AL-BĪRŪNĪ'S MASUDIC CANON

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Of the one hundred and forty-six writings estimated as having been composed by Abū Rayḥān al-Bīrūnī (b. 973), the great scientist of Central Asia, a hundred and twenty-three seem to have disappeared. Of the few which are extant, seven can be regarded as major works, and of these, four have been edited in the original and translated into a European language. Two more have been published, but in Arabic only. One of the latter is *al-Qānūn al-Mas'ūdī* (listed under *Canon* in the bibliography) an exhaustive astronomical treatise written after the manner of Ptolemy's Almagest. It is a prime source for the history of the medieval exact sciences, and portions of it have been translated (or paraphrased) into German, while other sections have been exploited for particular studies. The translation of the document as a whole has repeatedly been called for, and this is underway in the U.S.S.R. pending the completion of this, and since there are many historians of science who read neither Arabic nor Russian, the present paper is offered as a temporary stopgap.

It is essentially a detailed table of contents of the excellent Hyderabad edition, and at least makes known the topics discussed in the *Qānūn*. The relevant literature, to the extent it is known to the author, has been listed in the bibliography at the end. References to the entries are made by using italicised abbreviations. The only detailed description of the *Canon* thus far to appear is *R & R*, but it is in Russian.

The title page and dedication are not paginated, nor are the two pages listing the seven MSS used in the edition. Abbreviations employed in the critical apparatus are also listed.

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Chapter 8, On the amount of the (solar) apsidal motion Here Bīrūnī reports the results of many of the astronomers mentioned in the preceding chapter and in addition al-Nairīzī's zīj called al-Mu'taḍadī 662

Chapter 9, On the verification of the solar mean (position) and the extraction of its base (motion) For this determination Bīrūnī uses the distance the sun has traversed between one of Ptolemy's observations and his own at Ghazna 686

(A Section on) the determination of the argument (of the solar longitude) and apogee for any time 690

A *table* of the solar mean motion and apogee, to seven places, the positions for years 400, 430, 460, , 820 Yazdigerd, the motion for each of the Persian months, for 1, 2, 3, , 30 Persian (i.e., Egyptian) years, and for 1, 2 3 60 days. 692–700

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Table of the solar equation Entries give, for each integer degree of mean longitude, the equation and first difference to four places. This table and the mean motion tables have been so set up that the equation function is always positive, i.e., it is always *added* to the argument and the true longitude results. 708–719

Chapter 11, On the equation of time, and the transformation of differing days into equal mean days 720

TREATISE VII (On the lunar motion) 725

Chapter 1, A mention of the motions of the moon, and a recital of the opinions as to its equable and variable travel. In the ensuing discussion Bīrūnī gives several sets of parameters These have been identified and restored by Dr David Pingree as follows 725

To "the Indians" (al-Hind) Bīrunī attributes in 788,958,225,000 days, 26,716,650,000 lunations, 28,87[6,6]50,000 lunar revolutions, and 28,632,597,071 lunar anomalistic revolutions 727

These are the numbers of the events indicated occurring in half a kalpa of the Brāmasphuṭasiddhānta. Following is a set associated by Bīrūnī with "Pulsa (or Paulśa) the Greek" In 889, 0[4]0 days are 30,105 lunations, 32,5[3]9 lunar revolutions, 32,265 lunar anomalistic revolutions, and 2,434 years. 727

These are found in the Old Sūrya-Siddhānta of Lāta and agree with the figures given in the *India*, vol. ii, p 18. This is followed by analogous Hipparchian parameters 727

Chapter 2, The approach to the two lunar motions by associating the sun with the moon where appropriate 729

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Chapter 3. On the verification of the two lunar motions. In deducing his own parameters Bīrūnī uses eclipses reported in the Almagest and three lunar eclipses observed by him: that of 19 February 1003 at Jurjān, of 14 August 1003 at Jurjān, and that of 4 June 1004 at al-Jurjāniya of Khwārazm 731

Table of the lunar mean motion and anomaly, to seven places, laid out like the solar table on p. 692 748–755

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Section 1. On the explanation of this motion and its verification. Here also parameters attributed to the Indians are given which Dr. Pingree has shown to be based on the Brāmasphuṭasiddhānta and the Old Sūrya-Siddhānta of Lāṭa 756

Section 2. On the position of the ascending node and the determination of its motion. Here Bīrūnī also uses eclipses recorded in the Almagest 766

Table of the longitude of the ascending node, laid out like the table on p. 692 772–775

