



An Overview of Prominent Arab Physicists

An Overview of Prominent Arab Physicists and Their Contributions

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Arab scholars during the Islamic Golden Age made huge advances in almost every field of the natural sciences, particularly medicine, physics (optics, mechanics), mathematics, geography, and astronomy. They refined ancient knowledge, translated ancient works into Arabic from Greek, Persian, and Indian sources, invented tools like the astrolabe and sextant, founded optics and the science of light, developed the scientific method of investigation, introduced algebra and trigonometry, established observatories, accurately charted stars, and proposed modern concepts such as the circumference of the Earth and its rotation. In fact, they opened a new world of research and investigation into nature and its global impacts, laying the foundational groundwork for modern science and the scientific method itself. Al-Idrisi was the first to construct an accurate world map in 1154 (1) and was the "most distinguished geographer and cartographer of the Middle Ages." (2) Ibn al-Baitar's innovative works on botany earned him recognition as the "greatest botanist and pharmacist of the Middle Ages," and he wrote "the most complete treatment of agricultural science in the whole Medieval period" (3). Al-Khwarizmi developed the first major astronomical tables, improved the astrolabe (4), gave the world Arabic numerals (5), and was the first to formulate algebra (6). Al-Battani (Albatenius) scientifically improved the astronomical tables, calculated the length of the solar year, demonstrated that the Earth rotates on its axis, designed advanced astrolabes, and pioneered early geodesy (measuring the Earth's circumference) (7).

Physics Contributions

Ibn al-Haytham (Alhazen) revolutionized optics with *Kitab al-Manazir* (Book of Optics), explaining the scientific principles of vision, light, reflection, and refraction through the experimental methods he introduced.

- **Mechanics & Devices:** The Banu Musa brothers worked on Archimedean problems; Ibn Firnas developed lenses for magnification.
- **Early Concepts:** Jabir ibn Hayyan (Geber) hinted at atomic energy; Ibn Yunus used pendulum clocks centuries before Galileo.

Foundational Impact

- **Preservation & Transmission:** The House of Wisdom in Baghdad preserved Greek and Indian texts and fostered scientific exchange.
- **Mathematics:** Developed algebra (Khwarizmi) and advanced trigonometry, crucial for astronomy.
- **Scientific Method:** Ibn al-Haytham championed experimental proof, influencing future science.
- **Legacy:** Islamic science provided the foundation and terminology (zenith, azimuth) for Renaissance European science, astronomy, and mathematics.

Al-Kindi, The Pioneer

Abu Yusuf al-Kindi is considered the pioneering Arab scholar in theoretical physics. Bibliographical records indicate that he authored approximately 50 books on the subject, addressing a diverse range of theoretical and applied physics problems.

Will Durant says, introducing his works:

"He studied the tides, sought the laws that determine the speed of a falling body, and investigated the phenomenon of light in a book on Optics, which influenced Roger Bacon." (8)

Al-Kindi wrote on various branches of physics and showed Muslim scientists' new dimensions of research and investigation, and, as described by modern scholars, "in Physics Al-Kindi is the most frequently named scholar" (9). No fewer than 265 works are ascribed to the first "Faylasuf al-Arab" (Philosopher of the Arabs) on philosophy and natural science; these works include at least 15 on meteorology, 52 on physics (optics, tides, specific weight, and light), and eight on music. Although the bulk of Al-Kindi's scientific works is lost, his investigation of optics was preserved in Latin translation and deeply influenced Roger Bacon and other Western scientists (10).

Al-Razi

Among the Arab scholars who made foundational contributions to this scientific domain, the second most prominent figure after al-Kindi is Abu Bakr al-Razi, widely regarded as one of history's most eminent scientists. His full name is Abū Bakr Muḥammad ibn Zakariyyā' al-Rāzī (864 or 865–925 or 935 CE), an all-time great physician, philosopher, physicist, and alchemist.

Al-Razi's broad range of works covers numerous fields, including medicine, physics, alchemy, and astronomy. He also made great contributions to philosophy, logic, ethics, and Arabic grammar. His medical treatises, such as *Kitab al-Hawi fi al-Tibb* (The Comprehensive Book on Medicine), were highly influential and served as essential references for centuries in both the Islamic world and European institutions. He is credited with distinguishing smallpox from measles in one of his pioneering works and with advocating for experimental medicine. For his great medical discoveries, he is widely regarded as one of the most important figures in the history of medicine (11).

