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en E.S.Kennedy

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The World-Year of the Persians

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And yet, despite failure, it cannot be concluded that the results of Selim's labors were all negative. Western innovations and particularly western ideas, did not end with Selim's reign. They found in the decayed Ottoman Empire a rich soil in which they eventually took root. Selim's diplomatic reforms made a particular contribution to this process. His establishment of permanent embassies in Europe did enable a few young Ottomans to learn a European language and to inform themselves about some of the revolutionary ideas current in Europe. Some, on their return, "became officials at the Porte, where they formed a Westward-looking minority among the bureaucratic hierarchy, similar to that created among the officers by the military and naval reforms."⁶⁹

new ideas from the west were perverted by many and "took the form of free-thinking, or were clothed in mysticism, and were displayed even among the dignitaries of the Palace and the Sublime Porte"; also Nuri, *Netaic*, IV, 41-42, on the resentment and opposition aroused by Selim's reforms.

⁶⁹ Lewis, *Emergence*, 61; also d'Ohsson, VII, 513.

Many of the specific reforms were left unchanged, though some fell temporarily into disuse. This is true especially in the case of diplomacy. When Mahmud II recommenced the task of reforming the Empire, he successfully adopted many of Selim's diplomatic reforms, most conspicuously, continuous diplomacy through resident missions abroad. Selim III's reign generated the forces of change and produced the essential precedents, indeed, even the necessary failures.

Examples of such men are "İngiliz" Mahmud Efendi and Galib Efendi (later Galib Paşa). On Mahmud Efendi see Mehmed Süreyya, *Sicill-i Osmani* (Istanbul, 1890-98), IV, 329-30, Cevdet, *Tarih*, VII, 5-6, A. Adnan, *La science chez les Turcs ottomans* (Paris, 1939), and Lewis, "The Impact of the French Revolution on Turkey," *Journal of World History*, I (1953), 112. On Galib Efendi see Uzunçarşılı, "Amedi Galib Efendinin Murahhaslığı ve Paristen Gönederdiği Şifreli Mektuplar," *Belleten*, I (1937), 357-410, F. Babinger, *Die Geschichtsschreiber der Osmanen und ihre Werke* (Leipzig, 1927), 331, and F. Köprülü, "Galib Paşa," *İslam Ansiklopedisi*, IV, 710-14.

THE WORLD-YEAR OF THE PERSIANS

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1. INTRODUCTION

The notion of cyclicly recurrent cosmic disasters, a catastrophe by flood alternating with one by fire, both accompanying conjunctions of all planets at the zero point of the zodiac, has been traced from ancient Babylonia and Iran through Pythagorean and Stoic philosophy, thence into the medieval world.¹ Because of its essential connection with astronomy, the concept of the world-year is of interest and utility to historians of science. Its ramifications provide clues elucidating the role of Sasanian Iran in the origin and transmission of scientific theory, particularly towards India. Translated below are two fragmentary versions of a chapter descriptive of the world-year and stemming ultimately from Abū Ma'shar² al-Balkhī,

the ninth century astrologer widely known in medieval Europe as Albumasar. He wrote a treatise called *Kitāb al-Ulūf* (Book of the Thousands), no copy of which is presently available. It was summarized, however, by Aḥmad 'Abd al-Jalīl al-Sijzī³ (fl. 1000) and the summary, though mutilated, has come down to us.

2. THE SOURCES

The first, referred to hereafter as A, appears on f. 236 of the anonymous MS (Paris) BN Arabe 5968. This important document, to which our attention was called by Mr. Marcel Destombes, is a collection of astronomical and genealogical tables and treatises evidently compiled by a member of the Ismaili sect. In fact, Blochet⁴ states that the

¹ See van der Waerden, B. L., "Das grosse Jahr und die ewige Wiederkehr," *Hermes* 80 (1952), pp. 129-155.

² Brockelmann, C., *G. A. L.* (Leiden, 1943), Vol. I (2d. ed.), p. 250; suppl. Vol. I, p. 394.

³ Brockelmann, C. op. cit., Vol. I (2d. ed.), p. 246; suppl. Vol. I, p. 388.

⁴ *Notices et extraits des manuscrits de la Bibliothèque Nationale*, XLI (1923), pp. 391-398.

manuscript is a holograph of the unknown author, that it was written in the fortress of Alamut during the time of Ḥasan-i Sabbāḥ, and that it is one of the books found in the Alamut library by the historian Juvaini when the place was taken and destroyed by Hulagu Khan⁶ in 1256.

Our passage is said to be from a work called *Al-Jāmi' al-Shāhī*. The same name is attached to British Museum MS Or. 1346, a collection of astrological writings by al-Sijzī. Among these is his summary of the "Book of the Thousands," and a cursory examination of the latter showed that its first section, which we will call B, is a version of A. There is so little material identical between the two, they evidently having suffered the mistakes and omissions of independent successions of scribes, that it seems best to translate both without attempting to piece together a single original. Doubtless we will still be lacking some phrases set down by al-Sijzī in the first place, and what we have will differ somewhat from his original version.

3. THE TRANSLATIONS

Numbers in parentheses indicate the beginnings of lines in the Arabic text. Words in parentheses do not appear in the original, but are added for clarification. The translations follow:

