The Writings of Qutbaddin Al-Shirazi in Physics and Astronomy

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ABSTRACT

Qutbaddin al-Shirazi was widely known as an encyclopedic scientist. V.V. Barthold considered him "a great astronomer and physicist who was looking for new ways in science."One of the first historians of science who turned to the study of the scientific heritage of al-Shirazi was E. Wiedeman, who researched and partially translated into German the "Treatise on rolling motion and the relation between a plane and a curve" relating to geometric optics and the shape of the Earth "Shah's gift in astronomy", The purpose of this work is to study and evaluate the scientific heritage of al-Shirazi in physics and astronomy, the formation of his scientific views, the influence on the scientific creativity of the scientist of the writings of his predecessors and the role of the scientific heritage of al-Shirazi in the work of subsequent scientists of the medieval Near and Middle East.

Keywords

Qutbeddin Mahmud ibn Mas'ud ibn Muslim al-Shirazi , Nasiriddin-at-Tusi (1201-1274), Euclid, Nicomachus, Aristotle, Ptolemy, Maragin Observatory, –"The crown jewel of the dpj decoration of Dabaj" (Durra at-taj li gurra ad-Dabaj), "The boundary of comprehension in the knowledge of the celestial spheres" (Nihaya al-idrak fi daraya al-aflaq), the sphere of steam and wind, . the atmosphere of the Earth, the "Shah's gift", The Earth does not hold on anything, al-Khorezmi, Ibn Korra, Al-Battani,al-Farabi,Abu'l-Wafa, Ibn al-Haysam,Ibn Sina,al-Biruni, Omar Khayyam, Ulugbek,Jamshid al-Kashi, Ibn ash-Shatyr, Venus, Mars, aerosol composition.

Qutbeddin Mahmud ibn Mas'ud ibn Muslim al-Shirazi was born in 1236 in the capital of Fars -Shirazi in the family of a doctor.His father, Ziaeddin Mas'ud ibn Muslim al-Kazeruni, a native of Kazerun (near Shiraz), was a famous doctor and a teacher of medicine in Shiraz.Having received an initial education in the basics of sciences and medicine under the guidance of his father; At the age of 14, Ash Shirazi works as a doctor and simultaneously studies mathematics, astronomy, philosophy based on the works of ancient and medieval scientists.In 1256, Fors, like all of Iran, Azerbaijan, and then Iraq, was conquered by the grandson of Genghis Khan Hulagu and became part of the state of the Ilkhans of the Hulaguids (1256-1353). The capital of the Hulaguid state becomes Maraga, where the largest astronomical observatory was built, which was headed by Nasiriddin-at-Tusi (1201-1274).

At the end of 1259 or at the beginning of 1260, Ash Shirazi became a researcher at the Maraghi Observatory, which was still under construction at that time. Studying astronomy and mathematics under the guidance of at-Tusi, he simultaneously participates in the construction of the observatory, conducts independent observations and writes commentaries on the

works of Euclid, Nicomachus, Aristotle, Ptolemy and scientists from the countries of the medieval Near and Middle East.

After ten years of work at the Maragin Observatory al-Shirazi around 1269. Appointed judge in Sivas and Malatia (Asia Minor). For some time he was engaged in teaching activities in Konia, and in 1282, as the ambassador of the Mongols, he was sent to Egypt.In 1290. Al-Shirazi moves to Tabriz, where the Hulaguids transferred the capital of the Ilkhanov state at that time, and becomes the head of the new Tabriz scientific school, which he directs until the end of his life. A large observatory is being built here, in which astronomical observations are carried out under the leadership of al-Shirazi, in particular, the lunar eclipse of 1295 is observed. And the solar eclipses of 1305 and 1306 . Qutbaddin al-Sherazi died in 1311.

Al-Shirazi was the author of numerous works on natural sciences and humanities.Some of his works are commentaries on the works of ancient and Middle-century scientists.These comments were written in the Tajik-Persian language, as a result of which they played an important role in the dissemination of physical and mathematical knowledge in Iran and Central Asia. Al-Shirazi was also the author of numerous original works on astronomy, mathematics, physics, philosophy and medicine.The works of al-Shirazi contain a list of 12 physics and mathematics with their brief annotations, the most important of which are three essays.The first of them is "The Crown Jewel of the dpj decoration of Dabaj" (Durra at-taj li gurra ad-Dabaj) - an encyclopedic work consisting of six parts, written in Tajik-Persian, dedicated to Emir Dabaj ibn Filshah ibn Rustamshah. The first part of this work consists of 5 books, published by S.M.Mashkutov in Tehran in 1932-1942. with a brief preface [2].

Two other works – "The boundary of comprehension in the knowledge of the celestial spheres" (Nihaya al-idrak fi daraya al-aflaq) and "Shah's gift on astronomy" (at-Tuhfa ash-Shahiyya fi-l haya) - astronomical works, similar in content, are written in Arabic. The first of them was completed in 1281, and the second in 1285. As a "Shah's gift", the last work was dedicated to the ruler of the Rum Sultanate, Amirshah Muhammad ibn Masdar. In these works, each of which consists of 4 books, the views of al-Shirazi on physics and astronomy, which are the subject of our research, are set out.

