Foundation for Science Technology and Civilisation

A cursory review of

Muslim Observatories

Author: **Salah Zaimeche** BA, MA, PhD
Chief Editor: **Professor Salim Al-Hassani**
Editor: **Professor Talip Alp**
Production: **Ahmed Salem** BSc

Release Date: **August 2002**
Publication ID: **4020**

FSTC Limited
9 Conyngham Road, Victoria Park, Manchester, M14 5DX, United Kingdom
Web: http://www.fstc.co.uk Email: info@fstc.co.uk

A CURSORY REVIEW OF

MUSLIM OBSERVATORIES

Most eminent Muslim astronomers include Al-Battani, al-Sufi, al-Biruni, and Ibn Yunus. Al-Battani (d 929) known to the Latins as Albategni or Albatenius was the author of the Sabian tables (al-Zij al-Sabi), a work which had great impact on his successors, Muslim and Christian, in equal measure.[1] His improved tables of the sun and the moon comprise his discovery that the direction of the sun's eccentric as recorded by Ptolemy was changing. This, in modern astronomy, means the earth moving in varying ellipse.[2] He also worked on the timing of the new moons, the length of the solar and sideral year, the prediction of eclipses, and the phenomenon of parallax, carrying us `to the verge of relativity and the space age,' Wickens asserts.[3]

Al-Battani also popularised, if not discovered, the first notions of trigonometrical ratios as we use them today.[4] During the same period, Yahya Ibn Abi Mansour had completely revised the Zij of Almagest after meticulous observations and tests producing the famous Al-Zij al Mumtahan (the validated Zij). For details on his work see the proceedings of the 23rd Annual Conference on the History of Arabic Science 23rd-25th October 2001, Aleppo, Syria.

Belonging to the same era, Abd-al Rahman al-Sufi (903-986) made several observations on the obliquity of the ecliptic and the motion of the sun (or the length of the solar year.)[5] He became renowned for his observations and descriptions of the stars, their positions, their magnitudes (brightness) and their colour, setting out his results constellation by constellation, for each constellation, providing two drawings, one from the outside of a celestial globe, and the other from the inside (as seen from the sky).[6] Al-Sufi also wrote on the astrolabe, finding thousands of uses for it. En par with other learned Muslims, he also pinpointed shortcomings of Greek astronomy.

Ibn Yunus (d 1009), in his observation endeavours used, amongst others, a large astrolabe of nearly 1.4 m in diameter, and made observations which included more than 10, 000 entries of the sun's position throughout the years.[7] His work, in French edition,[8] was centuries on the inspiration for Laplace in his determination of the `Obliquity of the Ecliptic' and the `Inequalities of Jupiter and Saturn's.' Newcomb also used his observations of eclipse in his investigations of the motions of the moon.[9]

Observation

Observation of the sky had begun in earnest in Islam. The observatory[10]as a distinct scientific institution for observation, and where astronomy and allied subjects were taught, also owes its origin to Islam.[11] The first to be set up was the Shammasiyah observatory, which Caliph Al-Mamun had built in Baghdad around 828. It was associated with the scientific academy of *Bayt al-Hikma* (House of Wisdom) (also set up by Al-Mamun.) The astronomers made observations of the sun, the moon and planets, and results were presented in a book called the '*Mumtahan* (Validated or Tested) *Zij,* see Yahya Ibn Abi Mansour above. In the same century more observations were made by the Banu Musa brothers mostly in Baghdad. Their accomplishments included the study of The Ursa Major (or the Great Bear). They also measured maximum and minimum altitudes of the sun, and observed lunar eclipses. Ibn Sina, Al-Battani, Al-Fargani, and scores more also devoted much of their attention and focus to observation and study of the sky.

In the eleventh century, the Seljuk Sultan Malik Shah (ruled 1072-1092) built a more advanced observatory, which functioned for almost 20 years. Two centuries later, approximately, was built the Maragha Observatory in Azerbaidjan. It was fitted with a large library (over 400,000 books) and also with instruments capable of greater performance (hence of large size). Maragha was managed by no less than Nasir Al-Din Al-Tusi (d. 1274) and Qutb Al-Din Al-Shirazi. Al-Tusi was the author of the IL-Khani Tables and the catalogue of fixed stars that were to rule for several centuries throughout the world. Maragha also became an institution for research, and an academy for scientific contacts and teaching. It lasted until at least the beginning of the fourteenth century. Today, however, all that remain are the foundations of it.