A

(f. 23a: line 1). A world-year, according to the generality of the astrologers, is from the time of arrival of the planets at the first of Aries until the time of their return (2) to the end of Pisces, without there being a difference in their amounts (i.e., longitudes). As for those in a region of India (3) and their adherents, they say that the seven planets and their apogees and nodes (4) begin the motion from the first of Aries, and they conjoin at the end of Pisces in (5) 4,320,000,000 years. As for the partisans of the year of *Arjabhaz* (Āryabhata), (6) they differ from them and make the world-year 4,320,000 years. (7) The partisans of the years of the *Arkand* said differently from this. The Persians (*ahl Fārs*) and some of (8) the Babylonians said that the world-years are 36[0],000 solar years, of which there are 365 days, (9) 15 minutes, 3[2] seconds, (and) 24 thirds, without requiring their apogees and nodes (to be

at Aries 0°). (10) If we divide the years of the Sindhind by a thousand there come out the *Arjabhaz* years. If we divide (11) by twelve thousand there comes out the year of the Persians. It is necessary to know that if the motions of (12) the apogees and nodes are the same it prevents their conjunction in one degree because they are scattered. (13) For the years of the Persians there are two characteristics. In the first place, if the mean motions are computed (14) by these years, one solar year by one year, there will be with the mean motions (15) a number which will increase an integer number of degrees in each thousand years, without a fraction. So if we take multiples of the mean motions (16) for each thousand years until the end of the world-year they all become degrees without fractions. This is not found (17) for the other cycles. The second characteristic is that the degrees elevated from the fractions of the sun, (18) especially if they are made days, the amount is 259 days, and these days are the base for the duration of (19) the child in the womb for a nine (month pregnancy?) and thereby the horoscope of the nativity is verified. The most famous and oldest of events is the Deluge, (20) in the time of Jam. Its time was at the mean conjunction of the seven planets (21) at the last (point) of Pisces on a Thursday, and verily half of the world-year had passed according to the belief of (22) the Persians. And what passed from the Deluge until the end of three thousand years was 1,095,776 (days), (23) and what passed of the fourth thousand until the Tuesday, the first of the reign of Yazdigerd (24) was 267,821 days, in solar years [733 and 86:9, 10, 48 days . . .] which is two hundred and sixty-six (25) years of Yazdigerd and 348 days upon the entry of the sun into the first minute (26) of Aries at the time of its rising, at the position of *Kankdidh* (i.e. *Kangdezh*) on the morning of the day, it being a place to the east of (27) China, if it is opposite the middle of the earth appearing to it, it would rise, and when it arrives (28) at the midheaven of that place it would rise at the middle of the apparent earth. And what passed from the Deluge (29) until the first day on which Yazdigerd arose is 3,735 Persian years and ten months (f. 236b: line 1) and twenty[-three] days and twenty-two hours. From the date of the Deluge to the first of the year of (2) the Hijra is [3,725] (the text has 37,350) Persian years and eleven months and fourteen (3) days. The conjunction indicating the Deluge was

⁶ See: *The History of the World-Conqueror*, by 'Ala-ad-Din Juvaini (transl. by J. A. Boyle), Manchester, 1958, Vol. II, p. 719.

before it two hundred and seventy-six years, and (4) between the Deluge and the Saturn-Jupiter conjunction indicating the religion (of Islam) is 3,679 years.

B

(f.80b: line 22) A J STATEMENT CONCERNING WORLD-YEARS AND THE CHRONOLOGY (*tawārikh*) (23) USED IN THIS BOOK. Verily, the generality of the learned among the people of India, and China, (24) and Rūm (the Byzantines), and Fārs, and the people of Babylon, and those who follow them among the peoples are agreed (on the fact) that the seven planets were in conjunction (25) at the first minute of Aries and that they conjoin at the end of Pisces at the end of the world. As for the Hindus, they claim that the planets (f. 81a: line 1) their apogees and nodes, were in conjunction in the first minute of Aries, and that they conjoin at the last (2) (point) of Pisces at the end of the world, and the years of the world are from the time of the conjunction of the planets at the first minute of Aries until the time of (3) their conjunction at the end of Pisces, it being one and the same place, except that they differ among themselves as to the travel of the planets in the heaven. (4) As for those of one of the regions of India, they claim that the years of the world are 4,320,000,000 (5), they being the partisans (*aṣḥāb*) of the Sindhind. However, the other group of them, they being the partisans of the years of Arjabhaz, they (6) claim that the years of the world are 4,32[0],000. But the author (*ṣāhib*) of the "Book of the Thousands" used the years of the Persians for the cycles and (7) *tasyīrāt*. However, some of the moderns used the world-years according to the way the partisans of the Sindhind explained them, (8) but we now, in this book, will utilize what the author of the "Book of the Thousands" used. So if you want to extract (9) the world-years and their days, look at the (number of) days and their fractions in which one of the planets rotates once around the heavens (10) in its mean motion, and multiply it by the days and fractions thereof in which another of the planets rotates once. (11) Then what results is the number of days in which the two will conjoin at the same position from which they started moving. (12) Then multiply what resulted of those days and fractions by the days and fractions in which another planet rotates (back) to the position in (13) which it was at the beginning of the motion, and thus according to

this manner. Then multiply what you obtain for all seven of the planets (14) and the nodes and apogees, and it will be the days of the world. Verily the author of the "Book of the Thousands" mentioned the revolutions of the planets in days of (15) the world and the quantity of each of their revolutions in days and hours and minutes. At any rate, the days of the world utilized in this book are (16) [131], 493, 240 (text has 313, 493, 240) that being in solar years 36[0],000 according to a year of three hundred (17) and sixty-five days and fifteen minutes and thirty-two seconds and twenty-four thirds. That which passed from (18) the first day of the world-year until the first day of the Deluge [. . . and what passed of the fourth thousand] until the Tuesday, the first day of the reign of Yazdigerd was two hundred thousand (19) and sixty-seven thousand and eight hundred and twenty-one days, and its depiction in the Hindu (numerals) is 267,821. That will be (20) in solar years seven hundred and thirty-three years and eighty-six days and nine minutes and ten seconds and (21) forty-eight thirds. And what remains of days until the fourth thousand finishes is 97,438 days. That will be in two hundred and (22) sixty-six years of Yazdigerd and three hundred and forty[-eight] days upon the entry of the sun into the first minute of Aries, at the time of (23) its rising, at the position of Kankdiz, it being a place to the east of China. And that which passed from the Deluge until the first day (24) on which Yazdigerd arose (is) three thousand years and [seven] hundred and thirty-five Persian years and ten months and (25) twenty-three days and twenty-two hours. And that which passed from the Deluge until the first day of the year in which (26) the Prophet, the prayers of God upon him and peace, fled from Mecca to Medina in Persian years is three thousand and seven hundred and twenty-five (27) years and eleven months and fourteen days. That will be, in solar years, three thousands and seven hundred and twenty-three (28) years and three months and twenty-eight days and eight hours and fourteen minutes. So this is the saying concerning the world-years (29) and chronology used in this book.