In the second chapter – "The development of physical ideas in the works of al-Shirazi" - the views of al-Shirazi on physics are considered. Since his main works are devoted to astronomy, when considering the issues of astronomy, he encountered many physical problems that required scientific explanation.Therefore, the physical ideas of al-Shirazi are closely related to his astronomical teaching.

Al-Shirazi's contribution to physics mainly relates to the field of kinematics, the doctrine of gravity, geometric optics, geophysics and astrophysics.

In kinematics, he introduces the concept of kinematic relativity, which is applied to the proof of the daily rotation of the Earth. Developing his ideas about the relativity of perception, al-Shirazi comes to the conclusion that the apparent movement of the heavenly bodies depends on the position of the observer, for example, if you put the observation point on the Moon, then the Earth will rotate around the Moon as the center of rotation.Following al-Biruni, Avicenna al-Shirazi conducts a kinematic study of the uneven motion of the Sun along the ecliptic.

In the matter of gravity, al-Shirazi adheres to al-Biruni's point of view that all heavy bodies are attracted to the center of the Earth, which is the center of the World.

The geometric optics of al-Shirazi represents a further development of the famous "Optics" of Ibn al-Haysam (965-1039).

In geophysics, al-Shirazi investigates such problems of atmospheric optics as Avicenna-twilight phenomena and the cause of the blue color of the sky, and also provides a method for determining the height of the atmosphere.Twilight phenomena in al-Shirazi are characterized as "a gradual weakening of daylight after sunset or a weakening of night darkness before sunrise" [I, l.148 b], and they "arise in the sphere of air" or in the "sphere of steam and wind" as a result of reflection of layered rays from dense layers of the

atmosphere, containing dust and water particles, i.e. it binds twilight light with the aerosol composition of the atmosphere. He associates the end or beginning of twilight with the position of the Sun below the horizon, when the maximum value of its height should not be more than -180 [I, l 147 b].

The reason for the blue color of the sky according to al-Shirazi is also the aerosol composition of the atmosphere. "The lower layers of air," he writes, "are more susceptible to light than the transparent layers, since they contain particles of terrestrial origin and water, and the sun's rays, reflected from them, will reveal the blue color of the sky... The high layers of air are completely free from dust and moisture particles.

The rays of the Sun and stars freely penetrate the transparent air and are not perceived by it.And therefore an observer at a high altitude above himself should see the darkness [I, l II a,b].

It is noteworthy that al-Shirazi associates the color of the sky with the lower layers of the earth's atmosphere, with its aerosol composition. It is clear that in the era in which the scientist lived, there could be no question of the wave nature of light scattering, developed in the second half of the XIX century by Tyndall and Rayleigh. But the fact that particles suspended in a turbid medium are the cause of scattering, and that there is no such scattering at high altitudes (except for molecular scattering) al-Shirazi was known, although he uses the term "reflection" instead of the term "scattering".

Based on the study of twilight phenomena and using the al-Jayani method (approx.989-1080), al-Shirazi determines the height of the dense part of the atmosphere, which, according to his calculations, is 80-95 km (translated into modern units).

The third chapter – "The development of astronomical ideas in the works of al-Shirazi" - presents the astronomical views of the scientist. First, here we consider the picture of the world according to al-Shirazi, which, like his predecessors, is geocentric. "The Earth," writes al-Shirazi, "is a natural place of heavy bodies, the gravity of all bodies is directed to the center of the Earth, which is located in the center of the world" [I, l. 15 a]. As you know, the question of "what the Earth is based on" remained unresolved until the discovery of Newton's law of gravitation. Therefore, al-Shirazi writes: "It is paradoxical that despite its enormous weight, the Earth does not hold on to anything" [I, l 15 b].

The order of the location of the luminaries at ash-Shirazi is somewhat different from the Ptolemy system. He believes that "Venus is close to Mars in its brightness, therefore, it should be placed between Mars and the Sun" [I, l II a].

A distinctive feature of the al-Shirazi system is that the central body of the world -the Earth, in his opinion, rotates, while in the Ptolemy system the Earth is stationary."Those people who neglected the daily rotation of the Earth did not achieve their goal," writes al-Shirazi, "the apparent daily rotation of the celestial sphere and other luminaries occurs as a result of the rotation of the Earth around its axis" [I, L. 14].

One of the important arguments of al-Shirazi in favor of the rotation of the Earth was the concept of the relativity of motion. "The observed movement of the firmament with stars from east to west," he writes, "is an apparent phenomenon: it looks like a boat floating on a river. It seems to us that only the water is moving, and the boat remains in place. In fact, this is not the case. The apparent movement of water occurs as a result of the movement of the boat.This can be seen if we compare the floor of the boat with the things on the shore" [I, l. 14 a]. Here we are not talking about the dynamic relativity of Galileo and Newton, but about the relativity of perception. The idea of relativity of perception was expressed by Ptolemy. But of all the astronomers of the medieval East known to us, only al-Shirazi applies it to the justification of the rotation of the Earth; in this sense, al-Shirazi can be considered as the immediate predecessor of Copernicus, for whom this was one of the main provisions in favor of proving his doctrine of the motion of the Earth.