Further advance in the construction of observatories is observed at Samarqand, in 1424, the work of Uluh Beg. It was a `monumental' building equipped with a huge meridian, made of masonry, symbol of the observatory as a long lasting institution.[12] A trench of about 2 metres wide was dug in a hill, along the line of the meridian, and in it was placed the segment of the arc of the instrument. Built for solar and planetary observations, it was equipped with the finest instruments available, including a 'Fakhri sextant', with a radius of 40.4 metres, which made it the largest astronomical instrument of its type. The main use of the sextant was to determine the basic constants of astronomy, such as the length of the tropical year. Other instruments included an armillary and an astrolabe. Uluh Beg also assembled the best-known mathematicians of his day among whom was al-Khashi, who wrote an elementary encyclopaedia on practical mathematics for astronomers, surveyors, architects, clerks and merchants.[13] Observations were quite advanced for their time, and so the stellar year was found to be 365 days, 6 hours, 10 minutes and 8 seconds, (only 62 seconds more than the present estimation).

The observatory at Samarqand remained active until nearly 1500 A.D,[14] but was later reduced to ruins, and apparently disappeared, until the archaeologist V. L. Vyatkin found its remains in 1908. Amongst the remains was a fragment of the gnomon of large size used to determine the height of the sun from the length of the shadow. There were also remains of a building of cylindrical shape with a complex interior plan.[15] It is also known through Abd-al-Razak that one could see a portrayal of the ten celestial spheres with degrees, minutes, seconds and tenths of seconds, the spheres of rotation, the seven moving planets, the fixed stars and the terrestrial sphere, with climate, mountains, seas, deserts etc.[16] Samarqand, in the early decades of the fifteenth century, Krisciunas observes, was `the astronomical capital of the world.' And for such, `it is deserving of further study.'[17]

Construction and Instrumentation of Observatories

The last, or some of the last observatories built by Muslims were by Jai Singh, Maharajah of Jaipur, who constructed observatories in Delhi, Jaipur, Ujjain and other Indian cities. The one in Delhi, the Jantar Mantar, was built in 1724 at the request of the Mughal ruler Muhammad Shah. Generally, the instruments found were based on those found at Maragha and Samarquand, although in architectural terms, the Indian observatory represented a major accomplishment as seen from current photographs.

The construction of an advanced observatory, early it was realised, was no mean undertaking; not least on the financial front. It was, hence, only natural such an institution demanded the patronage of kings, princes, or very wealthy people. As a matter of fact, the observatory soon took on the prerogative as a royal institution.[18] Al-Mamun gave the lead; Uluh Beg, centuries later was wholly, and personally involved in the undertaking (more than in the running of stately affairs). The Buwayyids, another instance, supported the use of advanced, larger and heavier equipment. Other than finance, observatories also required the co-operation of well trained astronomers and engineers, for the success of their operations.[19]

In all cases, however, the instruments gradually became bulkier, the aim being to minimise error as much as possible.[20] Each piece was also devoted for a particular class of observations.[21] At Maragha, the ecliptical consisted of five rings, the largest of which being twelve feet across.[22] Included, too, was a meridian armillary consisting of a graduated bronze ring in the shape of an alidade set upon the meridian to measure solar altitudes in zenith distance; a large stone sundial accurately aligned to the meridian and used only for determining the obliquity of the ecliptic; an equatorial armillary made in the form of a bronze ring set firmly parallel to the plane of the equator; and a parallactic instrument, a type of transit used to measure the zenith distance of a star or the moon at culmination.[23] To gain the required rigidity, instruments were built of masonry when the foundations of the structure could be made secure, as at the Indian observatories.

The impact of Al-Battani on European Astronomy

Observation in Islamic times reached beyond what much of scholarship gives it credit for. Many aspects of it were pioneering as can be observed from few extracts on the life and works of al-Battani by Carra de Vaux.[24] The merit of al-Battani, the author points out, is to pioneer the use of trigonometry in his operations. Al-Battani is also quoted saying:

> *`after having lengthily applied myself in the study of this science, I have noticed that the works on the movements of the planets differed consistently with each other, and that many authors made errors in the manner of undertaking their observation, and establishing their rules. I also noticed that with time, the position of the planets changed according to recent and older observations; changes caused by the obliquity of the ecliptic, affecting the calculation of the years and that of eclipses. Continuous focus on these things drove me to perfect and confirm such a science.'*

More crucially, al-Battani, once pinpointing and demonstrating operations, by providing mathematical support, summoned others after himself: `to continue observation, and to search,' saying that it was no impossibility that with the passing of time, more was found, just as he himself added upon his predecessors. `Such is the majesty of celestial science, so vast, that none could ever encompass its study by himself.'

Al-Battani also used the widest variety of instruments: astrolabes, tubes, a gnomon divided into twelve parts, a celestial globe with five armillaries, of which, likely, he was the author, parallax rules, a mural quadrant, sundials, vertical as well as horizontal. And, understandably, he opted for the largest instruments; the measures taken by the parallax rules relate to a circle of no less than five meters in diameter; and the quadrant was no less than one meter.