4. COMMENTARY

References to the sources give an A or a B followed by a colon and a number to identify the line of the text. Folio numbers will be given only when necessary to avoid ambiguity.

A: 2, B: 4.

This span of time is the *Kalpa*, the fundamental Hindu period upon which the Brāhma-sphuṭa-siddhānta⁶ and the new Sūrya-siddhānta⁷ are based.

$$\begin{aligned} 1 \text{ Kalpa} &= 1,000 \text{ Mahāyugas} \\ &= 1,000 \times 4,320,000 \text{ years.} \end{aligned}$$

At the beginning of a Kalpa all seven planets, as well as their apogees and nodes, were supposed to be at 0° Aries, just as our texts say. There is good reason for thinking that the Sindhind⁸ of the Islamic astronomers was an Arabic translation of the Brāhma-sphuṭa-siddhānta, so that all is well thus far. Curiously enough, the scribe of B used the symbol for sexagesimal zeroes to denote the zeros in his decimal numerals.

A: 5-6, B: 5-6.

In the system of Āryabhaṭa the fundamental unit is indeed taken as the Mahāyuga, a thousandth of the Kalpa, and except for the missing zero to be restored in B the texts are still reliable.

A: 7.

The Arkand is the name of an early Islamic translation⁹ into Arabic of Brahmagupta's *Khaṇḍakhādīyaka*. The ahargana of the latter is reckoned from the Śaka year 587, i.e., it does differ from the system first named.

A: 8, B: 6, 16.

In spite of the omission of a zero in the length of the Persian world-year as given in both A and B, considerations derived from the texts themselves, reinforced by statements in other sources, enable us to make the restoration with complete confidence. For one thing, if we perform the operation prescribed in A: 11 and divide the years of the Sindhind, 4,320,000,000, by 12,000, we obtain 360,000, not 36,000. Bīrūnī in several

places¹⁰ attributes the 360,000 year cycle to Abū Ma'shar, and Abū Ma'shar himself in his book on conjunctions¹¹ repeats the same numbers.

Thus we have:

The world-year of the Persians = 360,000 years = 131,493,240 days, hence one solar year in this system is

$$\frac{131,493,240}{360,000} = 365.259 = 365;15,32,24 \text{ days.}$$

These numbers can be verified by direct division, but all of them either occur in or are restorable from our A and B, or from the writings referred to above.

Concerning "some of the Babylonians" Bīrūnī¹² says, "The astrologers have tried to correct these years, beginning from the first of the conjunctions of Saturn and Jupiter, for which the sages among the inhabitants of Babel, and the Chaldaeans have constructed astronomical tables, the Deluge having originated in their country."

A: 12.

Since, in the Kalpa system, the apogees are all at Aries 0° at the beginning of the Kalpa, it follows that not only the mean planets, but also the true planets are then at Aries 0°. On the other hand, in Āryabhaṭa's system and in the Sasanian astronomical handbook, the Zīj-i Shāh, the apogees are fixed, hence at the beginning of the world-year the true planets will not be in conjunction, but will be "scattered."

A: 15.

The Persian system assumes that each planet accomplishes an integer number of revolutions in 360,000 years, i.e., its advance in degrees during this period is an integer multiple of 360. It follows that in each thousand years the planet will advance by the same integer number of degrees, and "this is not found for the other cycles."

A: 18.

Duration of pregnancy computations were of interest to astrologers because by many of them the instant of conception was considered to be of more importance for casting a horoscope than the instant of birth. We have seen that the length of

⁶ This work has been published as: *Brāhmasphuṭasiddhānta*, by Brahmagupta, edited with his own commentary by M. S. Divedin, Benares (Medical Hall Press), 1900, reprinted from Pandit, vol. 24.

⁷ Translated by E. Burgess, *JAOS*, 6 (1860), pp. 141-498; reprinted Calcutta, 1935; new edition of the Sanskrit text by K. S. Shukla: *The Sūrya-siddhānta with the commentary of Paramesvara*, Lucknow Univ., 1957.

⁸ See the translation of Bīrūnī's "India" by E. Sachau (London, 1910), Vol. I, p. 368; also *Al-Bīrūnī on Transits* (Beirut, 1959), p. 141.

⁹ See, e.g., Bīrūnī's "India" (transl.), Vol. II, p. 7.

¹⁰ Cf. *The Chronology of Ancient Nations*, translated by E. Sachau (London, 1879), p. 29; also *Al-Qānūn al-Mas'ūdī* (Hyderabad-Deccan, 1956), Vol. III, p. 1475.

¹¹ Escorial MS Arabe 937, f. 4r.

¹² *Chron.*, transl., p. 28.

a Persian solar year, written as a pure decimal is 365.259 days. "To elevate" in a medieval Arabic mathematical context is to perform an operation analogous to moving the decimal (or sexagesimal) point to the right; that is, to multiply by some integer power of the base, here ten. Elevation of the fractions of the number above (the "fractions of the sum" of A) by a thousand gives 259 the alleged duration of pregnancy.

A: 20.

In the three versions of the Persian traditional chronology reported by Bīrūnī¹³ the reign of the legendary Jam(shīd), son of Tahmūrath of the Pishdadian dynasty, falls approximately between the years -3400 and -2800 of the Christian era. We will see presently that Abū Ma'shar puts the Deluge in -3101, hence it occurred during the reign of Jam.

B: 14.

We can only regret that al-Sijzī neglected to pass on Abū Ma'shar's mean motion parameters for the planets. Fortunately, as in so many other instances, most of them have been preserved for us by the incomparable Bīrūnī, and they are discussed in Section 6 below.

A: 22.

