

A review on

Muslim Contribution to Astronomy

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

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9 Conyngham Road, Victoria Park, Manchester, M14 5DX, United Kingdom

Web: <http://www.fstc.co.uk> Email: info@fstc.co.uk

A REVIEW ON

MUSLIM CONTRIBUTION TO ASTRONOMY

Obscuring Islamic Astronomy

Like others who dealt with the history of science, Kevin Kruiscunas¹ could hardly fail to notice the generalised black-out imposed on Muslim astronomy. His opening statement of chapter two went as follows:

'It is a common misconception that astronomical research fell into a dazed slumber following Ptolemy (the Greek scientist who lived long before Islam), not to reawaken until the time of Copernicus. I have briefly sketched in the previous chapter the efforts on the part of various Greeks in preserving their astronomical science. These efforts continued up to the time of the conquest of Egypt by the Arabs, who were not the book burning fanatics that some have made them out to be. Those who think that these Arabs made no contributions of their own have not investigated the subject.'

Kruiscunas then points that during the Middle Ages the principal astronomers were Moslems, Jews, and some Christians, and what they had in common was that they wrote in Arabic. 'This was the principal language of astronomy of the ninth through the eleventh centuries, just as English is today.'²

Obscuring Muslim astronomy is common to the treatment of all Muslim sciences as expertly pursued by a number of historians, some 'illustrious' and others less so. This obscuring of the Muslim achievements is, of course, today, complemented with a blowing out of proportion of anything negative about the Muslims, or distorting facts against them, something that can be observed all the time around us.

In the field of history of science, as a whole, many instances regarding such obscuring can be seen. Here, one in the field of mathematics as pointed by the authors of the Mac Tutor site at the University of St Andrews in Scotland, who state:³

'There is a widely held view that, after a brilliant period for mathematics when the Greeks laid the foundations for modern mathematics, there was a period of stagnation before the Europeans took over where the Greeks left off at the beginning of the sixteenth century. The common perception of the period of 1000 years or so between the ancient Greeks and the European Renaissance is that little happened in the world of mathematics except that some Arabic translations of Greek texts were made which preserved the Greek learning so that it was available to the Europeans at the beginning of the sixteenth century.'

The authors pursue, stating:

'That such views should be generally held is of no surprise. Many leading historians of mathematics have contributed to the perception by either omitting any mention of Arabic/Islamic mathematics in the historical development of the subject or with statements such as that made by Duhem that: 'Arabic science only reproduced the teachings received from Greek science.'

Recent research, however, the authors add, is painting a very different picture of the debt that we owe to Arabic/Islamic mathematics, recognising that modern mathematics is closer to Muslim mathematics than the Greek, and as they also put it:

'Certainly many of the ideas which were previously thought to have been brilliant new conceptions due to European mathematicians of the sixteenth, seventeenth and eighteenth centuries are now known to have been developed by Arabic/Islamic mathematicians around four centuries earlier.'

In the particular field of astronomy so many examples of distortions can be cited. Thus, the two guiding lights of Western historians of astronomy, Neugebauer⁴ and Delambre,⁵ both find nothing to report about Islamic astronomy. It is as if it never existed, and no Muslim ever looked at the sky, or measured whatsoever. For Duhem,⁶ the inspiration for all scholars wishing and willing to find only doom, gloom, and chaos with Islam, things went as follows:

'The revelations of Greek thought on the nature of the exterior world ended with the 'Almagest,' (by Ptolemy) which appeared about A.D. 145, and then began the decline of ancient learning. Those of its works that escaped the fires kindled by Mohammedan warriors were subjected to the barren interpretations of Mussulman commentators and, like parched seed, awaited the time when Latin Christianity would furnish a favourable soil in which they could once more flourish and bring forth fruit.'

If Duhem is to be followed, the Muslims are responsible for one thing, and for its total opposite, both at once. Indeed, according to him the Muslims were fanatic, rampaging hordes, burners of Greek science, and also pale imitators, copiers of the Greeks. They cannot be both, though. How can you copy a book that you have burnt; or convey a science that you have destroyed on first contact? Incidentally, both these conflicting opinions can be found not just with Duhem, but also with his crowd of followers, who pursue the same aberrations of history. More recent amongst these is another Frenchman, J.P. Verdet,⁷ who in a History of astronomy, manages to jump from Ptolemy to Copernicus, skipping nearly 1500 years, as if in his whole lifetime, and a scholar with access to tens of libraries, he never came across one single work dealing with Muslim astronomy.