Chapter 5. On the lunar latitude. Bīrūnī refers to the work of Ibn Ismaʿīl and Yaḥyā Ibn Abī Manṣūr in this connection. He says rightly that in Ḥabash's zīj the maximum value of the lunar latitude is $4;46^{0}$, in which, as usual, he claims, Ḥabash leaned on the observations of the Banū Mūsā. The topic leads naturally to a discussion of the lunar parallax and the technique of observing it. Bīrūnī reports (via al-Nanīzī's commentary on the Almagest) an observation of a meridian passage of the moon made on 11 December 870 by the Banū Mūsā 776

Table of the lunar latitude having an entry to four places, for each integer degree of the argument. The maximum is the Ptolemaic 5^{0} 781–784

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Section 1. On why the moon needs an apsidal heaven, and the determination of its eccentricity 789

Section 2. On the inclining of the epicycle diameter, and the opposite point. Answer of a question as to the best means of observing the elongation. Bīrūnī prefers the armillary sphere *(dhāt al-ḥalaq)* 795 798

Chapter 8. On the situation of the lunar equations 802

Section 1. The explanation of each of the tables 802

Section 2. The operation (for determining) the true lunar longitude with our tables 808

Table of the lunar equation. Entries are to seconds of arc for each degree of the argument, the latter running through each integer degree to 360^{0}. Five functions are tabulated, numbered in the text with Arabic alphabetical numerals at the head of each column. We will denote them by $f_1, f_2, \ldots f_5$ and their graphs have been sketched in Figure 1. The functions are analogous to those found in the corresponding tables of the Almagest except for f_5 which gives the small correction in the lunar position caused by the fact that the lunar orbit is not in the plane of the ecliptic, but in a plane slightly inclined to it. As with the solar equation, Bīrūnī keeps the operation of subtraction at a minimum by adding suitable constants to the equation functions so that they will be non-negative, where practicable. The mean motion tables have been modified in an appropriate manner. 812–835

Directions for computing a true lunar longitude where η is the mean elongation, λ the mean longitude, and γ the anomaly (cf. *Neugebauer*, p. 198, see also *S & K*, *Neugebauer*, *Biz.*, and Jensen) are

Find $f_1(\eta)$ and $f_2(\eta)$

Then put $\gamma + f_1(\eta) = \gamma'$, the modified anomaly,

and find $f_3(\gamma')$ and $f_4(g')$.

Compute $\Delta\lambda = f_3(\gamma) + f_4(\gamma).f_2(\eta)$.