The number of days in three thousand Persian solar years is

$$3,000 \times 365.259 = 1,095,777 \text{ days,}$$

which is the same as the text, except that the terminal digit of the latter is 6.

A: 23, B: 18.

In these sections gaps in each of the two versions can be filled, but only partially, by utilizing one against the other. B: 18 does not make sense as it stands. But at least it is clear that a passage is missing, as indicated by the square brackets, and that the end of the missing passage should be restored as shown in the translation. Now the sum of the number of days in three thousand Persian solar years plus the number of days given in both versions is

$$1,095,777 + 267,821 = 1,363,598 \text{ days.}$$

This is precisely the span in days from Thursday, 17 February -3101, the Deluge date of

al-Khwārizmī¹⁴ and al-Bīrūnī¹⁵ to Tuesday, 16 June, 632, the first day of the Yazdigerd calendar.

A: 24, B: 20-22.

To convert 267,821 days into Persian solar years we divide this number by 365.259, the number of days per year, and obtain 733 as a quotient and a remainder of $86.153 = 86;9,10,48$. Thus the number given in B is verified, and it is shown that the restoration made in A, which is lacking in the text, is valid.

The number of days given until the end of the fourth thousand in B: 21, when added to the elapsed days of the fourth thousand is

$$97,438 + 267,821 = 365,259,$$

the number of days in a thousand Persian solar years. So it has been transmitted without error. Furthermore, since Yazdigerd years have just 365 days,

$$97,438 \text{ days} = 266 \text{ Yazdigerd years and } 348 \text{ days.}$$

So the statement in A: 24, 25 is correct, and that of B: 21, 22 is restored with the addition of an "eight."

A: 26, B: 23.

Kangdezh was a mythical Iranian castle built by Jam, evidently regarded as being at the eastern edge of the habitable part of the globe. Bīrūnī says that Abū Ma'shar used it as the base locality for his zij.¹⁶ The habitable part of the earth was thought of as extending through 180° of longitude. The idea seems to be that noon at Kangdezh would be sunrise in the middle of the inhabited regions.

A: 29, B: 24.

Recalling that the "Persian" (or Egyptian) calendaric year has 365 days and each Persian month thirty days, we have for the span from Deluge to Yazdigerd

¹⁴ See: "Die astr. Tafeln des Muḥ ibn Mūsā al-Khwārizmī . . ." herausgeg. von H. Suter (Kopenhagen, 1914), *Kgl. Danske Vidensk. Skrifter*, 7. R., Hist. og. filos. Afd. 3, 1; "The Astronomical Tables of al-Khwārizmī," transl. w. comm. by O. Neugebauer, *Hist. filos. Skr. Dan. Vid. Selsk.* 4, no. 2, (Kopenhagen, 1962).

¹⁵ *Chron.* (transl.), p. 133.

¹⁶ In the "India" (transl.), Vol. I, p. 304, Sachau writes "his geographical canon," but the text (Hyderabad-Deccan, 1958), p. 259, simply says "his zij."

¹³ *Chron.*, Transl., pp. 109-114, 200-203, 220.

1,363,598 days = 3,735 Persian years,
10 months, 23 days.

This number enables us to restore scribal omissions in A and B made in different places in the two versions. So the matter is settled down to integer days, but the additional twenty-two hours appearing in both A and B pose a difficulty. Quite plausibly the mention of Kangdezh just preceding was to account for a time difference due to geographical location and to the time of day taken as epoch. Now the time difference from Kangdezh to a place of longitude 90° is six hours; that between noon and sunrise epoch or between sunset and noon, is of the same order of magnitude, but no combination of these gives anything near twenty-two hours.

A: f.236b:1, B:26.

The number of days from the Deluge date given above to 15 July, 622, the beginning of the Hijra calendar, is 1,359,974. This contains 3,725 Persian 365-day years plus a remainder of 349 days. The latter contains eleven Persian months plus a remainder of nineteen days. Before 1006, however, it was customary to insert the five epagomenal days at the end of the eighth month instead of at the end of the year. If the former is done the remainder will be reduced to 14 days, the number given in both versions. Calculated thus, the result is reported correctly in B, but A has been garbled.

B:28.

To convert 1,359,974 days into Persian solar years we divide by 365.259. The quotient is 3,723, as in the text, with a remainder of 114.743 days, or three thirty-day months, twenty-four days, and 17:50 hours. We see no way of reconciling the last part of this result with the twenty-eight days and 8;14 hours of the text.

A: f.236b:3.

Our source states that 276 years before the Deluge there was a conjunction. In such a context "conjunction" usually means a Saturn-Jupiter conjunction. It will be shown in Section 5 below that the time between mean conjunctions of this sort, according to the parameters of Abū Ma'shar's book of conjunctions is

$$\frac{360,000}{18,138} \approx 19.848 \text{ years,}$$

where a year is 365.259 days. Fourteen conjunctions will take about 277.9 years, and the number

in the text is too low for a fourteen conjunction interval and out of the question for any other.

A: f.236b:4.

The conjunction indicating the rise of Islam (*qirān al-milla*) the 185th conjunction of Saturn and Jupiter since that of the Deluge year, took place in 571 A.D. Testifying to this are horoscopes cast for the instant of the sun's entry into Aries on that year, several being versions of computations by Abū Ma'shar himself.¹⁷ The interval from Deluge to this conjunction is 3,672 years, not 3,679 as claimed by our text.

5. THE DOCTRINE OF ABŪ MA'SHAR

We shall now compare the Persian system our sources mention with the doctrine of Abū Ma'shar, which is also based upon the assumption of a cycle of 360,000 years. This doctrine is known from several passages in the writings of Bīrūnī and from various versions of Abū Ma'shar's book of conjunctions.