In alchemy, al-Razi is recognized for his systematic approach and detailed descriptions of chemical processes and apparatus. His contributions to philosophy include critiques of religious dogma and a focus on rational inquiry. Al-Razi's intellectual legacy underscores his pivotal role in the advancement of scientific thought during the Islamic Golden Age (12).

Ikhwan al-Safa

Rasa'il Ikhwan al-Safa (Epistles of the Brethren of Purity) is a 10th-century outstanding research work on various aspects of philosophy and natural science, a great Arabic encyclopaedic work by an anonymous Ismaili-linked fraternity in Basra, Iraq, aiming to reconcile science, philosophy (Greek, Persian, Indian), and religion (Quranic studies) through 52 treatises covering almost all basic branches of the natural sciences, math, logic, physics, ethics, humanities, literature, and more, presenting humans

as microcosms of the universe for spiritual purification and universality. The full title of this work is *Rasa'il Ikhwan al-Safa wa Khullan al-Wafa* (Epistles of the Brethren of Sincerity and Friends of Loyalty). The text, written by a mysterious group of philosophers in the Buyid era, is composed of 52 treatises/books and deeply influenced later intellectual leading lights of the Muslim world, such as Ibn Arabi; it was transmitted as far abroad within the Muslim world as the Umayyad Caliphate in Spain. The period of the authorship of the encyclopaedia has not been conclusively established by historians, though the work has been mostly linked with the period of some Isma'ili leaders. Idris Imad al-Din, a 15th-century Isma'ili leader in Yemen, credited the work to Muhammad al-Taqi, the 9th Isma'ili Imam, who lived at the beginning of the Abbasid Caliphate (13).

This historic group of philosophers, largely known as *Ikhwan al-Safa* (Brethren of Purity), worked as a secretive group (14) of 10th-century urban intellectuals, likely from Basra and Baghdad (15), and contributed in different areas of science including geography, astronomy, physics, and many other natural phenomena (16). The language of these epistles is very scientific and technical and shows "that Arabic had become an adequate instrument for expressing scientific thoughts" in all their various styles (17).

Ibn Sina

Ibn Sina (c. 980–June 1037), who is known in the West as Avicenna, is described by the world's scholars and historians as the father of early modern medicine and one of the all-time great physicians. Ibn Sina's contribution to science was a seminal part of the Islamic Golden Age, and he was an influential figure for European medical and Scholastic thought in the Medieval period (18). Besides medicine, philosophy, and botany, Avicenna's works include his historic investigations of geography, astronomy, geology, chemistry, psychology, Islamic-Quranic ideologies, logic, poetry, mathematics, and physics (19).

John Philoponus (c. 490–570), a Greek philosopher, Aristotelian commentator, and Christian theologian, rejected the Aristotelian theory of motion and held that an object moves or acquires an inclination to move when it is influenced by a motive power. Ibn Sina scientifically adopted this idea in the eleventh century. He argues that a moving object possesses force which is dissipated by external agents like air resistance. Ibn Sina differentiates between 'force' and 'inclination,' which he called in Arabic *mayl* (or *maylan*); he believes that an object acquires *mayl* (inclination) when it moves in the direction opposite to its natural motion. Thus Ibn Sina concludes his theory that continuation of motion results from this inclination, or *mayl*, which is transferred to the object, and that the object will continue in motion until the inclination is spent. He further explained that an object propelled with force (a projectile) in a vacuum would not stop unless acted upon (20). This was proposed long before later science endorsed the theory that an object thrown into space upon which the only acting force is gravity would continue indefinitely.

Avicenna's conception of motion is consistent with Newton's first law of motion, inertia, which states that an object in motion will continue in motion unless acted upon by an external force (21). This idea of motion, which disagreed with the Aristotelian view, was roughly ignored until it was described as "impetus" by the Parisian philosopher John Buridan, who is considered the most influential French philosopher of the fourteenth century. John Buridan seems to have been deeply influenced by Ibn Sina (22).

Al-Farabi

Abu al-Nasr al-Farabi holds a prominent position in the classification of sciences. In his magnificent work *Ihsa' al-Uloom*, he divided science into five basic parts and then established their separate branches. He combined optics with mathematics and also described the science of geometry or technology (*Ilm al-Hiyal*) as a separate branch under mathematics. However, he mentioned *Al-Fiziqia* (Physics) in a separate unit, combining it with Metaphysics (*ma ba'd al-tabi'iyat*) (23).