Then the desired longitude is

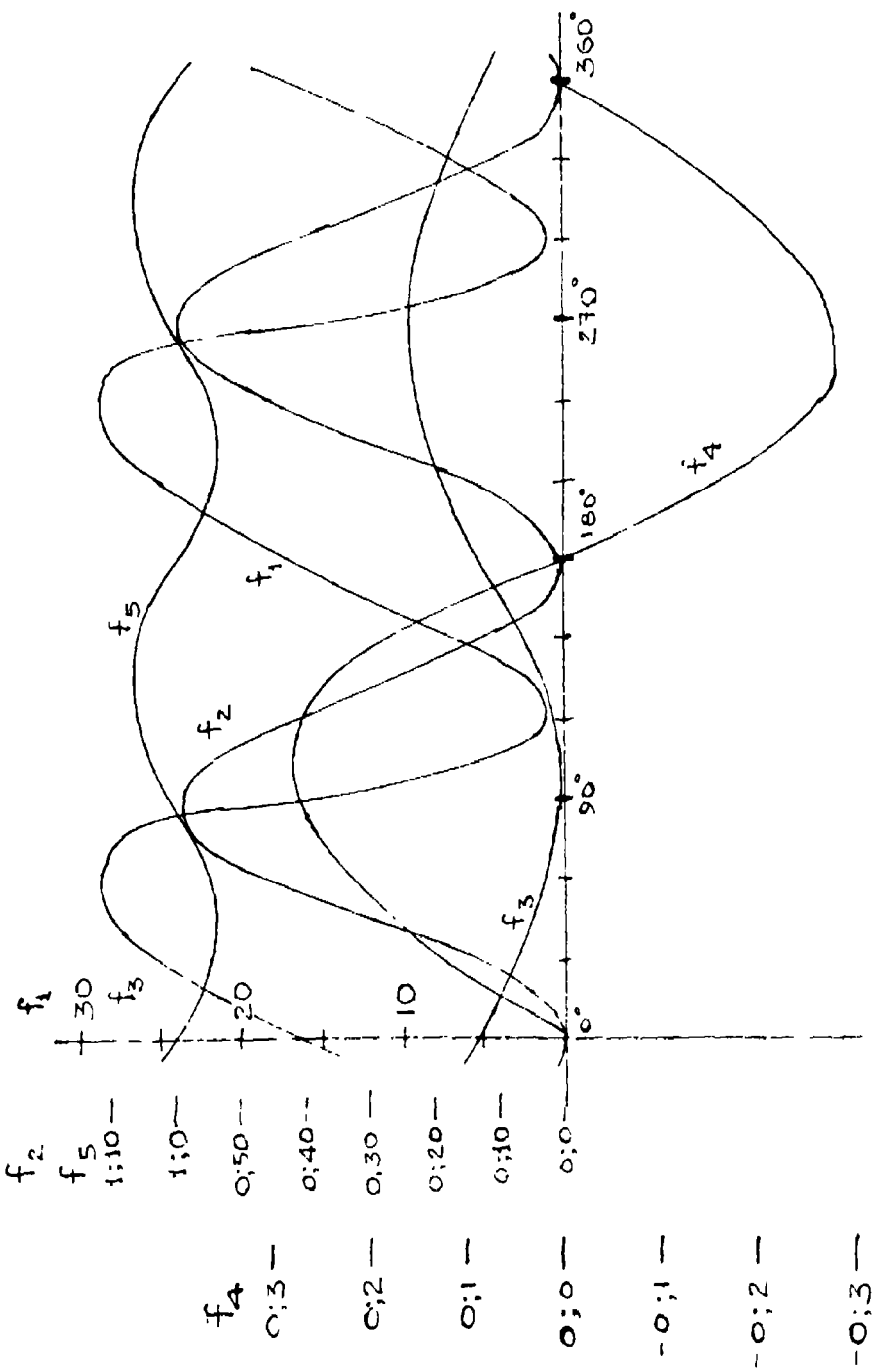

Figure 1 Lunar equations in the Canon

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$$\lambda = \chi + \Delta\lambda - 1 + f_3(K_\beta),$$

where K_β is the argument of the lunar latitude

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The table is used as follows. In a lunar eclipse, let m be the apparent diameter of the lunar disk, s that of the shadow disk, and c the common chord between them. Then

$$A\left(\frac{21c}{s}\right) + A\left(\frac{21c}{m}\right)$$

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Chapter 12, On the (apparent) shapes of the lighted (surface of the) moon. 947

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Chapter 14, On crescent visibility (of the new moon) 950
Section 1, On the possibility of seeing (the new moon) and what prevents it, and its necessity (i.e. what makes it certainly visible) Bīrūnī says that the Muslim astronomers differ on this subject. Some, like al-Farazārī, Ya'qūb bin Ṭāriq, al-Khwārizmī, and al-Nairizi, who follow the Indians, base the determination on the time between sunset and moonset. Others regard as critical the solar depression at moonset. The methods of al-Nairīzī, al-Battānī, al-Khwārizmī, and Habash are sketched. 950
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Chapter 7, On the eastern and western (first and last appearances) of the stars (See *India*, Chap lvii) Bīrūnī refers to Ptolemy's book on the risings and settings of the fixed stars, giving 12° as the critical solar angle of depression for the settings of first magnitude stars, and for heliacal risings 6° depression for the first magnitude and 7 1/2° for the second magnitude 1129