In his *Chronology* (transl., p. 29), Bīrūnī writes about Abū Ma'shar:

He supposed that the Deluge had taken place at the conjunction of the stars in the last part of Pisces, and the first part of Aries, and he tried to compute their places for that time. Then he found that they—all of them—stood in conjunction in the space between the twenty-seventh degree of Pisces and the end of the first degree of Aries. Further, he supposed that between that time and the epoch of the Aera Alexandri, there is an interval of 2,790 intercalated years, 7 months and 26 days . . . Now, when he thought that he had well established the computation of this sum according to the method, which he has explained, and when he had arrived at the result, that the duration of those periods, which astronomers call 'star-cycles,' was 360,000 years, the beginning of which was to precede the time of the Deluge by 180,000 years, he drew the inconsiderate conclusion that the Deluge had occurred once in every 180,000 years, and that it would again occur in future at similar intervals.

This man, who is so proud of his ingenuity, had computed these star-cycles only from the motions of the stars, as they had been fixed by the observations of the Persians; but they (the cycles) differ from the cycles, which have been based upon the observations of the Indians, known as the 'cycles of Sindhind,' and likewise they differ from the *days of Arjabhaz*, and the *days of Arkand*.

Here, we see that Bīrūnī distinguishes, just as our sources do, three kinds of cycles: The Persian

¹⁷ E.g. in MS PB20.B41, f.29a, of the Near East School of Theology, Beirut.

cycle of 360,000 years, of which Bīrūnī says that it is based upon the observations of "the Persians," the cycle of Āryabhaṭa or Mahāyuga of 12 Persian cycles, and the "cycle of Sindhind" or Kalpa of 1000 Mahāyugas, which is said to be "based upon the observations of the Indians." In fact we know that the mean motions of the "Sindhind" are the same as those of Brahmagupta's Brāhma-sphuṭa-siddhānta,¹⁸ and that the fundamental period of the Sindhind is just the Kalpa of Brahmagupta. Hence, Bīrūnī's testimony confirms several statements of our sources.

As we have seen, the duration of the year:

365;15,32,24 days

is also the same in Abū Ma'shar's book of conjunctions and in the Persian System.

Still, we have to be careful in using the evidence from Abū Ma'shar for the reconstruction of the "Persian system." According to Bīrūnī's account, Abū Ma'shar had computed the places of the planets for the time of the Deluge and found positions between 27° Pisces and 1° Aries. Now, in the Persian system, the mean longitudes of the planets are exactly zero at this epoch, and the true places, calculated by the "Method of the Persians," are not at all between 27° and 1° Aries. It seems that Abū Ma'shar used, in his calculations, tables that were not in accordance with the Persian system.¹⁹

We have checked some horoscopes²⁰ ascribed to Abū Ma'shar and found that he assumed the numbers of revolutions of Jupiter and Saturn in 12 times 360,000 years to be

364,220 and 146,568.

These are just the figures of the new Sūrya-siddhānta. The number for Jupiter is not divisible by 12. In the Persian system, the numbers must be divisible by 12, because all planets return to their original positions in a period of 360,000 years.

It seems that Abū Ma'shar, in his theoretical expositions, uses the Persian System, but in his calculations a mixture of several systems.

¹⁸ Burckhardt, J. J., *Vierteljahresschrift der naturf. Ges.*, Zürich, 106, p. 213 (1961).

¹⁹ The mean positions at Abū Ma'shar's "epoch of the Deluge," as calculated by Brahmagupta's Brāhma-sphuṭa-siddhānta, are just between 27 Pisces and 1 Aries. Possibly Abū Ma'shar used this system.

²⁰ From MSS: Paris BN Arabe 2581; British Museum Or. 1346; Near East School of Theology, Beirut, PB20. B41.

For this reason, we shall calculate the numbers of revolutions of the planets not from Abū Ma'shar's text, but from other sources, and use his text only as a check.

6. THE NUMBERS OF REVOLUTIONS

Āryabhaṭa's fundamental period, the Mahāyuga, contains just 12 times 360,000 years. Therefore, if we divide the number of revolutions of any planet in a Mahāyuga by 12, we obtain the number of revolutions in a Persian World Year (according to Āryabhaṭa).

The numbers of revolution in Āryabhaṭa's first system the "midnight system," are the same as those in the Khaṇḍakhādya and in the Old Sūryasiddhanta.²¹ The numbers are quite near to reality and to those of Babylonian planetary theory (see Table 2 in B. L. van der Waerden, *Vierteljahresschrift der naturf. Ges.*, Zürich 100, p. 165). Hence, if we divide these numbers by 12, we ought to get at least approximately the same numbers as in the Persian System. The division gives

Saturn	12,214 — $\frac{1}{3}$	Mercury	1,494,750
Jupiter	30,352 — $\frac{1}{3}$	Moon	4,812,778
Mars	191,402	its apogee	40,685 — $\frac{1}{12}$
Venus	585,199	its node	19,352 + $\frac{1}{3}$.

It is a remarkable fact that four of the eight numbers are actually divisible by 12. The last two numbers are nearly divisible by 12, the remainders of the divisions being —1 and +2 respectively. For Jupiter and Saturn we have to add 4 to the numbers of revolutions in a Mahāyuga in order to obtain divisibility by 12.

If we neglect the fractions, the resulting numbers for Saturn, Jupiter, Mars and the Moon are even. This means that not only at the beginning and end, but also in the middle of the period of 360,000 years, at the "epoch of the Deluge," the planets are in conjunction with the sun, as they should be in the Persian system. For Venus the number is odd, but this does not matter: if we have an inferior conjunction in the beginning, we shall have a superior conjunction in the middle of the period, and vice-versa.

How far can the numbers of revolutions in the Persian system differ from those calculated by division? The mean longitudes of the planets at the vernal equinox of —3101 are zero in the Per-

²¹ See Sengupta, P. C., *The Khaṇḍakhādya of Brahmagupta*, Univ. of Calcutta, 1934.

sian system as well as in Āryabhaṭa's. Now, if we add one unit to the number of revolutions of any planet in 360,000 years, the motion in 3,600 years, and hence the longitude in the year 499 is increased by 3.6 degrees. If we add 2 units in order to keep the number even (as we must for the upper planets and the moon), the longitude in 499 is increased by 7.2 degrees. Now, Āryabhaṭa's longitudes are in good accordance with modern calculations, and a shift of 7.2 degrees would disturb this agreement altogether. Hence, the numbers given for Saturn, Jupiter, Mars and the Moon (without the fractions) are most probably the correct numbers of the Persian system, and the numbers computed for Venus and Mercury cannot differ from the correct numbers by more than 1 for Venus and 2 at most for Mercury.