Browsing through our modern means of communication, the web, also gives an early impression that the Muslims never looked at the sky, or put a pen on anything approaching that science called astronomy. Thus at <http://w3.restena.lu/al/pub/indivs/wagnjean/astronomy.htm> medieval what one finds is that Greek astronomy was transmitted to the Arabs; and although 'compiling new star catalogs, and developing tables of planetary motion, the Arabs made few useful contributions;' and that the Arabic translations of Ptolemy's Almagest filtered into Europe. And that was it. On this last point, anybody without sufficient knowledge would believe that Ptolemy's Almagest was the only work translated from Arabic into Latin. The Almagest was, indeed, one of hundreds of translations from Arabic into Latin by Christian scholars assisted by Jews. Amongst such translations that led to the awakening of Europe from its dark slumber were the astronomical works of Al-Khwarizmi, Al-Battani, Al-Fargani, Mash'Allah, Al-Zarqali, Al-Bitruji, Jabir Ibn Aflah, and so on.

Moving further on the web, reveals other sites such as <http://dmoz.org/Science/Astronomy/History>. Nothing surprising here either. Out of the so many astronomical topics listed not a single reference to Muslim astronomy. Another site <http://homepages.tcp.co.uk/~carling/astrhis.html>, and nothing, again. The author just jumps from Ptolemy to Copernicus, skipping those 1500 years. One would search in vain for a paragraph on the Muslims, or the Chinese (the greatest scientists of all times, and the other major victims of historical distortions) but nothing. The author, however, laments the burning at the stake of Giordano Bruno for adopting Copernican beliefs that were viewed with hostility by the Church.

Also on the web is the site of the International Astronomical Union (IAU) at: <http://www.astro.uni-bonn.de/~pbrosche/iaucomm41>. The union was founded in 1919 with the aim of 'promoting the science of astronomy through international cooperation.' Commission 41 of the union and devoted to the History of Astronomy was created at the 1948 General Assembly, with Otto Neugebauer as its first President. From a look at the activities of such an organisation, the conferences it held, and also the membership of the current officers (years: 2000-3), nothing could be found regarding Islamic astronomy.

The Real Story

Yet, against what has just preceded, reality in relation to astronomy is considerably different. It will be impossible to go through even a summarised version of Muslim achievements here. The briefest of mentions will be made of different aspects of the science, some of which will hopefully be developed at a future stage. It also belongs to Muslims and others with minimal honest intentions to go through the abundant, old reference material, of primary and secondary sort, now being eagerly buried, and give a much truer picture of the Muslim contribution to this science, a reality that some try to hide for eternity.

Sources for writing on Muslim astronomy exist in large abundance in German in particular, the work of Germans and also of others who expressed themselves in German. Heinrich Suter, for one, has numbered over 500 Muslim astronomers and mathematicians, giving for each of these the titles of their works that are known, and their still extant manuscripts.⁸ Since Suter more have been added by Brockelmann⁹ and Sezgin¹⁰ (all in German). George Sarton in his voluminous Introduction to the History of Science¹¹ (already referred to abundantly) gives a very thorough picture, too, of the vast array of Muslim works in astronomy as in other sciences. Sedillot¹² (in French) and Nalino¹³ (in Italian) have delivered plenty good information in the same field, too. Closer to us, David King, Julio Samso, George Saliba, E.S. Kennedy, W. Hartner and A.I. Sabra have added more regular contributions, King, in particular, providing a gigantic contribution to the subject. Other scholars have given very good summaries of Muslim astronomy, first amongst whom being Baron Carra de Vaux¹⁴ and Aldo Mieli,¹⁵ scholars of great repute from earlier in the century, Aldo Mieli founding one of the two greatest reviews on the history of science ARCHEION, (the other being ISIS by George Sarton.) Incidentally, both De Vaux and Mieli are being pushed into oblivion by second or third rate modern scholars who today fill departments of history of science. Before leaving the subject on contributions, Rashed,¹⁶ again, managed in volume one of his Encyclopaedia of Arabic science to gather a number of excellent contributions to this science, on top of providing an extensive bibliography at the end, very useful for whomsoever wishes to go deeper into the matter.