Al-Khazini

The medieval mathematician, astronomer, mechanic, and physicist Abul Fath Abd al-Rahman Mansur al-Khazini, who belongs to the period of the Seljuq dynasty, is one of those Muslim scientists known for their original scientific observations based on experiments. Al-Khazini wrote his famous book on physics and mechanics, *Kitab Mizan al-Hikmah*, written in the 12th century (The Book of the Balance of Wisdom), a pioneering work and a comprehensive encyclopaedia on scales and water-balance. This book advances scientific arguments on hydrostatics, theories of density, specific gravities of metals and precious stones, gravity of the earth, gravity of the air, theories of density and liquids, and provided solid principles of equilibrium; it proposes a theory of a central universal attraction (gravitation) force of the earth drawing all elements towards its centre. The book contains a very scientific table with details of the gravitation of liquid and solid elements, including a history of the subject. His historic contribution to physics gives the tables of the gravitational force and details how this gravitation works with the gravity of liquid and solid elements, which is basically a developed form of al-Biruni's work (24). It also includes a system for the measurement of time with the application of his theory of balance, astronomical observations, and observations on how a liquid can rise or fall in a small space in wet or dry form, impressed by intermolecular forces or how the capillary rise phenomenon takes place under various applications. In short, most of his discoveries were made in the field of kinetics (the study of motion and its causes—forces/torques/dynamics). Among his remarkable works are his theory of Obliquity and Inclination (dynamics) and the Theory of Impulse, and these two investigations of al-Khazini played an instrumental role in the development of kinetics (25).

The mechanism formulated by al-Khazini introduces an accurate system that has been considered the world's most precise instrument to check the weight of objects, analyze specific gravities, and examine combinations forming homogeneous mixtures or the composition of alloys of metals with other metals or non-metallic elements. He developed this mechanism to assess the composition of two or more elements, typically created to examine properties like strength, hardness, or corrosion resistance beyond those of the pure constituent elements, with common examples being steel (iron + carbon), brass (copper + zinc), and bronze (copper + tin).

Will Durant writes about this work:

"The outstanding work of physical science in this age was *Kitab Mizan al-Hikmah* or Book of the Balance of Wisdom, written about 1122 by a Greek slave from Asia Minor, Abul-Fath al-Khuzini. It gave a history of physics, formulated the law of the lever, compiled a table of specific gravity for many liquids and solids, and proposed a theory of gravitation as a universal force drawing all things towards the centre of the earth." (26)

For his great contributions to physics and mechanics, al-Khazini has been recognized as "the physicist of all physicists" (27), known to have been "one of the greatest scientists" of the Middle Ages; historians and scholars also consider him one of the greatest inventors of scientific instruments and machines of any time (28).

Al-Biruni

Abu Raihan al-Biruni (973–1050) is also one of the renowned Muslim physicists of the Medieval period; he has even been considered "the most original and profound scholar Islam produced in the domain of natural science" by some historians (29). He is one of the Arab scientists who founded the science of hydrostatics (30).

Besides his great work in developing the hydrostatic balance, al-Biruni also contributed extensively in this field with experimental and accurate descriptions on the topic of density, including the different types of densities and how they are measured; he determined the specific density of 18 types of precious stones. His work on the subject was very influential and later influenced scientists like Galileo and Newton, who used his conclusions in their own research.

Al-Biruni established the law of communicating vessels, which proved that the specific density of a body is equivalent to the volume of water it displaces; his observations gave the scientific reason for the rise of water from geysers and wells, explaining the theory of hydrostatic pressure due to which water rises upward after a specific level, as happens in natural springs or artesian wells where the water naturally flows back to the surface due to underground pressure (31). He very accurately measured specific weights and "defined the ratios between the densities of gold, mercury, lead, silver, bronze, copper, brass, iron, and tin" (32).

Ibn al-Haytham

The full name of one of the greatest scientists this world has ever produced is Abu Ali Mohammad Ibn Hasan Ibn al-Haytham. Ibn al-Haytham (in Latin, Alhazen) was born in Basra (in modern-day Iraq) in 965, migrated to Egypt during the reign of the Fatimid Caliph al-Hakim, and died in Cairo in 1039 (33).

