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Reassessment of Islamic Astronomical Sciences

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Abstract: This paper attempts to reevaluate Muslim input to astronomy. Underling the efforts and the contributions of Al–Biruni and Al–Battani to astronomy is the core concern of this paper. Astronomy is one of the sciences that have existed since the dawn of recorded civilization. It has been called the queen of sciences and it incorporates many disciplines such as physics, optics in particular, and mathematics, as well as celestial mechanics. Reassessing the contributions of Muslim scholars and Qur'anic views on astronomy is an urgent call in a time when knowledge is claimed by one civilization, the Western civilization.

Key words: Islamic astronomy, Quranic views on astronomy, Muslim contributions to astronomy, Al–Biruni, Al–Biruni

INTRODUCTION

Astronomy is that branch of engineering sciences that deals with the origin, evolution, composition, distance and the motion of all bodies and scattered matter in the universe. In the Arabic peninsular before the advent of Islam, there was an intimate knowledge of the sun and the moon as well as the night sky whereby meteorological phenomena were associated with the changing patterns of these celestial objects throughout the year with reasons.

The expansion of the Islamic intellectualism began in 622 AD with the journey of Prophet Mohammed from Mecca. Within a century, Muslims dominated the whole Middle East and extended eastwards across northern India to the borders of China, and westwards across Asia Minor and North Africa, from there to Spain and part of Europe. Muslim scholars became enthusiastic intellectuals and benefited from the achievements of the great civilizations of the past developing interest for astronomy and other fields. This was in line with one of the characteristics of Islam, that is, to have love for wisdom and knowledge. The Qura'nic dictum on astronomy reads:

> "We have not created the heaven and the earth and all that is between them in mere idle play. None of this have We created without an inner truth." (Al–Quran, Surah al–Dukhan, verse 38)

The Nature of Astronomy:

Shaharir Mohd Zain argues that the word *Astro* is a Greek word which brings into mind the meaning of stars – astronomy can thus be regarded as the science that investigates all matter–energy in the universe, which includes its distribution, composition, physical states, movements and evolution. (Shaharir Mohd Zain, 1985).

According to Sharma astronomy in the etymological level denotes the *law of the stars* - from the Greek word αστρονομία- is a science involving the observation and the explanation of events occurring outside earth and its atmosphere. Astronomy studies the origins, evolution, physical and chemical properties of objects that can be observed in the sky as well as the processes involving them. (Arvind Sharma, 1983) Astrophysics, which discusses the physical properties and structure of all cosmic matter, is thus, a branch of this field.

Dick Teresi contends that a tolerant, multiracial, highly literate society, with a predominant language, Arabic, also fostered the growth of astronomy in Islam. (Dick Teresi, 2003) The stars were used for navigation in the desert whereas the moon regulated the Islamic calendar. The Quran states in that line that:

> "They ask you about new crescent moons, say they are but signs to mark fixed period of times for mankind and Hajj." (Al–Quran, Surah Al–Baqara, verse 189)

The sun was used in calculating the five daily prayer times as well as the fasting period based on the position of the sun in the horizon. It was also by the means of astronomy that Muslims determined the precise direction of the *Qibla*, the holy figure they face five times a day in fulfilling their daily prayers.

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Teresi confirms that Astronomy entered the Islamic tradition from three directions: Persia, India and Greece. He wrote:

> "With conquest, they brought an Arab folk astronomy that mixed with local knowledge, especially the mathematical traditions of Indian, Persian, and Greek astronomy, which they mastered and adapted to their needs." (Dick Teresi, 2003)

The first major astrological text translated into Arabic came from India. This was the *Siddhanda*, translated in Baghdad around 770 and known to the Muslims, as the *Sindhind*. (Dick Teresi, 2003) Nonetheless, the Greek contribution to the Islamic astrology was by far the greatest. The conquests of Alexander the Great had spread Greek civilization right across the ancient world; consequently, Greek ideas had greatly influenced the indigenous astrology of Persia and India. The great cultural center of Alexandria in Egypt which was renowned as 'The Hub of the World' in Hellenistic times fell to Muslims in 642. This enabled the intellectual legacy of Greece which was contained in thousands of manuscripts in its famous library to be opened up to Islamic scholars.