Before addressing other aspects of astronomy, and first and foremost, to the many pseudo historians who keep stating and re-stating that Muslim astronomers merely copied their Greek predecessors, no better evidence to the contrary than the many articles by George Saliba,¹⁷ following Sedillot, much earlier, dealing with the corrections made by Muslim astronomers to Greek astronomy. And for Braudel, Ptolemy's errors were too glaring to escape Muslim scholars, who were better equipped with precision instruments.¹⁸

To have a very thorough picture of the contribution of various ethnic groups to astronomy in general, the Chinese, above all, no better work than Sarton, of course, but also the more recent excellent work by Hetherington: *A chronicle of pre-Telescopic astronomy*.¹⁹ In it the author surveys each and every single achievement in the science, and every event of importance, year by year, from the very ancient times until our times; Hetherington, to his credit, not leaving the thousand years from 500 to 1500 blank as is customary with others.

Observation of the sky and observatories in Muslim times have been expertly dealt with by Sayili²⁰, following Sedillot, just cited. Kruiscinas,²¹ too, gave ample account of Islamic observations. Hartner, for his part, corrects Neugebauer's remark²² that colossal observational instruments stood only at the end of the Muslim civilisation (14th-15th century). These were already in use as early as Al-Mamun's reign (9th century) and remained in use throughout the centuries.²³ Hartner also notes that it was only in the seventeenth century, thanks to Brahe, that high standards of Islamic observation were reached again by the Europeans.²⁴ On the specific point of instruments for observation it is useful to mention one amongst many contributions by R.P. Lorch on Jabir ibn Aflah and the Torquetom.²⁵

Nautical Astronomy

In nautical astronomy, and to correct the erroneous views so abundant in the field, no better source than Steinschneider, a source suffering constant attempts by modern writers to erase it.²⁶ Joaquim Bensaude²⁷ has kept Steinschneider alive, just for himself to be blotted out as well.²⁸ Duhem,²⁹ again, holds that the use of the baculus was introduced among the Portuguese navigators by the German scientist Behaim towards the end of the fifteenth century, whilst Bensaude (just cited) had demonstrated that the baculus was known in Portugal long before the time of Behaim. Dreyer also raises one of the so many contradictions proper to Duhem, that he (Duhem) quotes this book (Bensaude's) in a footnote without noticing that it demolishes what he had just stated in the text. Also contrary to assertions made by Duhem, that some revival was begun in France, the studies of Bensaude have shown that 'the scientific light spread by the Arabs in Spain and Portugal had never been put out,' which amongst others impact considerably on navigation to the Indies and the New World.³⁰ Another contribution of interest to this very subject is by Howse, and can be found in the *Journal of Renaissance and Modern Studies*.³¹

The Astrolabe

The astrolabe is described as 'the most important astronomical calculating device before the invention of digital computers and was the most important astronomical observational device before the invention of the telescope.'³² Its uses are varied, and not just in astronomy, but also in surveying and navigation.³³ In astronomy, it was used to calculate the altitude and azimuth (an Arab term) of the sun, the moon, stars and planets. It was also used to measure distances and heights.³⁴ Of all the works on the astrolabe, by far

the best is by A.L. Mayer on Islamic astrolabists and their works.³⁵ It describes and gives all names of those who made astrolabes through the ages of Islamic history, their places of birth and work, dates, and also the whereabouts of such astrolabes throughout the museums of the world and various international collections. Bibliographies about such makers and their works are also added, a very thorough work, indeed.

The Globe Earth

A point of crucial importance is raised by Dreyer³⁶ on a matter which is possibly the most blacked out of all, and that is the spherical shape of the earth, a notion which until the modern times led its authors to burning at the stake. In the world of Islam, Dreyer, however, holds, there was no such hostility to science, and there exists no record of any Muslim being persecuted for stating that the earth was a sphere that was capable of being inhabited all over; and that it was also very small compared to the size of the universe.³⁷