So great was al-Battani's impact, De Vaux observes, that subsequent observation bore his mantel. Thus, Jewish scientists, Ibn Ezra, Maimonides, Levi Ben Gerson, and others, who through the centuries scattered Islamic learning in all regions of Europe, made al-Battani's calculations the foundations of theirs. Amongst the Christians, Robertus Cestrensis (Retinensis) devised tables of the celestial movements for the meridian of London for the year 1150 after him. Albertus Magnus, Alphonso X, Regiomontanus, Nicolas Cusanus, Copernicus, and Tycho Brahe are amongst others, on whom, al-Battani, in one way or another impacted. It was left to Nallino, who most recently edited al-Battani's work in Arabic with a Latin translation.

Krisciunas on Uluh Beg

On the web, are very few articles devoted to the subject of Muslim observatories. One of such by Kevin Krisciunas is on The Legacy of Uluh Beg, and can be found at:
http://www.ukans.edu/~ibetext/texts/paksoy-2/cam6.html

Without going into the detail of such article, but just to add to some points already made, Krisciunas reminds us that Uluh Beg is to be remembered not for his princely role, but for his role as patron of astronomy, an astronomer, and observatory builder. His distinction was that he was one of the first to advocate and build permanently mounted astronomical instruments. The importance of his observatory is further enhanced by the large number of astronomers, between sixty and seventy, involved in observation and seminars. Of crucial importance, too, is that observations were carried on a systematic basis for lengthy periods of time, as from 1420 to 1437. The reason, as Krisciunas makes clear, why observations are not completed in one year but instead require ten or fifteen years, is:

> *`the situation is such that there are certain conditions suited to the determination of matters pertaining to the planets, and it is necessary to observe them when these conditions obtain. It is necessary, e.g., to have two eclipses in both of which the eclipsed parts are equal and to the same side, and both these eclipses have to take place near the same node. Likewise, another pair of eclipses conforming to other specifications is needed, and still other cases of a similar nature are required. It is necessary to observe Mercury at a time when it is at its maximum morning elongation and once at its maximum evening elongation, with the addition of certain other conditions, and a similar situation exists for the other planets.'*

> *`Now, all these circumstances do not obtain within a single year, so that observations cannot be made in one year. It is necessary to wait until the required circumstances obtain and then if there is cloud at the awaited time, the opportunity will be lost and gone for another year or two until the like of it occurs once more. In this manner there is need for ten or fifteen years. One might add that because it takes Saturn 29 years to return to the same position amongst the stars (that being its period of revolution about the Sun), a period of 29 years might have been the projected length of the Samarkand programme of observations.'*

In his article, Krisciunas, although recognising the crucial role of Islamic observation, still finds sources of disagreement with the notion that the Samarqand observatory exerted decisive influence on Europe. That, of course, is exactly the matter which plagues most minds of Western scholarship, refusing to acknowledge the Eastern impact (not just Islamic, but also Indian, and above all Chinese) on their civilisation. Krisciunas is not just one of the most fair minded, but also one of the most able scholars in the field. And his point of view has to be addressed on equal academic reasoning.

Final Remarks

It was under Islam that modern astronomy took shape. The Muslims gave names (still with us) to stars and constellations. They also devised maps and astronomical tables that were used in both Europe and the Far East in subsequent centuries. Early in the ninth century, on the orders of Caliph Al-Mamun (813-833), Muslim astronomers had also measured the earth's circumference at 40, 253.4 kms, (the exact figures being 40, 068.0 km through the equator, and 40, 000.6 km through the poles.)[25] That was six hundred years before in Europe it was admitted the planet was not flat.[26]

Endnotes:

[1] Regis Morelon: Eastern Arabic Astronomy, in *Encyclopaedia of the History of Arabic Science*, edited by Roshdi Rashed, Routledge, London, 1996, pp 20-57 at pp. 46-7.

[2] C. Singer: *A short History of scientific ideas to 1900*; Oxford University Press, 1959; p. 151

[3] G.M Wickens: The Middle East as a world Centre of science and medicine, in *Introduction to Islamic Civilisation,* edited by R.M. Savory, Cambridge University Press, pp 111-118, pp 117-8.

[4] P.K. Hitti: *History of the Arabs*, tenth edition, Mac Millan St Martin's Press, 1970, at p. 572.

[5] R. Morelon: Eastern Arabic, op cit, p. 50.

[6] C. Ronan: The Arabian Science, in *The Cambridge Illustrated History of the World's Science*; Cambridge University Press, 1983, pp 201-244 at p. 213.