In the early ninth century, Al–Ma'mun, the caliph of Baghdad, founded an academy called the House of Wisdom which became the center of an ambitious project to translate all the surviving texts of antiquity into Arabic. (J. J. O' Conner & E. F. Robertson, 1999) Aristotle's work in physics, the astronomy of Hipparchus and Ptolemy's astrology, which revolutionized Islamic science were some of the many works that were translated here.

The mathematical astronomy possessed a pronounced Islamic flavor until the nineteenth century. The discovery of the theories of Ptolemy and Hipparchus brought new scientific rigors to the field. This was further stimulated by contact with India and the application of the advanced techniques. The numerical symbols 1, 2, 3, and the decimal system of notation based on the symbol zero, which were unknown to the Greeks and Romans, came originally from India. Toby Huff contends that:

> "It is useful to consider the history of astronomical thinking in medieval Islam. For astronomical work in Islam during this period was both intense and far in advance of equivalent thought in Europe". (Toby E. Huff, 1993).

Theories and designs were gradually improved until the precision of Islamic Astronomy surpassed to that of the Greeks. The philosophical foundation to Islamic astrology was laid down by Al–Kindi, Ma'mun's physician, and one of the most learned man of all times. Drawing upon classical ideas, Al–Kindi evolved a philosophy of 'cosmic sympathy' that linked macrocosm and microcosm. The correspondence between celestial configurations and events on earth demonstrated the wholeness of creation – the theories of Aristotle and Ptolemy provided a respectable scientific framework for the former.

The fatalism implicit in astrology was broadly compatible with the teachings of Islam, which means, 'submission' to the Will of Allah. Astrological symbolism became an important element in the esoteric doctrines of the Sufi mystics, though more orthodox theologians argued that astrology was irrelevant at best; at worst, it was a dangerous, delusion bordering on the magical and demonic – since Allah is all–powerful. Similar objections were raised by the Christian theologians when astrology began to filter into medieval Europe through Islamic universities of Moorish Spain.

The Mathesis of Firmicus Maternus was the first classical text to be translated from Arabic to Latin around 1000 AD. (David Plant, 2005) It was followed by a flood of astrological, scientific and philosophical works over the next two centuries that revitalized all aspects of European learning. The original Arabic texts mixed with that of the classical authors gave a distinctly Islamic flavor to medieval astrology that can be traced down to the 17th century.

Some of the rules and aphorisms of Islamic scholars like Albumazar (Abu–Ma'shar), Alfraganas (Al–Farghani) and AlKindus (Al–Kindi) were even quoted in Lilly's Christian Astrology. However, with the historical enmity between Islam and Christianity, it was fashionable amongst European astrologers to regard any dubious methods such as the Arabic distortions of classical doctrines.

As an example, the high–minded and progressive Kepler dismissed horary and most other traditional practices as 'Islamic Sorcery', though horary and even the much–maligned 'Arabian parts' were well–known in classical astrology. Virtually all the Arabic texts that influenced medieval astrology remain in Latin translation, making them inaccessible to most astrologers today.

David King agrees the history of astronomy in Islamic civilization has been documented by a series of scholars of diverse backgrounds. (David A. King, 1986) Yaqub ibn Tariq, Al–Khawarizmi, Al–Battani, Al–Farghani, Al–Sufi, Al–Biruni, Al–Tusi, and Omar Khayyam are just a few scholars who have left a lasting mark in the annals of astronomy. Among these scientists however al-Biruni and al-Batani's contributions to Astronomy stand high on the rostrum.