Bīrūnī, in his "Book of Instruction in Astrol-ogy," translated by R. R. Wright (London 1934), gives the numbers of revolutions of the planets according to Abū Ma'shar (p. 114 of the translation). The figures for Saturn, Jupiter, Mars, Venus and the Moon agree exactly with the results of our division. For Mercury Bīrūnī gives 751 instead of 750. Possibly 751 is the correct figure, although 750 agrees exactly with Babylonian planetary theory and with Rhettorius (*Catal. Cod. astrol. Graec.* I, p. 163).

For the lunar apogee Bīrūnī gives 19,365, which is quite impossible. Still, the 5 at the end agrees with our calculation. The preceding digits 1936 are probably copied from the number for the node.

For the lunar node, Bīrūnī gives 19,360 revolutions. This number would give an error of 28.8 degrees in the position of the node for 499. Such an error would spoil all calculations of eclipses. Therefore, our number 19,352 is much more likely.

The numbers of revolutions of Jupiter and Saturn, 30,352 and 12,214, are just the same as in the book of conjunctions of Abū Ma'shar.²² The difference between these numbers is 18,138. This implies that there are 18,138 Jupiter-Saturn conjunctions in every cycle of 360,000 years. From one conjunction to the next, the motion of Saturn is

$$\frac{12,214}{18,138} \cdot 360^\circ = 242;25,17,10,6$$

degrees. This number is also given in Abū Ma'shar's book of conjunctions.

The lapse of time from one conjunction to the next is

$$\frac{360,000}{18,138}$$

years. Starting with the assumed conjunction of the year - 3101, the times of the successive mean conjunctions can be calculated. For these calculated times, the mean longitudes of Jupiter and Saturn may be calculated by modern tables. If the mean motions of the Persian system were correct, the differences of the mean longitudes ought to be zero at the times of the calculated mean conjunctions. Actually, they are not zero. The error is approximately

$$\begin{aligned} &5^\circ \text{ in the 3rd century A. D.,} \\ &4^\circ \text{ in the 4th century A. D.,} \\ &2^\circ \text{ in the 5th century A. D.,} \\ &1^\circ \text{ in the 6th century A. D.} \end{aligned}$$

From these errors we conclude that the Persian system in the form in which we know it, with 18,138 mean conjunctions in 360,000 years, cannot have originated before the 5th century. Errors of 1 or 2 degrees are tolerable, but errors of 4 or 5 degrees would spoil the calculation of the conjunctions altogether.

This gives us 400 A.D. as a lower limit to the date of invention of the Persian system. To obtain an upper limit, we shall compare it with the system of Āryabhaṭa.

7. ĀRYABHAṬA AND THE PERSIAN SYSTEM

Āryabhaṭa was just 23 years old in March 499, at the time of the spring equinox, as 3,600 years of the Kaliyuga had passed.²³ He developed two slightly different astronomical systems, the "midnight system" and the "sunrise system." The latter, known to us from his own treatise Āryabhaṭīya, is based upon the assumption of a mean conjunction of all planets at 0° Aries on

Friday, Febr. 18, - 3101, at sunrise.

In the midnight system, known from the Pañchasiddhantikā of Varāha Mihira and from the Khaṇḍakhādyaka, the mean conjunction of all planets is 6 hours earlier, at midnight in the night from Thursday to Friday. In both systems, the great conjunction marked the beginning of the present *Kaliyuga*, the last quarter of the *Mahāyuga*

²² Escorial MS Arabe 937, f.4^a.

²³ Clark, W. E., *The Āryabhaṭīya of Āryabhaṭa* (Chicago, 1930).

of 4,320,000 years. Āryabhaṭa himself calls the Mahāyuga *Caturyuga*, i. e., fourfold cycle.

The Caturyuga is 12 times the Persian cycle, and the numbers of revolution in the midnight system are 12 times the Persian numbers; only for Saturn and Jupiter they are 12 times the Persian numbers minus 4, as we have seen. Moreover, Āryabhaṭa's date for the great conjunction of -3101 differs only by 1 day from the Persian date. Obviously, the Persian system and the astronomy of Āryabhaṭa are not independent. Either the Persians modified the system of Āryabhaṭa or Āryabhaṭa modified the Persian system.

For several reasons, the second possibility seems more probable. To begin with, astronomical periods usually become longer and not shorter in the course of time. Kallippos multiplied the 19-year cycle of Meton by 4 in order to obtain an integer number of days. The Babylonians used a lunar period of 248 days, Hellenistic texts made use of periods of 248 and 3,031 days, and in Tamil astronomy both periods were combined to a larger period of 12,372 days.²⁴ The old Sūrya-siddhānta is based upon the Mahāyuga, but the new Sūrya-siddhānta is based upon the Kalpa. The examples could be multiplied still more.

The tendency to longer periods is easy to explain. Longer periods give the astronomer more freedom to adapt the elements of his system to the observations. An example will illustrate this.

In the Persian system, the mean motion of a planet in 1,000 years is an integer number of degrees. Hence, the mean motion in 3,000 years is a multiple of 3°. For Saturn, Jupiter, Mars and the moon, it is even a multiple of 6°. Now suppose an astronomer, who made observations in the year -101, i. e. 3,000 years after the great conjunction of -3101, wants to fix the number of revolutions in such a way that the positions of the planets agree with his observation. He has to round off the observed mean places to multiples of 3° or even 6°. If he observes in the year 499, he has to make his mean longitudes multiples of 36° or 72°. This means he cannot attain any great accuracy. On the other hand, in the system of Āryabhaṭa, the mean positions in 499, March 21st at noon had to be multiples of 12° only. This advantage was a consequence of his using a larger period.

