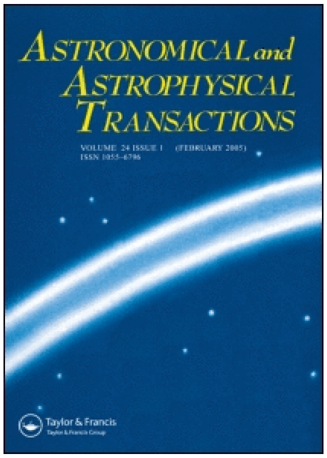

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A review of: "Historical eclipses and earth's rotation"

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Book Review

HISTORICAL ECLIPSES AND EARTH'S ROTATION

by F. Richard Stephenson

Cambridge University Press/Cambridge, 1997, 557 pp.

(Received December 28, 1999)

The application of early astronomical records to problems in modern astronomy, has developed rapidly in recent years. Historical astronomical observations – both pre-telescopic and telescopic – have played, and continue to play, an important role in such diverse subjects as Earth's variable rotation; supernova studies; cometary and planetary orbits; and solar variability – to name just a few aspects. The book under review is an outstanding achievement in the field of Applied Historical Astronomy. The main purpose of the book is to investigate in detail long-term variations in the length of the day (changes in the Earth's rate of rotation) using pre-telescopic observations of eclipses.

About 300 pre-telescopic observations of both solar and lunar eclipses collected by the author prove of value in the study of Earth's past rotation. These records mainly originate from Babylon (including Assyrian records), China (including Japanese and Korean records), Europe (including Alexandrian records), and the Arab lands and they effectively extend as far back as about 700 B.C. Numerous early accounts of eclipses were found in astronomical works. Others were scattered in variety of writings – the Greek and Latin classics, imperial annals of China and monastic chronicles of Europe. Many of the observations were carefully timed. In other cases the record clearly states that a certain solar eclipse was total at a given location or that the Sun or Moon rose or set whilst eclipsed. Using both timed and untimed data, significant non-tidal variations in the length of the day on the millennial time-scale were traced.

The book comprises fourteen chapters. In chapter one the variations in the length of the day in a historical perspective are discussed. The author notes that in studying changes in the length of the day which have occurred in recent centuries (since the invention of the telescope), more accurate data than eclipses are available. However, observations of eclipses provide by far the most consistent and reliable source of information on variations in the terrestrial rate of rotation during the pre-telescopic period. The second chapter deals with problems of tidal friction and the ephemerides of the Sun and Moon. Having considered the accuracy of adopted solar and lunar ephemerides in the chapter, the author is now in a position to discuss the various techniques available for the analysis of solar and lunar eclipse observations. This forms the subject of chapter 3. Despite their relatively low precision, pre-telescopic observations cover a sufficient time-span for long-term trends in the length of day. This is the main reason why archaic observations are so important in study of the Earth's past rotation. The various simple techniques developed in this chapter may be used to derive Earth's rotational clock error ΔT from the ancient and medieval eclipse observations. The techniques are used to analyse the observations discussed in chapters 4 to 13.

Practically all of the ancient and medieval eclipse observations which are of value in the investigation of long-term changes in the length of the day originate from only four civilisations: Babylon (700 BC to 50 BC), China (700 BC to AD 1500), Europe (500 BC to AD 1600), and the Arabian dominions (AD 800 to 1300). Babylonian astronomers systematically observed eclipses with many other celestial phenomena. The roughly contemporaneous Babylonian observations are of great value in the determination of changes in the length of the day. Without them little would have been known concerning the terrestrial rotation in the BC period. Chinese eclipse records are also dominated by the observations of astronomers, who maintained a regular watch of the sky for all kinds of celestial events. Nearly all early European accounts of eclipses are the work of historians or chroniclers rather than astronomers. Most ancient records of eclipses are of dubious reliability. They are largely found in the Greek and Latin Classics. From about AD 800 to 1500, Arab chroniclers frequently documented the occurrence of both solar and lunar eclipses, as well as other striking celestial phenomena such as comets and meteors.

Combining the above four sets of data, the author obtained a unique material – a remarkable series of more than 300 useful observations of both solar and lunar eclipses, extending from about 700 BC to the telescopic era.