Al–Biruni's Contributions to Astronomy:

Astronomy, a prime interest to the human mind since the Stone Age itself, has been approached in every way possible by the Muslim astronomers – Al–Biruni was of no exception. In fact, Seyyed Hossein Nasr argues that no other Muslim astronomer had dealt with astronomy as thorough and as rigor as Al–Biruni. (Seyyed Hussein Nasr, 1979) In one of his masterpiece, the *al–Qanun al–Masudi, fi al–Hai'a wa al–Nujum*, he had discussed about many astronomical theories that require a great deal of time and deep thought to be understood.

Al–Biruni had always pondered upon the controversy of geocentrism and heliocentrism. The Encyclopedia of Britannica defines a geocentric system as any theory of the structure of the solar system (or the universe) in which earth is assumed to be at the center of all. (Encyclopedia Britannica) The same reference defines a heliocentric system as a cosmological model in which the Sun is assumed to lie at or near a central point (of the solar system or of the universe), while the Earth and other bodies revolve around it. (Encyclopedia Britannica) According to Nick:

> "Al Biruni proposed the notion that the earth rotates around its axis. Although adhering to the then broadly accepted geocentric view of the world, with the earth in the middle of the universe, he was curious of the heliocentric view of the world – with the sun being in the middle. Because of this, Al Biruni was the first to undertake experiments related to such astronomical facts. Eventually however, he left the heliocentric argument because of his inability to present actual confirmation." (Martin Nick)

Some modern scholars criticized Al–Biruni for accepting the geocentric theory, a theory he shared with his teacher, Abu Mansur Nasr. Scholars like A–Razi, Ibn Sina and the others their own opinion regarding this matter. (Abd. Latif Samian 1992) The absence of the telescope and other modern scientific apparatus during that era made it difficult for them to come to a common ground. They did not accept any new theory without clear scientific evidences. The geocentric model was well accepted, though false in actuality, until the late 16th century. Al–Biruni had also discussed the question on whether the earth rotates around its axis centuries before the rest of the world.

In his well known book, the *al–Athar al–Baqia*, he had discussed the rotation of the earth and has given the correct values of latitudes and longitudes of various places. (Abu Raihan) He had also discussed this issue in his *al–Qanun al–Masudi, fi al–Hai'a wa al–Nujum.* Seyyed Hossein Nasr asserted that it was one of the most important Muslim astronomical encyclopedias that discussed for the first time, the idea that the earth rotates around its own axis. (Seyyed Hussein Nasr, 1979)

In relation to his interest in the planetary motions of the universe (geocentrism & heliocentrism), Al–Biruni had also delved greatly into the study of *Cosmogony*. Unlike cosmology, which studies the universe at large throughout its existence, cosmogony is the study of the evolutionary behavior of the universe and the origin of its characteristic features. (Encyclopedia Britannica) That is, it is the study of the origination or the coming into existence and the creation of the universe.

Although his *al–Qanun al–Masudi, fi al–Hai'a wa al–Nujum* did not discuss the origin of the universe, Al–Biruni had reported the findings of his work on cosmogony in detail in his book *Al–Tahdid*. (Abd. Latif Samian, 1992) He denied the opinions that say that this world is everlasting. He also objected to Aristotle's concept of movement, which states that there is neither a beginning nor an end to life and that everything is constantly moving.

After having delved into several fundamental tribulations related to planetary motion, Al–Biruni's next interest was on imaginary spheres and signs that have always been discussed in astronomy, such as the pole, equator line, horizontal line, vertical line and zodiacal signs. Al–Biruni believed that there was no way to know the parallax of stars – the stellar parallax phenomenon in particular. The stellar parallax phenomenon can be exemplified by the event of the movement of the earth along the orbital path which gives an illusion of the stars moving. This phenomenon (stellar parallax) was of great interest during that era because of its significance in measuring the distance between the earth and the sun. Al–Biruni had doubts in Ptolemy's opinion that the distance between the earth and sun is about 286 times the earth's circumference.