Next, al-Shirazi's theory of the movement of the Sun is considered, which he expounds within the framework of the geocentric system. Having proved the equivalence of Ptolemy's eccentric and epicyclic hypotheses, al-Shirazi uses the eccentric hypothesis to determine the elements

of the Sun's motion. Together with other astronomers of the Marginsky Observatory, he experimentally established the movement of the apogee of the Sun.Al-Shirazi writes: "According to our measurements, the change is one degree in 70 years.However, Ptolemy did not find it... According to Potlemy, the longitude is 65 and a half degrees. However, the new measurements that we carried out in 650 Yazdigerd gave a result equal to 29 degrees and six minutes of Gemini" [I, ll. 43b, 45a].Thus, in 1282, al-Shirazi received 8906' for the longitude of the apogee of the Sun, thereby confirming and clarifying the conclusions of al-Battani, al-Biruni and at-Tusi about the change in the position of the apogee of the Sun.

Next, the theory of planetary motion and the definition of the elements of this motion are considered. After a brief presentation of the Ptolemaic model of planetary motion and its modification, at-Tusi considers a new model of ash-Shirazi, if we remain on the point of view of the Ptolemaic geocentric system, more accurately depicts the visible motion of the planets and makes it possible to more accurately calculate the parameters of this motion.At the same time, the principle of uniform circularity remains unchanged. To explain the complex movement of Mercury, al-Shirazi offers a separate model, which also differs in its orginality from the models of its predecessors.Al-Shirazi's ideas on the theory of planetary motion were further developed by Ibn al-Shatir (1304-1375).

In the same chapter, the theory of lunar and solar eclipses by al-Shirazi is considered about the nature of the ashy light of the Moon, as well as its glow during the full phase of the eclipse. "At the new moon, writes al-Shirazi, the Moon glows with secondary light reflected from the sphere of air (i.e., the Earth's atmosphere), and the light coming at an obtuse angle is stronger than the one that falls due to reflection at an acute angle.Consequently, the luminosity of the Moon during an eclipse will be stronger than at a new moon" [I, l. 107 a]. Thus, according to al-Shirazi, during the eclipse, the Moon is illuminated by the sun's rays that have passed through the Earth's atmosphere, and ash light is the result of reflected sunlight from the Earth's atmosphere hitting the Moon.

These statements of al-Shirazi to a certain extent anticipated the ideas of Leonardo da Vinci (1452-1519) that the ashen light of the Moon arises due to the fact that the rays of the Sun reflected from the surface of the Atlantic Ocean fall on the Moon.

Here, the views of al-Shirazi on the nature of the glow of the planets are considered.Al-Shirazi expresses the idea that all the planets glow with reflected sunlight and admits that for a lunar observer, the Earth will also be a luminous body. He's writing: "Let's say that someone finds that someone is on the moon; then the Earth will be visible to him just as we see the Moon. He will see that the "Moon" seems to be rotating around him, and within one month he will observe all those phases that the "Moon" has [I, l. 113 b]. Copernicus has similar statements.

The end of the third chapter is devoted to stellar astronomy and astronomical measurements of al-Shirazi, among which his teaching on the precessional axis of the world should be noted, his teaching on the precessional movement of the axis of the world, i.e. the axis of the Earth, should be noted. "The pole of the world at the present time," writes Al-Shirazi, "is located in the constellation Ursa Minor. By new measurements, it was found out that it moves by one degree in 70 years ... The half-life of this change is twelve thousand six hundred years" [I, ll. 25 b , 26 a]. From this it can be concluded that al-Shirazi, along with other astronomers of the Maragin Observatory, received 51", 3 for the value of the annual precession, and -25200 for its period (modern values are -50", 2 and 26000 years, respectively). If we take into account the level of development of measuring instruments of that time, then these results speak for themselves as fairly accurate.

In conclusion, an assessment of al-Shirazi's contribution to the development of astronomy and physics in the Near and Middle East is given. Studies show that Qutbaddin al-Shirazi was one of the first scientists to come up with the idea of the rotation of the Earth, which he justified using the concept of relativity of motion. His ideas on atmospheric optics, the nature of the Moon's ashen light, as well as its glow during

eclipses, the nature of the glow of planets, and the precessional movement of the Earth's axis are significant contributions to physics and astronomy. No less important are his works on the theory of planetary motion.

The study of the scientific heritage of scientists from the East has a prominent place in the development of world science, such as al-Khorezmi, Ibn Korra, Al-Battani,al-Farabi, Abu'l-Wafa, Ibn al-Haysam, Ibn Sina,al-Biruni, Omar Khayyam, Nasiraddin at-Tusi, Ulugbek, Jamshid al-Kashi and others, and their works have left a noticeable mark in various fields of human knowledge, including in the exact sciences of mathematics, astronomy and physics.

The scientific heritage of al-Shirazi had a noticeable impact on the work of subsequent astronomers of the Near and Middle East and other countries.

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