

# Arab Origins of the Discovery of the Refraction of Light

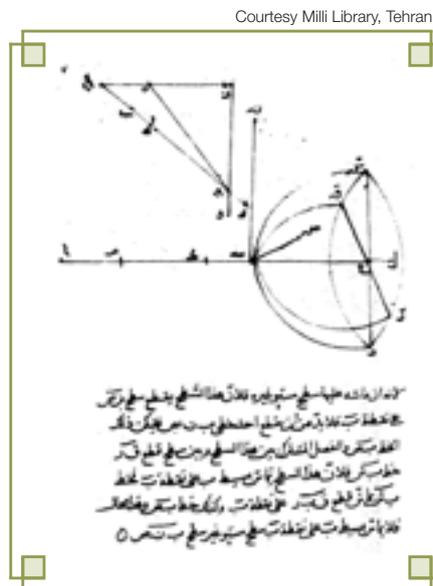
Sameen Ahmed Khan

You've heard of DaVinci, Descartes and Newton, but what about Ibn Sahl and Ibn al-Haytham? These Arab scientists were describing the fundamental properties of light centuries before their European counterparts.

Between the 8<sup>th</sup> and 13<sup>th</sup> centuries, intellectual activity in the Arab world went through two stages: translations followed by original contributions, both of which enjoyed an official patronage. Ancient science and philosophy that was written in the Sanskrit, Pahlavi, Syriac and Greek languages would have been lost forever had the scholars around Baghdad not translated them into Arabic, which was later translated into European languages.

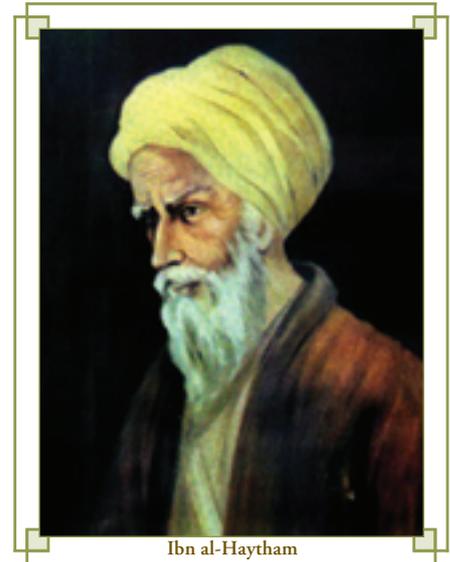
The phenomenon of reflection of light was understood by the Greeks prior to Archimedes, who, according to some accounts, tried to burn the Roman fleet approaching Alexandria using the reflection of light. Among the vast literature that was translated into Arabic were Ptolemy's *Optics* and the *Conic Sections* of Apollonius.

Applications of parabolic mirrors for burning instruments, first described by Anthemius of Tralles, were also known to the Arabs in Iraq. In 1990, science historian Roshdi Rashed brought to light the discovery that the geometric study of refraction, hitherto attributed to Snell, Descartes, and Fermat in its sine law form, was known and written upon by Abu Sa'd al-'Ala' Ibn Sahl (940–1000 A.C.E.), who was working in the Abassid court in Baghdad.



Ibn Sahl's diagrams for refraction (see p. 9 in K.B. Wolf's *Geometric Optics on Phase Space*) and the plano-convex lens (see ISIS 81, 467) are reproduced from Ibn Sahl's book, *On the Burning Instruments*, written in 984 A.C.E.

Ibn Sahl had translated Greek books on optics, including Ptolemy's *Optics*. He succeeded in stating the law of refraction of light with a diagram. It had long been known that Ibn Sahl wrote on burning mirrors; it is cited in the works of Ibn al-Haytham, among others. Libraries in Damasacus and Tehran contain antique



Ibn al-Haytham

manuscripts bearing this title. Based on the catalogue information, these were perceived to be copies of the same book until 1990, when Rashed organized and studied them.

The pages turned out to be parts of the same dishevelled manuscript, pages mixed and some lost, unnumbered, but providentially containing the key results of the work. This is Ibn Sahl's book, *On the Burning Instruments*, written in 984.

Rashed reassembled it, translated it and published it. Ibn Sahl's book is both experimental (he provides the mechanical means to draw the conic sections) and theoretical. In it, he describes the law of refraction with a diagram. He analyzed burning mirrors, both parabolic and ellipsoidal; he considered hyperbolic plano-convex lenses and hyperbolic biconvex lenses. This treatise makes Ibn Sahl the first mathematician known to have studied lenses and shows that, in the first half of the 10<sup>th</sup> century, catoptricians were actively working on refraction.