He claimed that Ptolemy's theory was based on the occurrence of an eclipse – however, Ptolemy did not bring into consideration of the occurrence if a full eclipse. Al–Biruni, however, proposed that the distance between moon and earth can be measured unlike the distance between earth and sun which could not be measured using apparatus available at that time. In his treatises, the *al–Qanun al–Masudi, fi al–Hai'a wa al–Nujum* and the *Tahdid–i–Amaken*, he had given an accurate approximation of the earth's radius and circumference. This is suggested by Mohaini Mohamed when she wrote:

> "Even in modern calculations, his measurements of earth's radius fell short by less than 12 miles and its circumference only by 70 miles. If the greatest scientist of the seventeenth century, Newton, had known the work of al–Biruni and knew that the earth's circumference is approximately 25,000 miles, he might not have to wait for more than a decade to publish his famous theory" (Mohaini Mohamed, 2000)

Al–Biruni's interest in planetary motion had also driven him into studying the moon and the amazing phenomena associated with it. Al–Biruni stated that the moon returns to the initial position relative to the sun but with a difference in a minute increase. He also claimed that the movement of the moon and all the matter that move in the sky could not be determined by a single observation – the observation must be carried on continuously. Al–Biruni had successfully explained the rule of tide. He stated that the increase and decrease of the level of tide happens based on the moon phase. He gave a clear definition about tides in Somnath and its etymological relationship with the moon.

An astronomer as well as a historian at the same time, the science of chronology was of great importance to Al–Biruni. Chronology is the science of locating events in time. As an astronomer, he was drawn into the natural events that occur in daily life such as the transition between dawn and dusk, the actual time period of daytime, the difference between day and night between different places and many more. He had made the incentive to study the *taqwims* (calendars) of the other races.

The quest to find the exact times for *solat* (prayers) drove him to perform more researches. His books from the *al–Athar al–Baqia* to *al–Qanun al–Masudi, fi al–Hai'a wa al–Nujum* were the result of these research works. He invented an apparatus to measure the daytime and wrote about it in *Ta'bir Al–Mayzan Al–Taqdir Al Azman*. He had also written an article in which, he described about day and night as well as proving the total daytime in a year at the pole area. In addition to that, Al–Biruni had arranged a simple article that describes how the Indian measure their time. His book, *Tanqih Al–Tawarikh* discuss about date. N another of his, the *Tasawwar amr Al–Fajr wa Al Shafaq fi Jahat Al–Gharb wa Al Sharq*, he had discussed about sunrise. He studied the motive behind the time period between dawn and dusk.

Ibn Al Haytham stated that the time for dusk is when the sun is ten degrees under horizon. However, Al–Biruni found that the dusk happens when the sun goes 18 degrees under the horizon. Al-Birunis al-Lam'at explains his observations on this issue.

The Indians had their own system whereas the Muslims used the knowledge of the Arabians and the annual calendar (taqwim) that predicted and explained the meteorological, agricultural and medical events. The Muslims were perhaps responsible for the establishment of the system of forecast meteorology. Al–Biruni studied all of the information through old observation methods, general knowledge as well as popular ideas that were related to this matter during that era. However, he had discovered that the idea (Anwa') was not universal. (Abd. Latif Samian, 1992) He stated scientifically that the idea of Anwa' related to the movement of sun in zodiac.

Astrology has received a great deal of attention by Al –Biruni's interest. Many astrologers had referred to Al–Biruni's works and treatises up to date. Al–Biruni's Book of Instruction in the Elements of the Art of Astrology, an English version of his *al–Tafhim–li–Awail Sina'at al–Tanjim*, a book that contains vast amount of knowledge in the field of astrology has received a great deal of attention from people around the globe. The picture of Islamic astrology that emerges is very similar to the Greek model as exemplified in Ptolemy's Tetrabiblos though with differing attributions and correspondences to reflect a different cultural environment. Al–Biruni makes frequent comparisons with Indian practices – along with the occasional dry note of disapproval where they offend his sense of propriety. His extensive list of the 'Arabian parts' was taken from Abu–Ma'shar though the concept was much older.