²⁴ See van der Waerden, B. L., *Centaurus* 4, p. 221, and 5, p. 177.

If the "Persians" had modified Āryabhaṭa's system by reducing his period, they had to sacrifice this advantage and to make the system less flexible and less accurate. This is improbable. It is more probable that Āryabhaṭa, who was an excellent theorist and who had rather accurate observations at his disposal, modified the Persian system, making it more flexible.

According to Ibn Yūnis²⁵ the Persians observed the solar apogee about 450 A.D. Āryabhaṭa lived 50 years later. Hence, Persian astronomy existed before Āryabhaṭa and may have influenced him.

In classical Greek and Hellenistic literature, the doctrine of the "Great Year" was already connected with the myths of the Deluge and Ekyrosis.²⁶ These catastrophes were supposed to return periodically when the planets came together in certain signs of the zodiac. In the Persian system, we still find the Deluge connected with a conjunction of the planets. Āryabhaṭa does not mention the Deluge; he only alludes to the "battle of Bhārata" on Thursday, February 17, -3101. The idea of a Deluge in the middle of a cycle of 360,000 years cannot be derived from India; it must have come to Persia from the West.

8. THE EPOCH OF THE PERSIAN SYSTEM

We shall now investigate, at what time of the day the Great Conjunction of the year -3101 was supposed to take place in the Persian system.

In Āryabhaṭa's first system this conjunction was at midnight between Thursday and Friday, February 18. Both systems of Āryabhaṭa yield excellent values for the moments of New Moon in the 5th and 6th centuries. The differences between the mean longitudes of the moon and the sun agree with modern calculation within a tenth of a degree.

For the Persian system, the agreement may be less good, but still the moments of Full Moon must be expected to come out without large systematic errors. Lunar eclipses are easily observable phenomena.

In Āryabhaṭa's first system, 3,600 years contain 6,5,15,31;30 days. In the Persian system they contain 6,5,15,32;24 days, i. e. nearly one day more. The number of revolutions of the moon is

²⁵ The statement occurs in the Leiden fragment of his Hākīmī Zij, Leiden Cod. Or. 143, p. 124. See also Taqīzadeh, S. H., *Gāh shumārī dar Irān-i qadīm*, Tehran, 1316 (Hijrī-i shamsī), p. 322.

²⁶ See van der Waerden, B. L., *Hermes*, 80, p. 129.

the same, hence, the mean longitudes of the sun and the moon at the end of 3,600 years after the conjunction of -3101 are exactly the same in both systems. If the date of this conjunction were the same, the moments of New Moon and Full Moon would come out nearly one day too late in the Persian system, which is impossible. Hence, the conjunction of -3101 must be shifted to the early morning of Thursday February 17, say between two and three hours Western India time, i. e. near midnight Babylon time.

According to Bīrūnī, Babylon was the base location of the Persian Zīj-i Shāh. Bīrūnī also informs us that, in contrast to most zījēs, the Zīj-i Shāh reckons the nycthemeron from midnight to midnight.²⁷ This agrees well with our conclusion that the Persians assume the conjunction of -3101 at midnight in the night from February 16 to 17.

9. PERSIAN TABLES

Islamic astronomy starts with two translations, one from Sanskrit and one from Pahlavi, viz:

(i) the *Sindhind*, a translation of an Indian Siddhānta, most probably the Brāhma-sphuṭa-siddhānta of Brahmagupta,

(ii) The *Zīj-i Shāh*, a set of tables translated from the Persian *Zik-i Shatro-ayār*.

A *zīj* is a set of tables for calculating solar, lunar and planetary positions, eclipses etc. In Bīrūnī's *Rasā'il* (Hyderabad-Deccan, 1948) zījēs based upon the *Sindhind* are called *Sindhind zījēs*, and zījēs related to the *Zīj-i Shāh* are called *Persian zījēs*. Among the Persian zījēs Bīrūnī includes those of Ya'qūb ibn Ṭāriq, al-Khwārizmī, Abū Ma'shar and the Shāh. He repeatedly states that Abū Ma'shar depends on "the Persians." In *Rasā'il* (iii) 89;10 he states that Ibn al-Farrukhān and Māshāllāh are intermediate between Abū Ma'shar and the Persians. Since Ibn al-Farrukhān lived about 780, we must conclude that "the Persians" lived before 780 A.D. This is also clear from the fact that the Zīj-i Shāh was translated about 790.

The Jewish astrologer called Māshāllāh (Messehalla in the West) was closely connected with the Persian tradition. He, like Abū Ma'shar, came from Balkh, the city associated with Zoroaster. In a British Museum manuscript (Add. 23400, f. 2a) he is referred to as "Yazdānkhwāst, known as

Māshāllāh" (more properly *mā shā'allāh*). Both names, in Persian and Arabic, respectively, mean "what God desired."

The question now arises, what was the relation between the Persians of our text, who used the cycle of 360,000 years, and the Persians of Bīrūnī, who composed the *Zik-i Shatro-ayār*. From the common designation "the Persians" we may tentatively conclude that in both cases approximately the same group of people was meant, and that they lived in Sasanian Persia. This is fully confirmed by a closer examination of the evidence.

First, both groups were very much interested in planetary conjunctions. Abū Ma'shar, in his book of conjunctions, deals at length with the calculation of Saturn-Jupiter conjunctions and their astrological significance.²⁸ Ibn Hibintā²⁹ copying from a lost book on conjunctions by Māshāllāh, gives the time between two successive conjunctions as $19^{\text{h}} 10^{\text{m}} 11^{\text{s}}$, and the gain in the zodiac as $242;25^{\circ}$. The latter figure is in agreement with Abū Ma'shar's calculation and with the Persian system, as we have seen already. Ibn Hibintā connected the conjunctions with important events such as the Deluge, the birth of Christ, the religion of Islam, etc. Just so, our sources A and B connect the Deluge and the religion with conjunctions. The conjunction of all planets in -3101, which forms the basis of the Persian System, is a "mighty conjunction" in the sense of the astrological theory.