Muslim Astronomers

Muslim scholars who worked on the subject of astronomy receive a good treatment in The Dictionary of Scientific Biography.³⁸ There are also, of course, Suter, Brockelmann, Sezgin and Sarton for more details on each of such astronomers. Amongst these astronomers was Al-Battani (d 929) who wrote The Sabian tables (al-Zij al-Sabi), a very influential work for centuries after him.³⁹ Al-Battani's work also includes timing of the new moons, calculation of the length of the solar and sidereal year, the prediction of eclipses and the phenomenon of parallax.⁴⁰ Al-Battani also popularised if not discovered the first notions of trigonometrical ratios used today,⁴¹ and made serious emendations to Ptolemy.⁴² 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.)⁴³ He also made observations and descriptions of the stars, setting out his results constellation by constellation, discussing the stars positions, their magnitudes and their colour, and for each constellation providing two drawings from the outside of a celestial globe, and from the inside.⁴⁴ Al-Sufi also wrote on the astrolabe and its thousand or so uses. Al-Biruni (973-1050) claimed that the earth rotated around its own axis.⁴⁵ He calculated the earth circumference, and fixed scientifically the direction of Makkah (Mecca) from any point of the globe. Al-Biruni wrote in total 150 works, including 35 treatises on pure astronomy, of which only six have survived.⁴⁶ Ibn Yunus (d 1009) made observations for nearly thirty years (977-1003) using amongst others a large astrolabe of nearly 1.4 m in diameter, determining more than 10,000 entries of the sun's position throughout the years.⁴⁷ Al-Farghani was one of Caliph Al-Mamun's astronomers. He wrote on the astrolabe, explaining the mathematical theory behind the instrument and correcting faulty geometrical constructions of the central disc, that were current then.⁴⁸ His most famous book *Kitab fi Harakat Al-Samawiyah wa Jaamai Ilm al-Nujum* on cosmography contains thirty chapters including a description of the inhabited part of the earth, its size, the distances of the heavenly bodies from the earth and their sizes, as well as other phenomena.⁴⁹ Al-Zarqali (Arzachel) (1029-1087) prepared the Toledan Tables and was also a renowned instrument maker who constructed a more sophisticated astrolabe: a *safiha*, accompanied by a treatise.⁵⁰ Jabir Ibn Aflah (d. 1145) was the first to design a portable celestial sphere to measure and explain the movements of celestial objects. Jabir is specially noted for his work on spherical trigonometry. Al-Bitruji's work '*Kitab-al-Hay'ah*' was translated by the Sicilian based Michael Scot, and bore considerable influence thereafter.

On how the works of various Muslim astronomers have been used, or relied upon by scholars who followed them has received attention by many of the sources already cited. There remains many matters of contention as can be expected. Indeed, if it is easy for many historians of science to find the Greek origin in many Islamic works, however flimsy the evidence, the other way round, that is recognising the Muslim origin of any breakthrough of significance amongst the likes of Copernicus, Galileo, etc, is denied even when the evidence is beyond the glaring. No better instance than Copernicus' theories based on those of Nasir al-Din al-Tusi and Ibn Shatir. Pedersen, for instance, noting the resemblance, still finds no line of transmission.⁵¹

This line of transmission North bluntly states it, holding that Greek and Latin materials that made use of al-Tusi's device were circulating in Italy at about the time Copernicus studied there.⁵² And North does not hesitate to add that Copernicus made repeated uses of al-Tusi's and his followers' devices.⁵³ On this issue see also works by Gingerich,⁵⁴ and above all the masterly delivery by George Saliba, which explains all about this matter at <http://www.columbia.edu/~gas1/project/visions/case1/sci.1.html>

The Transmission of Muslim Astronomy to Christian Europe

How Muslim scientific knowledge, in general, and astronomical, in particular, passed to the west is abundantly studied. Haskins,⁵⁵ Sarton, Myers, Mieli etc have described that in great detail. Spain played a major part in such a passage. It was from Catalonia that the early treatises on the astrolabe travelled north of the Pyrenees in the late 10th century via Gerbert of Aurillac (later Pope Silvester II). It was also to Toledo where flocked in the 12th century, in particular, scholars from all Christian lands to translate Muslim science, and start the scientific awakening of Europe.