It was a popular technique amongst Muslim astrologers and so, it became closely associated with them. Al–Biruni lists over 150 parts or 'lots' and still criticized that it is impossible to enumerate the lots which, have been invented for the solution of horary questions as they increase in number every day. The *lunar mansions* or *stations of the Moon* is one purely Arabic concept, though Al–Biruni limited himself to the astronomical description only.

It is the astronomical dimension to Al–Biruni's astrology that distinguishes it from the classical texts, reflecting the advances and refinements of Islamic science. His discussion of the subtleties of interpretation arising from different phases of the planetary orbits puts our present understanding of *accidental dignity* to shame.

Al–Biruni's Book of Instruction in the Elements of the Art of Astrology, an English version of his *al–Tafhim–li–Awail Sina'at al–Tanjim* by R. Ramsay Wright, was written for Lady Rayhanah, one of the members of the Khwarizm court carried off to Ghaznah by Mahmood in 1017. Virtually nothing is known about her, though R. Ramsey Wright rather patronizingly says, 'she is marked out among oriental women by her craving for scientific knowledge and by the rare distinction of having a book dedicated to her.

Al–Biruni's instructions to Rayhanah were comprehensive – According to Wright, the Book of Elements may be regarded as a primer of 11th century science. The assertion made by the School of Mathematics of University of St. Andrews that is untrue:

> "It appears clear that, despite his many works on astrology, al–Biruni did not believe in the 'science' but used it as a means to support his serious scientific work." (J. J. O' Conner & E. F. Robertson, 1999)

Al–Biruni took the time to actually compose the Book of Instructions, which is a basic astrology text. In the beginning of the Book of Instructions, he states:

> "The comprehension of the structure of the Universe, and of the nature of the form of the Heavens and the Earth and all that is between them, attained by rehearsing the information received is extremely advantageous in the Art of Astrology ... I have begun with Geometry and proceeded to Arithmetic and the Science of Numbers, then to the structure of the Universe and finally to Judicial Astrology, for no one who is worthy of the style and title of Astrologer who is not thoroughly conversant with these for sciences." (Al-Biruni Mainpage, 2005)

The Book of Instructions begins with sections on geometry and arithmetic leading to a thorough exposition of Ptolemaic astronomy that includes a detailed description of the use of the astrolabe. This is followed by sections on geography and chronology. Al–Biruni insisted that no one is entitled to call himself an astrologer without a good knowledge of these ancillary sciences. All these clearly indicate that he had used science extensively in his works.

He recognized five divisions of judicial astrology. The first, *natural astrology* is concerned with meteorology, earthquakes, floods, and all other 'vicissitudes and disasters of nature'. The second is *mundane astrology*, which deals with the rise and fall of kingdoms, battles, revolutions and etc. *Individual natal astrology* constitutes the third division where, like Ptolemy, Al–Biruni was fully aware that considerations of heredity and environment should modify any astrological indications.

The fourth division has to do with all *human activities and occupations that are found on beginnings or origins*. This would include horary and electional astrology, though this area shades into the fifth division where *astrology reaches a point which threatens to transgress its proper limits.* The astrologer is on one side and the sorcerer on the other one enters a field of omens and divinations which has nothing to do with astrology although the stars may be referred to in connection with them.

Al–Battani's Contribution to Astronomy:

Abu Abdallah Mohammad ibn Jabir Al–Battani is one of the most important role–model in the development of science. The reason for this can be clearly seen from the influence of his work on scientists such as Tycho Brahe, Keppler, Galileo and Copernicus. A great debate has been going on how Al–Battani managed to produce more accurate measurements of the motion of the sun to that of Copernicus. Some sources indicate that Al–Battani obtained more accurate results simply because of the location of his observations, which were made from more southerly latitude.