He is truly referred to as "the father of modern optics," "the first true scientist" (34), and Pioneer of Modern Optics, as called by UNESCO while celebrating the International Year of Light. He is regarded as the "very first theoretical physicist" and "father of the modern scientific method" by the famous physicist Professor Jim Al-Khalili of the University of Surrey (35). "So he can be regarded as the very first theoretical physicist, too... He is perhaps best known for his invention of the pinhole camera and should be credited with the discovery of the laws of refraction." (36) Indeed, his discoveries in this field make him the founder of modern optics.

Abū 'Alī al-Ḥasan Ibn al-Haytham al-Baṣrī (965–1040 CE), known in the West as Alhazen, is considered by many Western scholars the first true scientist of known history. He grew up in Basra and was educated in Baghdad and Basra. From Basra, he moved to Cairo during the reign of the Fatimid Caliph al-Ḥākīm, who had invited him there specifically to continue his scholarly works under the patronage of his caliphate. He wrote vital parts of his famous work, *al-Manazir*, or the Book of Optics, in Cairo. Al-Haytham died in Cairo in 1040 (37).

Ibn al-Haytham is widely recognized as "The First Scientist's Guide to Truth: Alhazen on Critical Thinking - The Marginalian" and is called the world's first true scientist because he brought a revolution to science by introducing a rigorous, experimental methodology—known today as the scientific method—that required testing hypotheses through repeatable experiments and practical assessment rather than relying solely on theoretical claims or philosophical and logical speculation (38).

Rosanna Gorini's writings on al-Haytham, particularly her 2003 article "Al-Haytham the man of experience: First Steps in the Science of Vision," characterize Ibn al-Haytham as the foundational "modern" scientist, shifting the understanding of light from Greek abstract theory to an experimental, empirical science. Gorini highlighted his contributions to physics and his role as a pioneer in ophthalmology and the founder of psychophysics. Gorini offered a great tribute to Ibn al-Haytham's introduction of his scientific method as follows: "According to the majority of the historians, al-Haytham was the pioneer of the modern scientific method. With his book, he changed the meaning of the term 'optics,' and established experiments as the norm of proof in the field. His investigations were based not on abstract theories, but on experimental evidences. His experiments were systematic and repeatable." (39)

Arab scholars called him the 'Second Ptolemy' (Baṭlamyūs Thānī). His works as a great scholar actually cover many disciplines: physics, mechanics, optics, mathematics, astronomy, medicine, etc. "He was one of the senior most members of the Muslim scholars' trio during the 10th–11th centuries, the other two being al-Bīrūnī (973–1048) and Ibn Sīnā (980–1037)."

Ibn al-Haytham was a prolific writer. According to his own testimony, he wrote 25 works on mathematical sciences, 44 works on (Aristotelian) physics and metaphysics, and also on meteorology and psychology. Moreover, his autobiographical sketch clearly indicates that he studied very thoroughly Aristotle's (natural) philosophy, logic, and metaphysics, of which he gave a concise account (40).

Ibn al-Haytham is one of the greatest medieval scientists and scholars, who influenced Western scientists the most. He is also known as the founder of modern optics. He produced many great works, most of which dealt with problems of physics, geometry, and optics (41).

He wrote summaries of the works of Greek philosophers, especially the scientific works of Plato, Aristotle, and Galen. His works on various topics of the natural sciences, such as physics, optics, astronomy, mathematics, and medicine, number no fewer than 200. Ibn al-Haytham wrote approximately 44 books focused on astronomy, physics, and metaphysics, and at least 15 books on light and vision (optics).

His outstanding treatise, *Kitab al-Manazir*, deals with great issues, especially a comprehensive study of light and vision. His synthesis of light and vision includes great studies such as eye vision, binocular disparity, the visual system, the process of sight, the structure of the eye, formation of images in the eye, the law of reflection, the principle of refraction in the least time (which would later be developed as Fermat's principle), the law of refraction, binocular vision, image inversion, pinhole projection, magnifying power of a lens, spherical and parabolic mirrors and spherical aberration, and the vertical and horizontal components of light rays (42).