[7] Ibid, p. 214.

[8] Edition Caussin De Perceval, Paris, 1804.

[9] S. M. Ziauddin Alavi: *Arab Geography in the ninth and tenth centuries*, Published by the Department of Geography, Aligrah Muslim University, Aligrah 1965, p. 36.

[10] For the most comprehensive study on Muslim observatories, see: Aydin Sayili: *The Observatory in Islam*, Turkish Historical Society, Ankara, 1960.

[11] L.A. Sedillot: Prolegomenes des tables Astronomiques d'Ouloug -Beg, texte, *Chrestomathie Persane*, vol 1, 1847, p. CVII.

[12] A. Sayili: The Observatory, op cit, p. 271.

[13] C.A. Ronan, op cit. p 223.

[14] Sedillot, 1853, in R. Morelon, General Survey of Arabic Astronomy, in Encyclopaedia, op cit, vol 1, pp 1-19; p 14.

[15] Francoise Micheau: The Scientific Institutions in the Medieval Near East, in Encyclopaedia, op cit, vol 3, pp. 985-1007. at pp. 1003-4.

[16] Ibid.

[17] Kevin Krisciunas: The Legacy of Uluh Beg; at http://www.ukans.edu/~ibetext/texts/paksoy-2/cam6.html

[18] A. Sayili: The Observatory in Islam; op cit, p. 121.

[19] Ibid, P. 329.

[20] G.M Wickens: The Middle East, op cit at p. 117.
[21] Baron Carra de Vaux: Astronomy and mathematics, in *The Legacy of Islam*, edt Sir Thomas Arnold and Alfred Guillaume, first edition, Oxford University Press, 1931., pp 376-397; at p. 396.
[22] Ibid.
[23] Instruments of Indian and Islamic origin, in *Dictionary of the Middle Ages*; ed; Joseph Strayer; New York, Scribner, 1982-1989.
[24] Barron carra de Vaux: Les Penseurs de l'Islam, Paris; Geuthner, 1921.Vol 2; pp 208-13.

Bibliography:

-S. M. Ziauddin Alavi: *Arab Geography in the ninth and tenth centuries*, Published by the Department of Geography, Aligrah Muslim University, Aligrah 1965.
-Barron carra de Vaux: Les Penseurs de l'Islam, Paris; Geuthner, 1921.Vol 2.
-Baron Carra De Vaux: Astronomy and mathematics, in *The Legacy of Islam*, edt Sir Thomas Arnold and Alfred Guillaume, first edition, Oxford University Press, 1931., pp 376-397.
-*Dictionary of the Middle Ages*; Instruments of Indian and Islamic origin, ed; Joseph Strayer; New York, Scribner, 1982-1989.
-Sir John Glubb: A Short History of the Arab Peoples; Hodder and Stoughton, 1969.
-P.K. Hitti: *History of the Arabs*, tenth edition, Mac Millan St Martin's Press, 1970.
-M. Ali Kettani: Science and technology in Islam: the underlying value system, in Z. Sardar edt: *The Touch of Midas; Science, values, and environment in Islam and the West.* Manchester University Press (1984); pp 66-90.
-Kevin Krisciunas: The Legacy of Uluh Beg; at http://www.ukans.edu/~ibetext/texts/paksoy-2/cam6.html
-F. Micheau: The Scientific Institutions in the Medieval Near East, in Encyclopaedia, op cit, vol 3, pp. 985-1007.
-R. Morelon: Eastern Arabic Astronomy, in *Encyclopaedia of the History of Arabic Science*, edited by Roshdi Rashed, Routledge, London, 1996, pp 20-57.
-C. Ronan: The Arabian Science, in *The Cambridge Illustrated History of the World's Science*; Cambridge University Press, 1983, pp 201-244.
-Aydin Sayili: *The Observatory in Islam*, Turkish Historical Society, Ankara, 1960.
-L.A. Sedillot: Prolegomenes des tables Astronomiques d'Ouloug -Beg, texte, *Chrestomathie Persane*, vol 1, 1847, p. CVII.
-C. Singer: *A short History of scientific ideas to 1900*; Oxford University Press, 1959.
-G.M Wickens: The Middle East as a world Centre of science and medicine, in *Introduction to Islamic Civilisation,* edited by R.M. Savory, Cambridge University Press, pp 111-118.

References:

[25] M. Ali Kettani: Science and technology in Islam: the underlying value system, in Z. Sardar edt: *The Touch of Midas; Science, values, and environment in Islam and the West.* Manchester University Press (1984); pp 66-90 at p. 75.
[26] Sir John Glubb: A Short History of the Arab Peoples; Hodder and Stoughton, 1969; p. 109.