In the four chapters (4 to 7) of the book devoted to Babylonian data, a large number of valuable results and limits for ΔT in period from 700 to 50 BC were deduced. There can be no doubt that the Babylonian data provide by far the most important source for information on ΔT before the medieval period. Further results from ancient observations were derived from Chinese (chapter 8) and European (chapter 10) data. Chapter 9 treats other East Asian observations of solar and lunar eclipses.

It was a complex problem to establish a relation between different historical scales of time. For example, the author describes this process in chapter 10 in the following way. In the case of the Babylonian eclipses recorded by Ptolemy, the dates of the Greek observations are expressed in terms of the 365-day Egyptian year. This enabled the exact number of days between any two selected epochs to be readily calculated. Some years are numbered from the era of Nabonassar of Babylon (747 BC), but on several occasions the Kallippic cycle is used. This cycle was named after the fourth century BC Athenian astronomer Kallippos, and was nearly equal to four Metonic cycles – each of 19 years. The first Kallippic cycle began in 330 BC. Ptolemy makes reference to the two subsequent cycles, starting in 254 and 178 BC. Each commenced around the time of the summer solstice.

Chapter 11 summarizes and treats the knowledge on eclipse records from medieval Europe. The term "medieval" is interpreted to mean the period between the close of the classical age in Europe (AD 500) and the beginning of the telescopic era. It thus includes the Renaissance. European reports of solar eclipses as well as lunar obscurations from Middle Ages and Renaissance are mainly found in historical works and chronicles. Only a few observations are reported in astronomical treatises. A large number of European chronicles have been published in their original language by the editors of the eighteenth and nineteenth centuries. The author notes that the search for records of specific phenomena occurring at widely spaced intervals is a very tedious operation. As a result the author has relied "almost exclusively on the printed texts". It is necessary to add that the monograph covers a very large amount of original information on historical eclipse observations and the main achievement of the book lies in a very profound treatment of this unique material.

Chapters 12 and 13 deal with solar and lunar eclipses recorded in medieval Arab chronicles and observations of eclipses by medieval Arab astronomers. The observations reported in these chronicles are essentially qualitative and measurements of any kind are fairly rare. But the author emphasizes especially that the eclipse observations made by medieval Arab astronomers are among the most accurate and reliable data from the whole of the pre-telescopic period. It gives a very interesting description of observational techniques used by medieval Arab astronomers. They were well aware of the hazards of observing solar eclipses with the naked eye. As a result, they were in the habit of viewing the Sun by reflection *in water* in order to reduce its glare. The author gives the following quotation from "Kitab Tahdid" by al-Biruni:

"... If one continues to look at it [Sun], one's sight becomes dazzled and dimmed, so it is preferable to look at its image in water and avoid a direct look at it, because the intensity of its rays is thereby reduced ...

Indeed such observations of solar eclipses in my youth have weakened my eyesight."

With the Earth's rotational clock error ΔT results obtained in chapter 13 from observations by medieval Arab astronomers, the author comes to the end of his compilation of data.

The chapters provide interesting reading due to the original approach and rich contents.

The fundamental objective of the final chapter (14th) of the book is to use these results to obtain the best fitting of the Earth's rotational clock error ΔT value curve to the data and hence to determine changes in the length of day over the historical period. It has been shown in chapter 14 that over the past 2500 years there is a variable non-tidal decrease in the length of day at an average rate of -0.6 ms/cy in opposition to the steady tidal increase of $+2.3$ ms/cy. The author discusses a number of geophysical reasons of the event. Although tides play a dominant long-term role in producing variations in Earth's rate of rotation, there are significant a