The most significant works of al-Haytham contain a complete formula for understanding the natural laws of reflection and a scientific investigation of refraction; this includes his experimental measures involving the study of rays that form angles of incidence and deviation. His work also includes

“Alhazen’s problem”—which he introduced to determine the point of reflection from a plane or curved surface, given the centre of the eye and the observed point; he formulated his solution by means of conic sections. His other optical research includes *Ḍaw’ al-qamar* (“Light of the Moon”), *al-Hāla wa-qaws quzah* (“The Halo and the Rainbow”), *Ṣūrat al-kusūf* (“The Shape of the Eclipse”); he is the first to discover the laws that led to modern photography and invented the camera obscura, and *al-Ḍaw* (“A Discourse on Light”) (43).

The Book of Optics as the Foundation Stone of Modern Physics

The famous work of al-Haytham, *Kitab al-Manazir*, or the Book of Optics, is considered by historians and prominent scholars the real foundation of optics and physics as well as modern science. The first three books of the Book of Optics, written by Alhazen in Cairo in very disturbed circumstances in the eleventh century, were translated into English by A. I. Sabra in 1989. Book I discusses the different aspects of optics, including the eye's structure, the origin of vision and light, and the formation of images in the eye. This book influenced all other works on optics from the Medieval period to the modern period, especially the thirteenth to seventeenth centuries. In fact, al-Haytham's works laid the foundation upon which Kepler produced the scientific formula of image formation. However, as Ian P. Howard described, Alhazen's work, *Kitab al-Manazir*'s Books II and III, has been "almost totally ignored" (44).

According to Ian P. Howard, these two books are full of very valuable content and contain hundreds of scientific formulas, experimental theories, and observations carried out by al-Haytham on a wide range of investigations on various topics that are today part of modern visual perception. He founded many of the fundamental principles of light and vision. Howard explains: The discoveries which are credited to scientists living in the last two hundred years include a "theory of unconscious inference"; the "law of equal innervation of the eye muscles"; the "principles of binocular direction"; "constancy of size, shape, and colour"; induced "visual motion"; the "vertical horopter"; the "fusional range of binocular disparity"; and many others (45).

The pinnacle of Ibn al-Haytham's research works and his reputation as a great mathematician are primarily due to his unparalleled discoveries in optics, but in fact the scope of his research and intellectual and scientific inventions is much broader. Great contributions were made by him to mathematics, astronomy, medicine, physics, chemistry, and philosophy. He is the author of about 200 books, but his real fame as a great scientist rests in physics, mathematics, and astronomy. He has about four dozen books on physics to his credit, of which the most famous and remarkable work is *Kitab al-Manazir* (كتاب المناظر), or "The Book of Optics," translated into Latin as "De Aspectibus" (6a). It is a seven-volume treatise on optics and other fields of natural sciences, written by the great Arab scholar Ibn al-Haytham, known in the West as Alhazen. The work consists of many new investigations and discoveries in optics, which is considered today one of the most important branches of physics; his book deals with light and its properties and primary behavior.

In fact, his work is a storehouse of vast knowledge and experiments about optics and other subjects and founded optics as a vast science, analyzing almost every important problem of light, covering many simple and complex subjects ranging from the source of the eye's vision, refraction, and reflection of light off a metallic surface to create an image, to the interaction of multiple layers. His investigations are recognized for presenting scientifically founded arguments with experimental proofs against the old extramission theory of vision held by Euclid in his Optics. His research refuted their conclusions, which

were mostly based on unprofessional assessments, and he presented a totally different idea widely known today as the modern intromission theory, which today accepts the formula that vision takes place by light entering the eye (46).

The book is also characterized by the scientific method, and its author is the first to use it. Its description of the camera obscura theory and formulation of 'Alhazen's problem' are enough to convince anyone of the revolutionary role of the book in the evolution of science and scientific methods. He was the first to discover the idea of the camera obscura; he conducted a historic experiment to examine the accuracy of his theory, observing the image of the sun in a half-moon shape during an eclipse. He observed it on the wall opposite a small hole he made in the window shutter. Thus, he laid the foundation of modern camera technology, and, as historians consider: "this is the first known mention of the Camera Obscura or dark chamber, on which all photography depends" (47).

The works of al-Haytham were frequently cited during the scientific revolution by Isaac Newton, Johannes Kepler, Christiaan Huygens, and Galileo (48). The book extensively influenced European intellectuals from the Medieval period to the modern period, inspiring them especially between the 13th and 17th centuries, and it guided the development of physics, optics, mathematics, and the mathematical method for solving scientific problems in Europe to new heights (49).

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