Amongst such translators were the Italian Gerard of Cremona, who amongst others translated the Toledan tables of al-Zarqali and Jabir ibn Aflah's *Islah al Majisti* (correction of the Almagest of Ptolemy). The Jew turned Christian, John of Seville, also made translations of the astronomical works of al-Battani, Thabit ibn Qurra, al-Qabisi, and al-Majriti. And later on, when Alfonso of Castille sought to construct an armillary sphere, 'the finest and best that had yet been made', he turned to the Muslim scholars.⁵⁶

Charles Burnett has given ample details on how such Muslim science entered England.⁵⁷ Burnett explains the early penetration of texts on the astrolabe, and also how al-Khwarizmi's tables were adapted to English locations. He also dwells on the education of King Henry II, and the influence of his Muslim inspired entourage. Most certainly the first English scientist ever was Adelard of Bath, the most 'Arabist' of all scientists, hence his lack of popularity amongst today's 'learned' circles, despite his considerable scholarly achievements, with a few exceptions, though.⁵⁸ Adelard's main works include the astronomical tables of Al-Khwarizmi, as revised by Maslama at Cordoba. Another Englishman, Robert of Chester, made an adapted version of al-Battani and al-Zarqali's tables in 1149. Petrus Alphonsi, another Jew convert to Christianity, served both Spanish and English royal courts, and is accredited with the introduction of Muslim astronomy into England. Also incomer to England in 1091 from Lotharingia (modern day Lorraine) was Walcher of Malvern, who had come into possession of the astrolabe, and who, for the first time, in Latin Europe, on 18 October 1092, used such instrument to determine the time of lunar eclipse that he had observed in Italy.⁵⁹

In France, Muslim learning was mostly concentrated in the Southern Languedoc-Provence region and

towns. By the 13th century, Montpellier was a well known centre of Muslim astronomy and also medicine. Marseilles, too, played its part, when a certain Raymond sought to adapt the astronomy of Muslim Spain north of the Pyrenees, declaring himself the first Latin `to acquire the science of the Arabs.'⁶⁰ His inspirations were al-Battani, Mash-Allah, and above all Al-Zarqali from whose astronomical canons his works are largely drawn.⁶¹

Final Remarks

In view of the so many sources just cited, the fact that books such as Verdet's in the 1990s, and the various <http://www> still ignore the Muslim contribution to astronomy is beyond the credible. It just serves to show the darker side of `scholarship' meant to be universal and devoid of prejudice. Hartner had already noticed this a while back; stating that in the writing of history:

*'Our time witnesses a most unfortunate tendency to write prententious `syntheses' on the basis of either of a wholly insufficient factual knowledge or of preconceived theories-religious, philosophic, sociological maintained only by twisting and suppressing facts at the author's pleasure.'*⁶²

On the same matter, T.F. Tout has recognised that:

*'Our (Western-European-British)) civilisation is not merely national but world-wide, and that neither Great Britain, nor even Greater Britain, can be understood, unless we know something about our neighbours and associates, our enemies even more than our friends.'*⁶³

Tout adds:

*'It is from the Middle Ages that our civilisation proceeds. If we could understand modern civilisation, we cannot make a fresh start a hundred or a hundred and fifty years ago.'*⁶⁴

And he concludes:

*'Europe did not go to sleep in the Middle Ages, and then woke up, open her eyes, and see light at some date, previously marked out as 1453, 1492, or 1494 by eminent authorities. In the long story of European evolution the Middle Ages form an integral part, and unless you make allowance for them, you see modern history all askew. The men of the Renaissance, like the men of the Age of Reason, despised and ignored the Middle Ages. It is painful to find that there are still people who believe that you can hop straight from the Periclean or the Augustan ages to the times of the Medici and Louis XIV... It is good to begin at the beginning, but we must on no account stop at an arbitrary time, jump over hundreds of years, and then start afresh.'*⁶⁵

