice and he has been wounded three times since the uprising against President Bashar al-Assad began in March 2011.

"But I had never thought of leaving Syria until now, nor did I ever feel any fear," Hakawati told AFP over the Internet.

"Just thinking of these mercenary killers hidden behind beards and masks makes my heart shiver with fear, and makes me want to kill myself."

Hakawati is friends with citizen journalist Mohammad Nour Matar, a Raqa native kidnapped by ISIL in August.

Matar's brother Mezar, himself a photographer, spoke to AFP from neighbouring Turkey, where dozens of Raqa activists have fled ISIL in recent weeks.

"It's become hard to work in Raqa because of the kidnappings, beatings, detentions and attacks against media activists," said Mezar Matar.

ISIL, he said, "sees all media activists as collaborators with the West."

Though no side in Syria's brutal war is innocent of abuses, ISIL has been accused of a systematic campaign in areas under its control to stamp out any group that could challenge its authority.

Sema Nassar, a prominent human rights defender, told AFP "there are no media activists left in Raqa. They've all left because they're being targeted."

Syria's revolt, which broke out in March 2011, brought with it a generation of activists who documented the uprising.

In Raqa, which became the first provincial capital controlled by the opposition when it fell in March, they worked freely for a few weeks, without fear of retribution.

But within months ISIL became the most organized, feared group in the city, and started kidnapping and torturing dozens of young Syrians.

Its actions have bolstered the regime's claim that all its opponents are "terrorists".

Asked why the army has not tried to retake Raqa, a general in Damascus told AFP: "We want to make an example out of Raqa. We want the people to see what happens when the rebels take over."

### Politics

## Nations estranged by decades of distrust

# Obama, Rouhani squeezed by hawks and hardliners

WASHINGTON, Nov 7, (AFP) — Their nations are estranged by decades of distrust — but Barack Obama and Hassan Rouhani share a common political problem.

Hawks and hardliners in Washington and Tehran are putting the squeeze on the US and Iranian presidents as they grasp for a landmark nuclear deal.

As new international talks on Iran's nuclear program open in Geneva, deep mutual suspicion leaves American and Iranian negotiators little time or political space to act.

In Washington, national security conservatives who view Iran's diplomatic charm offensive through the same skeptical lens as Israeli Prime Minister Benjamin Netanyahu, want the White House to swear off inducements for Iranian concessions and threaten to tighten sanctions.

In Tehran, clerical and political conservatives, temporarily silenced by Rouhani's election, disdain talks with the "Great Satan" America.

"It is entirely possible that there are political considerations on either side that will complicate this," said Suzanne Maloney of the Brookings Institution.

"Both sides have to insulate against that to the extent that it is possible."

For Obama, a deal to disable Tehran's nuclear program without using military force would offer a shining foreign policy legacy.

But Democratic and Republican hawks steeped in decades of antipathy towards revolutionary Iran doubt a genuine deal is possible.

A new Senate push for even tougher sanctions than those currently hobbling Iran's economy prompted intense lobbying from a White House fearful that hardliners in Tehran could torpedo Rouhani's diplomatic outreach.

But powerful Democratic Senate Foreign Relations Chairman Robert Menendez and Republican colleague Mark Kirk argue Iran only came to the table because of sanctions — and urge more tough medicine.

Convincing the Senate to hold off on new measures to further choke Iran's oil sector is one thing — selling a divided, dysfunctional Congress on interim and final deals brokered by the US team in Geneva is another.

Although Obama has the power to waive certain sanctions on the Islamic Republic, he would need help from lawmakers to offer the full relief that might motivate Iran to do a deal.

But his sway on Capitol Hill is waning



A general view taken on Nov 7, shows participants before the start of two days of closed-door nuclear talks in Geneva. (AFP)

amid criticism over his handling of the Syria crisis and a second term malaise.

The likely shape of any final deal will prove politically contentious.

Menendez is on record with a bipartisan group of senators as saying Iran must be barred, among other restrictions, from enriching uranium — in line with Israel's red lines on a nuclear deal.