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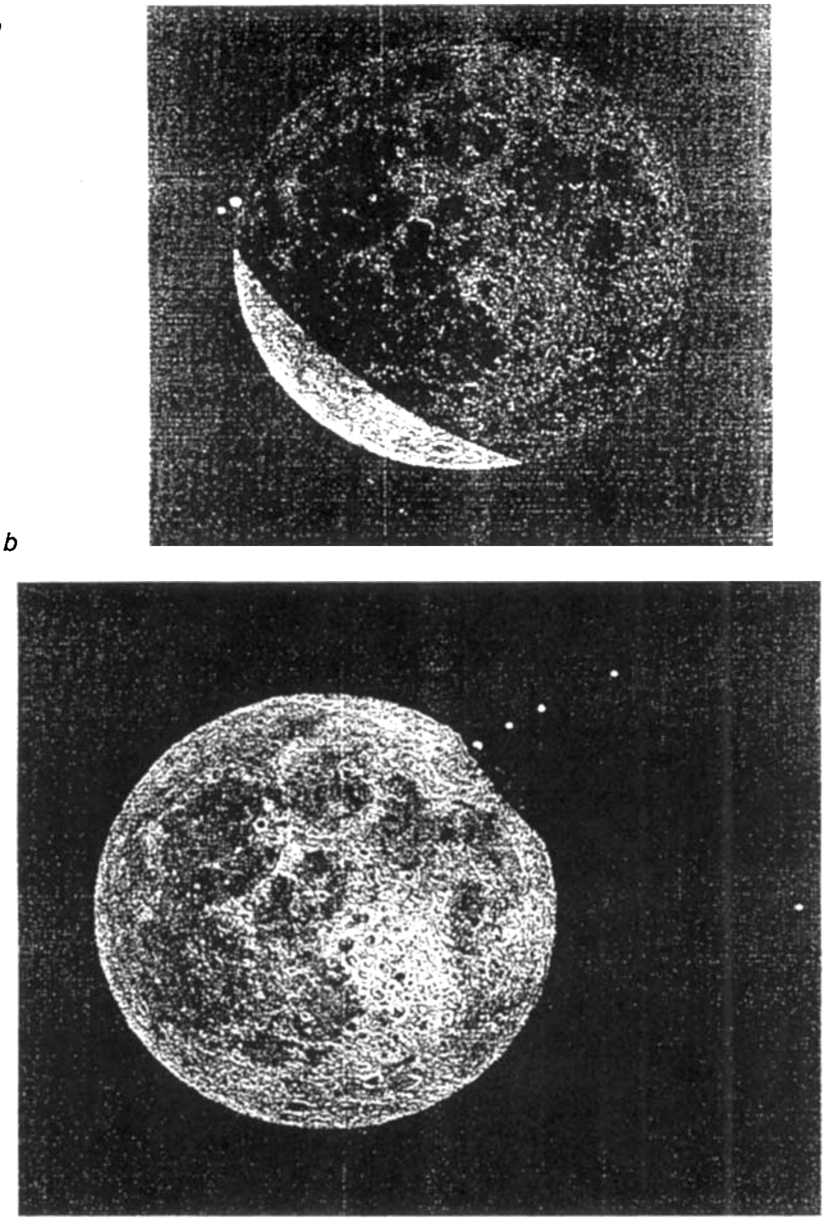

Figure 1 Calculated position of the Moon relative to the planet Jupiter at phases of the total lunar eclipse of AD 755 Nov. 23/24 (the pictures are modeled by RedShift-3, Maris Multimedia); *a* – before the first contact; to the left from Jupiter – Jupiter's moon Io;bottom left part of the Moon – area of the penumbral eclipse; *b* – before the last contact; to the right from Jupiter–Jupiter's moons Europa, Ganymede, and Callisto; to the right from the Moon – star BSC 1831; near appulse, top right part of the Moon – area of Earth's shadow.

non-tidal changes in opposition to the main trend. From the data obtained it might be concluded that the investigation of long-term changes in the rate of rotation of the Earth using historical observations raises a few geophysical issues which await further development.

In the concluding remarks of the chapter 14 the author notes that the study of Earth's past rotation is just one of several modern scientific disciplines in which ancient and medieval astronomical observations play a major role.

The book contains a great variety of illustrations including photographs of the ancient astronomical documents such as Babylonian tablets etc. Unfortunately, historical astronomical events are illustrated by sketch-maps only. Meanwhile there are available computer multimedia products which can create a visual model of the event with high precision. For example, the unique event of an occultation of the planet Jupiter by the eclipsed Moon in AD 755 (sketch in Fig. 11.10, p. 429 of the book) may be presented by the precise visual model shown in Fig. 1. The author could be recommended to use such up-to-date possibilities for the next edition of a very interesting and useful book.

The Appendices contain more than 400 values of ΔT derived from timed and untimed data. The book is accompanied by an extensive bibliography, by Index of eclipse records, by Index of places of observation, by Name index, and by Subject index.

The work under review is the first major book on this subject to have appeared in the last 20 years. Any attempt to continue the investigation is to be warmly welcomed. The book will be interesting for geophysicists, astronomers, historians, and orientalists.

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