This is explained by the effect of refraction which were relatively little on his meridian observations during the winter solstice at the southerly site of Raqqah whereby the sun was higher in the sky. From his observations at Aracte and Damascus, where he died, he was able to correct some of Ptolemy's results, previously taken on trust. One of the Al-Battani's well known discoveries is the remarkably accurate determination of the solar year as being 365 days, 5 hours, 46 minutes and 24 seconds; which is very close to the latest estimates. Following that discovery, Dr Muhammad Saud asserted that:

> "He noticed an increase of 16° 47' in the longitude of the sun's apogee since Ptolemy's time. This led to the discovery of the motion of the solar apsides and of slow variation in the equation of time." (Muhammad Saud, 1986)

Al–Battani compiled new tables of the Sun and Moon, long accepted as authoritative, discovered the movement of the Sun's apogee and assigned to annual precession the improved value of 55". This implied the important discovery of the motion of the solar apsides and of a slow variation in the equation of time. He did not believe in the trapidation of the equinoxes, although Copernicus held it. Al–Battani determined with remarkable accuracy the obliquity of the ecliptic, the length of the seasons and the true and mean orbit of the sun. (N. Swerdlow, 1972)

Al–Battani proved, in sharp contrast to Ptolemy, the variation of the apparent angular diameter of the sun and the possibility of annular eclipses. However, according to Swerdlow, the influence of Ptolemy was remarkably strong on all medieval authors, and even a brilliant scientist like Al–Battani probably did not dare to claim a different value of the distance from the Earth to the Sun from that given by Ptolemy. (N. Swerdlow, 1972) This was despite the fact that al–Battani could deduce a value for the distance from his own observations that differed greatly from Ptolemy's. (J. J. O' Conner & E. F. Robertson, 1999) According to Phillip Hitti, a well–versed scholar in Islamic history from the Princeton University:

> "He (Battani) made several emendations to Ptolemy and rectified the calculations for the orbits of the moon and certain planets. He proved the possibility of annular eclipses of the sun and determined with greater accuracy the obliquity of the seasons and the true and mean orbit of the ecliptic, the length of the tropical year and the seasons and the true and mean orbit of the sun" (Abu Abdullah Al-Battani)

He rectified several orbits of the moon and the planets and propounded a new and very ingenious theory to determine the conditions of visibility of the new moon. His excellent observations of lunar and solar eclipses were used by Dunthorne in 1749 to determine the secular acceleration of motion of the moon. Dunthorne, then determined many astronomical coefficients with great accuracy: Precession of Equinoxes 54.5" a year and inclination of the Ecliptic 23º35'.

It is also from a perusal of Al–Battani's work on apparent motion of fixed stars that Hevilius discovered the circular variation of the moon. Al-Battani wrote many books on astronomy and trigonometry. His most famous book, *Kitab al–Zij*, an astronomical treatise with tables, was translated into Latin in the twelfth century with the title *De Scienta Stellarum – De Numeris Stellarum et motibus.* His *Zij* was, in fact, more accurate than all others written by that time. His treatise on astronomy was extremely influential in Europe till the Renaissance, with translations available in several languages. His original discoveries both in astronomy and trigonometry were greatly discussed in his *Zij*. The overall work contained 57 chapters.

Besides his observations, it contains a description of the division of the celestial sphere into the signs of the zodiac. The necessary background and the mathematical tools needed, such as the arithmetical operations on sexagesimal fractions and the trigonometric functions were also introduced. The third chapter of his *Kitab al–Zij* is devoted to Trigonometry.

He was the first to replace the use of Greek chords by sines, with a clear understanding of their superiority. As an astronomer as well as a mathematician at the same time, he found more accurate values for the length of the year, the annual precession of the equinoxes and the inclination of the ecliptic. He also improved the calculation for the sinusoidal functions and had developed the concept of cotangent, furnishing their table in degrees. Al–Battani also provided very ingenuous solutions for some problems of spherical trigonometry using the methods of orthographic projection. (Encyclopedia of Islam, Leiden)

Al–Battani's *Kitab al–Zij* is by had also discussed a large number of different astronomical problems following to some extent material from the Almagest – the subject of planetary motions in particular. Towards the end of his text, he had discussed the construction of a number of astronomical instruments. (Encyclopedia of Islam, Leiden)

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