But former Obama administration non-proliferation official Robert Einhorn says a "perfect" deal may already be out of reach.

"The problem is that Iran is exceedingly unlikely to cave in to demands that it regards as tantamount to surrender," he said, in a speech in Tel Aviv last month widely interpreted as hinting at administration thinking.

"Most observers who follow Iran and its internal dynamics believe that no matter how devastating the sanctions, no matter how persistent we are at the negotiating table, and no matter how credible the military option we are able to threaten, Iran will not agree to the maximalist terms that the Israeli government and some Americans advocate."

If Einhorn is right, Obama will have to convince skeptical lawmakers that a less than ideal agreement — which leaves Iran short of "breakout" capacity to building a nuclear bomb but does not deprive it of the "right" to enrich uranium, is worth supporting.

Rouhani's limited room for political maneuver was reflected in his diplomatic dance at the United Nations in September

— when he dodged a meeting with Obama but spoke to him by phone.

Many Iran watchers here interpret Iran's desire for quick results in the talks as a sign Rouhani is on borrowed time, after winning election in June on a pledge to ease US sanctions. They also noted Supreme Leader Ayatollah Ali Khamenei's comment Sunday that talking would do Iran no harm.

But Khamenei, with ultimate authority over the nuclear program, also warned he was "not optimistic."

"The reason why the Supreme Leader came out two days ago in support of the negotiating team was to silence some of those opponents who were talking about a sellout," said Haleh Esfandiari, director of the Middle East program at the

Woodrow Wilson International Center for Scholars.

"So far he has the support of the Supreme Leader. How long that will last we don't know," she said at a packed Center for Strategic and International Studies forum which reflected high interest in US-Iran gambit in Washington.

US officials are privately satisfied with the makeup of the Iranian negotiating team under Foreign Minister Mohammad Javad Zarif, who experienced US-style politics close up during law studies in Denver and as UN ambassador.

But while there may be some tactical advantage derived from a "good cop, bad cop" routine with lawmakers, there is concern that hawks in Tehran might interpret tough talk in Congress as a provocation.

Sometimes called "the father of modern optics", he made significant contributions to the principles of optics and visual perception in particular, his most influential work being his *Kitāb al-Manāẓir* ("Book of Optics"), written during 1011–1021, which survived in the Latin edition. It was translated into Latin as *Opticae thesaurus Alhazeni* in 1270. Ibn al-Haytham's discoveries in optics and vision overturned centuries of misunderstanding. In his experiments, he observed that light coming through a tiny hole travelled in straight lines and projected an image onto the opposite wall. (Fig. Ibn al-Haytham was born during a creative period known as the golden age of Muslim civilization that saw many fascinating advances in science, technology and medicine. This article titled, *Ibn Al-Haytham: The Father of Modern Optics*, gives us a glimpse of the great contribution made by Muslim scientists throughout history. Ibn Al-Haytham's contribution to mathematics and physics was extensive. In mathematics, he developed analytical geometry by establishing a link between algebra and geometry. He studied the mechanics of motion of a body, and was the first to maintain that a body moves perpetually unless an external force stops it or changes its direction of motion. This would seem equivalent to the first law of motion. The list of his books runs to 200 or so, very few of which have survived. Even his monumental treatise on optics survived through its Latin translation. *ibn al-haytham. 4. optics. 1. father. 1. modern. 1. ibn.* Review of Hakim Mohammad Said, *Ibn al-Haytham Hamarneh S et al.* *Al-Haytham the man of experience: First Steps in the Science of Vision* Gorini R et al. *J Inter Soc for the History of Islamic Medicine (JISHIM)* 2003. *The history of the microscope for use in ear surgery* Mudry A et al. *Am J Otol* 2000. *History of the operating microscope: From magnifying glass to microneurosurgery* Kriss TC et al. *Neurosurgery* 1998. *The evolution of microscope design from its invention to the present days* Kalderon AE et al. *Am J Surg Pathol* 1983. *The eye as an optical instrument: From camera obscura to Helmholtz's perspective* Wade NJ et al.