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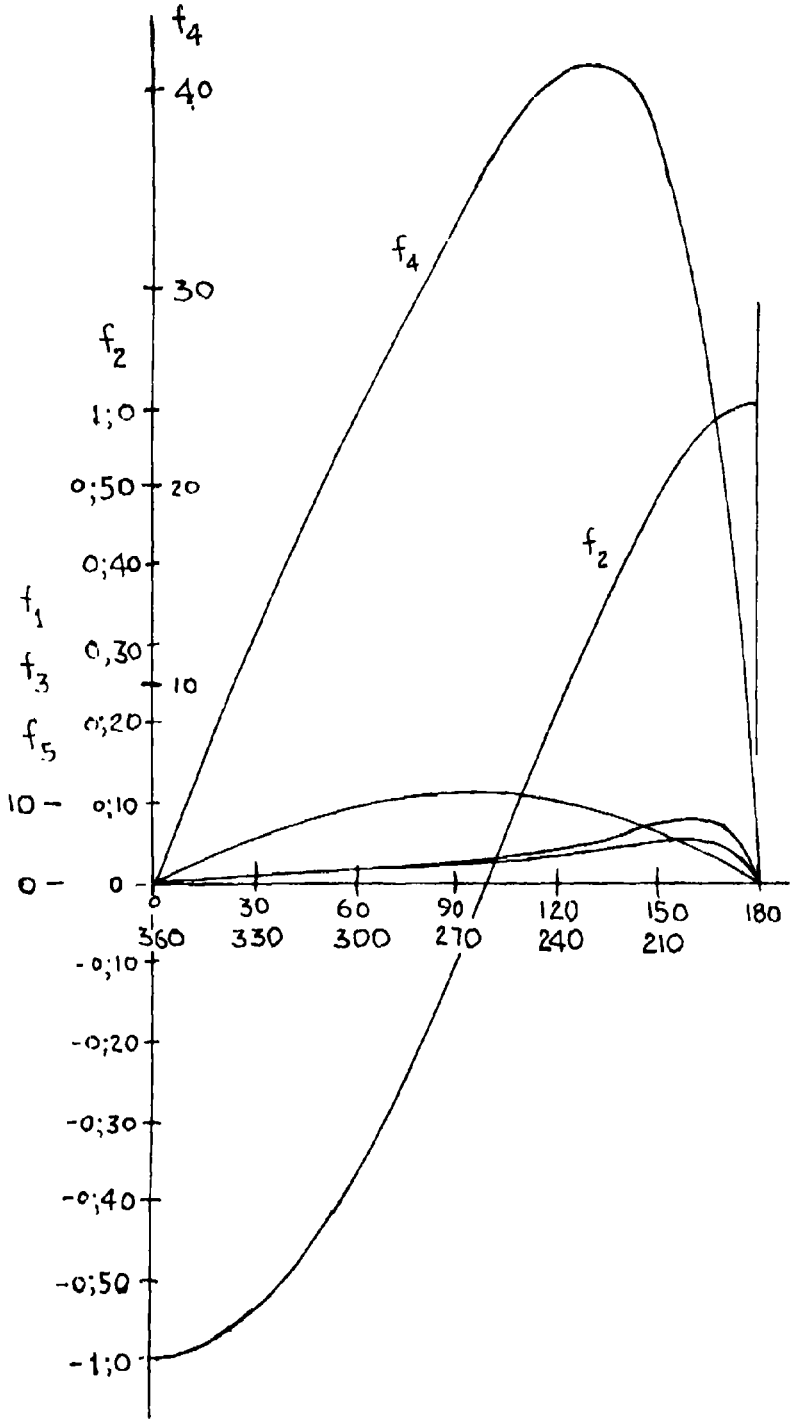

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	Saturn	Jupiter	Mars	Venus	Mercury
Pulisa the Greek	2	8	1	16	4
Khaṇḍakhādyaka = Karaṇtilaka	0;2,30	0,3,30	0,2	0,4	0,3
Ghurrat al-Zījat	5	7	4	8	6

He says that in the Mustakhraj Zīj the values are different. He reports the following length *(R)* for the radius of the defining circle of the trigonometric functions

Pulisa	3438′
Brāhama (?)	3270′
Khaṇḍ	150′
Ghurrat al-Zījāt	200′
Al-Zīj al-Mustakhraj	300′

apparent diameters given above are mean values, he says. In order to find the apparent diameter at a particular time, multiply the mean value by *R* and divide the product by the distance from the earth to the planet at the time in question, the mean distance being taken as *R* 1310

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Mercury	0 2,8,57°
Venus	0,3,18,26
Mars	0,1,36,13°
Jupiter	0,2,41,12°
Saturn	0,1,17,28°

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Colophons of the various copies used for the edition	1182
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Index (in Arabic) of personal names	5
Index (in Arabic) of places and peoples	

Beginning from the other end of the volume is material in English: title page, dedication, list of MSS used in the edition, and

General Introduction of eighteen pages, the last five of which describe five of the Mss used.

The place of the Qānūn-i-Mas'ūdi in the History Science, by H. J. J. Winter, in fifteen pages, the pagination beginning anew.

Al-Bīrūnī and His Magnum Opus, Al-Qanun al-Mas'ūdi by S. H. Baraam, in seventy-five pages, again paginated anew, this time in numerals, consisting of a useful and interesting biographical sketch of Bīrūnī and abstract of the Qanūn.

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