

Muslims And Astronomy

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Precise observation and an ability to find new mathematical solutions to old problems were] the two main strengths of Muslim scientists in the Middle Ages. Celestial mapping sprang from a religious concern: the need to establish correct coordinates of cities so that Muslims could determine the direction of Ka'bah - the qibla - towards which all Muslims face themselves in prayer five times a day. This need led to significant developments in Trigonometry, a field fundamental to terrestrial mapping and to the computation of planetary orbits. The medieval qibla tables were often accurate to within one or two minutes. Muslim scientists were the first to express doubts about many of the details of the Ptolemaic system. Al-Battani (ninth century) showed, contrary to Ptolemy, annular eclipses were possible, and that the angular diameter of the sun was subject to variation. He also developed a theory of the conditions of visibility of the new moon. The greatest Muslim physicist Ibn al-Haytham (Alhazen) argued that the Milky Way was quite far from the earth no matter what Aristotle said, and estimated the height of the earth's atmosphere at about 32 miles, very close to 31 miles as we know today. Arabs also excelled at making astronomical instruments - particularly astrolabes which were used for navigational purposes and for determining the positions of stars.]

To scientists in Islam's Golden Age - whose bold thoughts laid the groundwork for today's exploration of space - the satellite might have been astonishing; but the Prince's photographic assignment and his other assignments would not have been totally unfamiliar. They too were knowledgeable about optics and astronomy and they were experts in ephemerides - tables showing the positions of celestial bodies on given dates.

Lunar observation, for example, was, and is, important to Muslims; for religious purposes they follow a lunar calendar [twelve months] and the new moon marks the beginning and end of [Islamic months] the fast of Ramadan and determines the date of the pilgrimage to Makkah (Mecca) - the Hajj - two of the five religious duties incumbent upon all Muslims.

Celestial mapping also sprang from a religious concern: the need to establish correct coordinates of cities so that Muslims could determine the direction of Makkah [Ka'bah] - the qibla - towards which all Muslims [face] prostrate themselves in prayer five times a day. And though observation of the new moon and determination of the qibla may seem prosaic subjects today, it was by pondering just such everyday phenomena that advances in science

were made.

The mathematical determination of the qibla, for example, was one of the most advanced problems in spherical astronomy faced by medieval astronomers and mathematicians and the trigonometric solution eventually found was of great sophistication. Trigonometry itself, largely an Arab development, is fundamental to the computation of planetary orbits as well as to terrestrial mapping, and consequently medieval qibla tables often attained great accuracy. That of al-Khalili, who wrote in Syria in the 14th century, gives the coordinates of a large number of

towns in degrees and minutes and is generally accurate to within one or two minutes.

It could be argued, in fact, that precise observation and an ability to find new mathematical solutions to old problems were the two main strengths of Muslim scientists in the Middle Ages. And though they, like their European counterparts, never fully escaped the tyranny of Aristotle and Ptolemy - whose models of terrestrial geography and of the heavens dominated men's minds until the Renaissance and were not finally demolished until the publication of

Newton's Principia in 1687.

Muslim scientists were the first to express doubts about many of the details of the Ptolemaic system. Indeed, it was the growing awareness of the divide between Ptolemy's theoretical model of the universe and observed reality that culminated in the discoveries of Nicolaus Copernicus, Tycho Brahe and Johannes Kepler during the 15th to 17th centuries, and some of those doubts had been transmitted to European scientists from Spain in 12th- and 13th-

century translations of Arabic scientific works.

Al-Battani, called by his European translators Albategni[us], is a case in point. He wrote in the ninth century on a wide number of scientific topics and some of his observations struck at cherished Ptolemaic dogmas. He showed, for example that, contrary to Ptolemy, annular eclipses - in which a ring of light encircles the eclipsed portion - were possible, and that the

angular diameter of the sun was subject to variation.

He showed - again contrary to Ptolemy - that the solar apogee was subject to the precession of the equinoxes; he corrected a number of planetary orbits; he determined the true and mean orbit of the sun. Interestingly in the light of Prince Sultan's observation of the new moon, al-

Battani also developed a theory of the conditions of visibility of the new moon.

Other Muslim astronomers also came up with data that conflicted with Ptolemy, one of them perhaps the greatest Muslim physicist of them all: Ibn al-Haytham, called Alhazen in the medieval West. Al-Haytham argued that the Milky Way was quite far from the earth no matter what Aristotle said, and estimated the height of the earth's atmosphere at 52,000 paces - a pace being roughly one meter, or three feet. Al-Haytham worked that out from his observation

that the astronomic twilight begins when the negative height of the sun reaches 19 degrees. Since the atmosphere is about 50 kilometers up (31 miles) and 52,000 paces is roughly 52 kilometers (32 miles), Ibn al-Haytham was very close indeed.

In the pre-telescope age, observational astronomy was, of course, carried out with the naked eye. Muslim scientists, however, perfected observatories in a number of places; those at Maragha and Samarkand are the most famous. At these observatories, astronomers gathered to refine Ptolemy's coordinates for the stars and, eventually, to revise Ptolemy's catalog of stars. This catalog which gave the positions of 1,022 stars, classified, as they are today, by magnitude, or brightness, was heavily revised, notably by the 10th-century astronomer Abd al-Rahman al-Sufi [Azophi], whose Book of the fixed Stars is the earliest illustrated astronomical manuscript known; the copy in the Bodleian Library, the work of the author's son, is dated 1009 and the author expressly states that he traced the drawings from a celestial globe.