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- ¹ K. Krisciunas: *Astronomical Centers of the World*; Cambridge University Press, Cambridge, 1988; at p. 23.
- ² Ibid.
- ³ Created by John J O'Connor and Edmund F Robertson at:
<http://www-history.mcs.st-andrews.ac.uk/history/index.html> In the chapter devoted to: Arabic mathematics: a forgotten brilliance.
- ⁴ *Astronomy and History*, Verlag, 1983.
- ⁵ *Histoire de l'Astronomie Ancienne*; Johnson Reprint Collection; New York, 1965.
- ⁶ P. Duhem: *Medieval Physics*, in R. Palter edition: *Toward Modern Science*; The Noonday Press; New York; 1961; Vol 1; pp 141-159; Quote at p. 141; This article is a reprint from "Physics, history of," *Catholic Encyclopedia*, XII (1911), pp 47-52.
- ⁷ J. P. Verdet: *Une Histoire de l'Astronomie*, Le Seuil, Paris, 1990:
- ⁸ H. Suter: *Die mathematiker und Astronomen der Araber und ihre Werke*; APA, Oriental Press, Amsterdam, 1982.
- ⁹ C. Brockelmann: *Geschichte der Arabischen Litteratur*, Weimar, 1898; reedited 1949.
- ¹⁰ F. Sezgin: *Geschichte des arabischen Schrifttums* (vol vi for astronomy); 1978.
- ¹¹ 3 Vols; Published for the Carnegie Institute of Washington, 1927-1948.
- ¹² Sedillot: *Memoire sur les instruments astronomique des Arabes*, *Memoires de l'Academie Royale des Inscriptions et Belles Lettres de l'Institut de France* 1: 1-229; Reprinted Frankfurt, 1985.
- ¹³ Nallino, C.A: *Raccolta di scritti Editi e Inediti*, Roma, 1944.
- ¹⁴ Baron Carra de Vaux:
-*Les penseurs de l'Islam*, Geuthner, Paris, 1921.
-Astronomy and mathematics, in *The Legacy of Islam*, edt Sir Thomas Arnold and Alfred Guillaume, first edition, Oxford University Press, 1931., pp 376-397.
- ¹⁵ A. Mieli: *La Science Arabe et son role dans l'Evolution scientifique mondiale*, Leiden, 1938.
- ¹⁶ R. Rashed (with collaboration of R. Morelon): *Encyclopedia of the history of Arabic science*, 3 vols, Routledge, London and New York, 1996.
- ¹⁷ G.Saliba: A 16th century Arabic critique of Ptolemaic astronomy: the work of Sham's al-Din al-Khafri; *Journal for the History of Astronomy*, Vol 25 (1994) pp 15-38;
G.Saliba: Critiques of Ptolemaic astronomy in Islamic Spain; in *Al-Qantara*, Vol 20, 1999; pp 3-25.
- ¹⁸ F. Braudel: *Grammaire des civilisations*, Flammarion, 1987, at p. 113.
- ¹⁹ Published by John Wiley and Sons, Chichester, 1996.
- ²⁰ Aydin Sayili: *The Observatory in Islam*, Turkish Historical Society, Ankara, 1960.
- ²¹ K. Krisciunas: *Astronomical Centers of the World*, op cit.
- ²² P.9 of his work.
- ²³ Essay review by W. Hartner of O. Neugebauer: A History of Ancient mathematical astronomy, Verlag, 1975; 3 vols; in *Journal for the History of Astronomy*, 9; pp 201-212; at p. 202.
- ²⁴ Ibid, p. 211, note 20.
- ²⁵ R.P. Lorch: The Astronomical Instruments of Jabir Ibn Aflah and the Torquetom; *Centaurus*, 1976; vol

20; pp 11-34.

²⁶ In order to revive the works of that great scholar before they are condemned to eternal oblivion, see as an instance:

M. Steinschneider:

-Etudes sur Zarkali; *Bulletino Boncompagni*; vol 20.

-*Notice sur les tables astronomiques attribuees a pierre III d'Aragon*, Rome, 1881.

-*Vite dei mathematici arabi*; Roma, 1874.

-*Die europaischen Ubersetzungen aus dem Arabischen bis Mitte des 17. Jahrhundert* (1904-5), repr.

²⁷ J. Bensaude: *L'Astronomie Nautique au Portugal*, Meridian Publishing, Amsterdam, 1967.

²⁸ J.L. E. Dreyer: Mediaeval Astronomy; In M. Palter ed, *Toward Modern Science*, Vol I, 1961, pp 235-256; at p. 253,

²⁹ (in Volume iv, p. 40 of his *Systeme du Monde*)

³⁰ Dreyer: *Medieval*, op cit p. 256.

³¹ D. Howse: Navigation and Astronomy the first three thousand years; in *Journal of Renaissance and Modern studies*, vol 30; pp 60-86;

³² Montgomery College's Planetarium home page. Web page by H. Alden Williams.