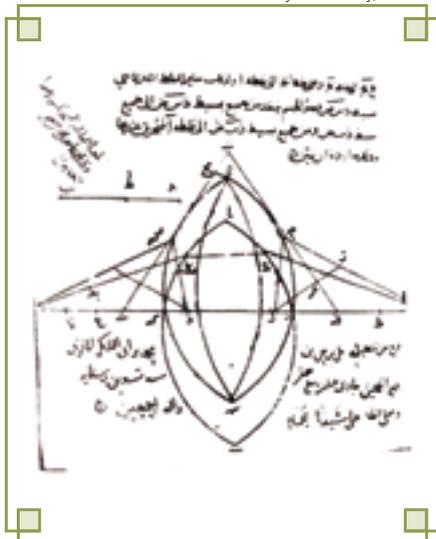
Ibn Sahl was well known among his colleagues and students. Abu Ali al-Hasan ibn al-Haytham (965-1039, known as Alhacen/Alhazen, the Latin transliteration of his first name al-Hasan) wrote several books on optics acknowledging his mentor Ibn Sahl.

Ibn al-Haytham started his career in Basra, Iraq, which was the chief center of translations and scientific activities at that time. Later, he migrated to Egypt, made experimental contributions of the highest order in optics and noted that a ray of light, in passing through a medium, takes the path that is the easiest and fastest. In this, he was anticipating Fermat's principle of least time by many centuries.

Ibn al-Haytham authored 14 books on optics alone. His magnum opus *Kitabl al-Manazir (Book of Optics)* earned him the title "Father of Optics." This book was translated into Latin in 1270 as *Opticae Thesaurus Alhazen*, and remained a significant work of reference for several centuries. In it, he examines the double refraction in a sphere and related problems.

Three centuries after Ibn al-Haytham, the Persian physicist Kamal al-Din al-Farisi (1267-1319) wrote an important commentary on the *Book of Optics*, in

Courtesy Milli Library, Tehran



Ibn Sahl's diagram for a biconvex hyperbolic lens (ISIS, 81) is reproduced from Ibn Sahl's book.

which he set out to explain many natural phenomena. For example, by modeling a water drop using Ibn al-Haytham's study of double refraction in a sphere, he gave the first correct explanation of the rainbow.

Al-Farisi also proposed the wave-nature of light. By contrast, Ibn al-Haytham had modeled light using solid balls in his experiments on reflection and

refraction. Thus, the question was proposed: Is light wave-like or particle-like?

Many prominent European scientists, including Roger Bacon (1214-1292), Leonardo da Vinci (1452-1519), Johannes Kepler (1571-1630), René Descartes (1596-1650) and Isaac Newton (1643-1727), benefited greatly from the Arab contributions to optics and other fields. ▲

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## Roshdi Hifni Rashed Awarded the 2007 King Faisal International Prize

The King Faisal Foundation in Riyadh, Saudi Arabia, announced science historian Roshdi Hifni Rashed as the recipient of the 2007 King Faisal International Prize (KFIP) for Islamic Studies (Topic: Muslims' Contribution to Pure or Applied Sciences), a cash prize of \$200,000.



He was declared the winner in recognition for his insightful studies, authentication, commentaries and translations of Muslims' contributions to pure science, in particular their achievements in the fields of mathematics and optics.

Rashed has translated several little known manuscripts, bringing recognition to some of the medieval Arab contributors of science, whose work had otherwise been lying unnoticed in libraries and museums. For his research, he was bestowed the Prize of the Third World Academy of Sciences in 1990, UNESCO's Avicenna Gold Medal in 1999, and a Medal from CNRS (National Scientific Research Center in France) in 2001.

He was especially acknowledged for his illustrious six-volume *Encyclopedia of the History of Arabic Science*; and his four-volume book on *Analytical Mathematics during the 9<sup>th</sup>-11<sup>th</sup> Centuries*. Rashed was born in Egypt in 1936 and completed his doctorate in the history of philosophy of mathematics from the University of Paris. He is an emeritus research director of the French National Center for Scientific Research and honorary professor at Tokyo University in Japan.

The King Faisal International Prizes are named after the third king of Saudi Arabia. There are currently prizes in each of five broad categories: Arabic literature, Islamic studies, services to Islam, medicine and science. The science subcategories cover physics, mathematics, chemistry and biology. This year's awards bring the total number of laureates to 182 individuals from about 40 countries. Twelve KFIP laureates in science and medicine have gone on to receive the Nobel Prize.

### References and Resources

- >> King Faisal Foundation: [www.kff.com/english/kfip/2007/islamicstudies.html](http://www.kff.com/english/kfip/2007/islamicstudies.html)
- >> Further details about Roshdi Rashed: <http://chspam.vjf.cnrs.fr/Personnel/Rashed.htm>

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