There is an even earlier representation of the heavens in an Umayyad hunting lodge built about A.D. 715 in Jordan. It is called Qasr al-'Amra and in the dome of the bath house in the lodge are fragments of a fresco showing some 400 stars and parts of 37 constellations, drawn on a stereographic projection - which implies a familiarity even at that early date, with Ptolemy's Planispherium.

Arabs also excelled at making astronomical instruments - particularly astrolabes which were used for navigational purposes, for determining the positions of stars and for solving problems in spherical astronomy. There were three sorts of astrolabes: planispheric, linear and spherical. These were used at the observatories of Maragha and Samarkand, and were substantially the same as the instruments used [later] by European astronomers until the invention of the telescope.

The observatory at Maragha was founded by the famous mathematician Nasir al-Din al-Tusi in 1259, one year after the fall of Baghdad to the Mongols. Because the Mongol invasions into the lands of Islam had opened a land route to China, Muslim astronomers were eventually able to work together with their Chinese counterparts.

The main theoretical work done at the observatory had to do with simplifying the Ptolemaic model and bringing it into line with the Aristotelian model, which postulated uniform circular orbits for the planets. Although they were often misguided, they made very important contributions; Ibn al-Shatir [early 14th century], for example, came up with models of the movement of the moon and of Mercury that are strikingly similar to those of Copernicus.

The observatory of Ulugh Beg at Samarkand, built between 1420 and 1437, was used to re-compute the positions of the stars in Ptolemy's catalog, and there is little doubt that the

organization of this observatory and the instruments employed there influenced Tycho Brahe's famous observatories at Uraniborg and Stjerneborg.

Another observatory thought to have influenced Tycho Brahe was that proposed and built in Istanbul in the 16th century. In 1571 in Istanbul, Taqi al-Din Mohammed ibn Ma'ruf, a former judge from Egypt and author of several books on astronomy was appointed head-astronomer of the Ottoman Empire and immediately proposed construction of an observatory. He wanted to begin the urgent task of updating the old astronomical tables describing the motion of the planets,

the sun and the moon. His request was well received by the Grand Vizier and patron of sciences, Sokullu Muhammad, but between 1571 and 1574 the Ottomans had to fight no less than three costly wars against the three major powers of Europe, Venice, Spain and Portugal, so it was not until mid-1577 that the project was completed.

Taqi al-Din's observatory consisted of two magnificent buildings, perched high on a hill overlooking the European section of Istanbul and offering an unobstructed view of the night sky. Much like a modern institution, the main building was reserved for the library and the living quarters of the technical staff, while the smaller building housed an impressive collection of instruments built by Taqi al-Din himself - including a giant armillary sphere and a mechanical clock for measuring the position and speed of the planets; aware that Europe was beginning to move ahead in astronomy he was determined to restore the Islamic world's once uncontested supremacy.

A few months later, unfortunately, on a cold November night - the first night of the holy month of Ramadan - a comet with an enormous tail unexpectedly edged into sight and set off a controversy that would put an end to his dream - and the observatory. Twisting and twirling, the comet grew brighter and steadier by the day for 40 days, and soon became a fireball soaring in the heavens like the sun and terrifying observers on earth.

One such observer was the Sultan Murad III, whose own father Sultan Selim, had died shortly after another comet had appeared. About to open a campaign in the Caucasus against Persia and its allies, Murad demanded a prognostication on the comet and Taqi al-Din, working day and night without food and rest, did so...Unfortunately for Taqi al-Din, his predictions didn't quite turn out right. Though two Persian armies were defeated in the war, the Ottomans experienced certain reverses, a devastating plague broke out in some parts of the empire and several important persons died, and within a short period of time the Ottoman court began to quarrel about the observatory. One faction, headed by the Grand Vizier Sokullu favored continued support of the institution, and the other led by Sokullu's political rival, said that prying

into the secrets of the future was...a waste of funds.

For a short period Sokullu prevailed and Taqi al-Din plunged into astronomy at a feverish pace for two years. But then Sokullu was killed and in 1580 a wrecking squad from the Marine Ordnance Division appeared on the premises, and its commander, citing the misfortunes that had befallen the Ottomans since the apparition of the comet, gave orders to level the buildings. Another subject allied to astronomy that deeply interested Muslim scientists - and to which they made important contributions - was optics. Thus Newton's Optics, published in 1704, had a long history of experimentation behind it. Classical theories of vision held that sight was the result of rays emanated from the eyes, rather than the reflection of light from the object viewed. It was Ibn al-Haytham who broke with this classical theory and developed a theory with mathematical proof, in accord with the facts. His work with the camera obscura and discovery of the mathematical principles behind the phenomenon of the rainbow were important steps in the development of optical instruments - though an explanation of the colors of the rainbow had to wait for Newton.

Other Muslim scientists also made important contributions to this subject, including the famous al-Biruni. One of the scientists connected with the Maragha observatory Kamal al-Din al-Farisi, wrote an important commentary on Ibn al-Haytham's work on optics, in which he gives the results of a fascinating series of experiments with the camera obscura. Men like these would have been fascinated at the idea of photographing the earth from outer space, and with the theories that make such achievement possible - theories that are in some cases based on observations they themselves originated. It is thus peculiarly fitting that an Arab Muslim should take part in a scientific mission in the heavens that so interested and perplexed the scientists of the Middle Ages to whom we all owe so much