³³ See: W. Hartner, 'The Principle and use of the astrolabe,' in W. Hartner, *Oriens-Occidens*, Hildesheim, 1968, pp. 287-318; and J. D. North: 'The Astrolabe,' *Scientific American* 230, No 1, 1974, pp 96-106.

³⁴ C. Ronan: Arabian Science, in *The Cambridge Illustrated History of the World's Science*, Cambridge University Press, 1983; pp 201-44; at p. 209.

³⁵ A.L. Mayer: *Islamic astrolabists*, Albert Kundig edition, Geneva, 1956.

³⁶ J.L.E. Dreyer: *A History of Astronomy from Thales to Kepler*, Dover Publications Inc, New York, 1953, at p. 249.

³⁷ Ibid.

³⁸ *Dictionary of Scientific Biography*, C.C. Gillispie editor in chief, Charles Scribner's Sons, New York, 1970-1980.

³⁹ Regis Morelon: Eastern Arabic Astronomy, in *Encyclopedia of the History of Arabic Science*, op cit, pp 20-57 at pp. 46-7.

⁴⁰ 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, Cambridge, 1976; pp 111-8.

⁴¹ P.K. Hitti: *History of the Arabs*, tenth edition, Mac Millan St Martin's Press, 1970, at p. 572.

⁴² Ibid; p. 376

⁴³ R. Morelon: Eastern Arabic, op cit, p. 50.

⁴⁴ C. Ronan: The Arabian Science: op cit, p. 213.

⁴⁵ M. A. Kettani: Science and Technology in Islam: The underlying value system, in Z. Sardar ed: *The Touch of Midas; Science, values, and environment in Islam and the West*; Manchester University Press, 1984, pp 66-90; at p. 76.

⁴⁶ R. Morelon: Eastern Arabic, op cit, p. 52.

⁴⁷ C. Ronan: The Arabian Science, op cit p. 214.

⁴⁸ Ibid, p. 207.

⁴⁹ R. Morelon: Eastern Arabic astronomy, op cit, p. 24.

⁵⁰ Carra de Vaux: *Astronomy and Mathematics*, op cit, p. 394.

⁵¹ O. Pedersen: *Early Physics and astronomy*, Cambridge University Press, 1974, at pge 273. This unfortunately is not Pedersen's (whose title of professor of history of science comes glaring on the title

page,) shortcoming. His whole work is to be set aside as one of those designed to rewrite another history of astronomy and physics than the real one. His treatment of Islamic contribution to both sciences hardly expresses what can be found in works in the bibliography he had at his disposal; and his justification in the preface of his work for omitting other contributions to such sciences, can at best be seen as a pathetic attempt to cover up for what sort of scholarship he represents.

⁵² John North: *Astronomy and Cosmology*, Fontana Press, London, 1994; at p. 195.

⁵³ Ibid.

⁵⁴ See for instance A Gingerich: A Tusi Couple from Shoner's de Revolutionibus?; see *Journal for the History of Astronomy*, Vol 15 (1984); pp 128-132.

⁵⁵ C.H. Haskins: *Studies in the history of Mediaeval science*; Frederick Ungar Publishing Co.; New York; 1967 ed.

⁵⁶ Carra de Vaux: *Astronomy*, op cit, at p. 396.

⁵⁷ C. Burnett: *The Introduction of Arabic Learning into England*; The Panizzi Lectures, 1996; The British Library; 1997.

⁵⁸ See:

-L. Cochrane: *Adelard of Bath*, British Museum press, 1994.

-C. Burnett: *Adelard of Bath*, Warburg, London, 1987.

-B.G. Dickey: *Adelard of Bath*, unpublished Thesis, University of Toronto, 1982.

⁵⁹ O. Pedersen: *Astronomy*, in *Science in the Middle Ages*, ed D.C. Lindberg; The University of Chicago Press, Chicago, 1978, pp 303-37; at p. 312.

⁶⁰ C.H. Haskins: *Studies*, op cit, p. 98.

⁶¹ P.K. Hitti: *History*, op cit, p. 571.

⁶² Essay review by W. Hartner of O. Neugebauer: *A History*, op cit at p. 201.

⁶³ T.F. Tout: The place of the Middle Ages in the teaching of history, *History*, New series, Vol 8 (1923-4); pp 1-18; at p.2.

⁶⁴ Ibid, p. 7.

⁶⁵ Ibid; p.8.

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