Thus, we see that there are many points of contact between the "Persian system" and Bīrūnī's "Persians." Still, the Persian system is not identical with the system of the Zīj-i Shāh. There are differences in the numbers of revolutions and the duration of the year.

The year of the Zīj-i Shāh has, according to the Escorial manuscript of the *Tabulae Probatae*,³⁰

365;15,32,30 days.

The same value is mentioned by Hāshimī,³¹ who says it was used by the Persians and Māshāllāh. Bīrūnī (*Chron.* Transl., p. 121) also confirms that

²⁸ Kennedy, E. S., *JAOS*, 78, p. 259.

²⁹ The only extant fragment of this work is Munich MS Cod. Arab. 852.

³⁰ Kennedy, E. S., *Trans. Amer. Philos. Soc.*, 45 (1956), no. 51, p. 132 and 147. On the Escorial codex Arabe 927 see also J. Vernet, "Las Tabulae probatae," *Homenaje a Millas Valliçrosa*, II, p. 501 (*Consejo sup. de invest. cient.*, Barcelona, 1956).

³¹ Kitāb 'ilal al-zijāt, Bodl. MS Seld. A.11.

²⁷ Kennedy, E. S., *JAOS* 78 (1958), p. 260.

it was used by the Persians. However, in the Persian system, the year has

$$365;15,32,24 \text{ days,}$$

and the same value is used by Abū Ma'shar.

The fragment of Ibn Hibintā's astrology contains a run of horoscopes calculated by Māshallāh, using the Zīj-i Shāh, for years in which conjunctions of Saturn and Jupiter took place.³² The mean motions of the planets and the duration of the year can be calculated from these horoscopes on the assumption that the mean longitudes at the epoch — 3101 were zero. The calculation, made by J. J. Burckhardt and B. L. van der Waerden, confirmed this assumption and yielded the following numbers of revolutions of Saturn and Jupiter in 360,000 years:

$$\begin{array}{ll} \text{Saturn} & 12,214 - \frac{1}{3} \\ \text{Jupiter} & 30,352. \end{array}$$

The numbers are just the same as in the Āryabhatīya. The number for Saturn is definitely not the same as in the Persian system, for in the Persian system it must be an integer.

Hence we may distinguish two stages of Persian astronomy, one represented by the "Persian system" of our text, and the other by the Zīj-i Shāh. The following table shows the differences between the two systems:

Number of Revolutions	Saturn	Jupiter	Year
Persian System	12,214	30,352	365;15,32,24
Zīj-i Shāh	$12,214 - \frac{1}{3}$	30,352	365;15,32,30
Āryabhatīya	$12,214 - \frac{1}{3}$	30,352	365;15,31,15

The difference between the two Persian years is very small. Āryabhaṭa differs from the Shāh by 0;0,1,15 days, which means that 3,600 years of Āryabhaṭa differ from the Shāh by 0,0,1;15 days, which means that 3,600 years of Āryabhaṭa contain one and a quarter day less than 3,600 years of the Shāh.

The difference of $\frac{1}{3}$ revolution of Saturn or 120 degrees in 360,000 years means a shift of 1.2 degrees in the position of Saturn at the time of Āryabhaṭa, and a better agreement between theory and observation. It is possible that the Zīj-i Shāh was influenced by Āryabhaṭa and that this influence explains why the Zīj-i Shāh deviated from the original Persian system.

Two stages of Persian astronomy are also mentioned by Ibn Yūnis. In the passage quoted under footnote no. 25, Ibn Yūnis states that the Persians observed the solar apogee at $77^{\circ} 55'$ about 450 A.D. and again at 80° about 610 A.D. Now, the sun's apogee cannot be "observed" in the strict sense. Ibn Yūnis knew this; he was a competent astronomer, who collected many ancient observations and made observations himself. So he must have meant that the Persians determined the solar apogee about 450 and again about 610, both times from observations. Possibly Ibn Yūnis had this information from the introduction of the Zīj-i Shāh. In fact, the Zīj-i Shāh located the solar apogee at 80° , as we know from Bīrūnī.

In Āryabhaṭa's midnight system, the solar apogee was also located at 80° . Moreover, Bīrūnī informs us that the maximum equations of the sun and the moon in the Zīj-i Shāh have passed from India to the Persians.³³ These facts and testimonies suggest that the Zīj-i Shāh in its latest form, which was translated into Arabic about 790, may have been influenced by Āryabhaṭa in some details such as the solar apogee and the number of revolutions of Saturn.

The testimony of Ibn Yūnis seems to indicate the existence of an earlier redaction, composed about 450 or a little later, in which the solar apogee was placed at $77^{\circ} 55'$.

The existence of an earlier redaction of the Zik-i Shatro-ayār is also implied by a statement of Bīrūnī in the Masudic Canon³⁴ to the effect that Khosro Anūshīrvān (531-578) convoked an assembly of astronomers for the purpose of correcting the Zik. Possibly this information was also drawn from the introduction of the Zīj-i Shāh.

We now combine the results of Section 7 with those of the present section. In Section 7 we adduced reasons for supposing that the "Persian system," with its cycle of 360,000 years, existed already before 500 A.D. We also know that the Zīj-i Shāh differed from the Persian system in the number of revolutions of Saturn and the duration of the year, but that the differences are only small, and that both systems were based upon the assumption of a conjunction of all planets in — 3101. In the present section we found that an earlier redaction of the Zīj-i Shāh, in which the solar apogee was placed at $77^{\circ} 55'$ probably existed be-

³² Kennedy, E. S., *JAOS*, 78 (1958), pp. 259 and 262.

³³ "Al-Bīrūnī on Transits (Rasā'il III)" 24:9, *Amer. Univ. of Beirut Oriental Series*, 32 (1959).

³⁴ *Al Qānūn al-Mas'ūdī*, p. 1423.

fore 500 A.D. and that the final redaction used a slightly different apogee. The sources used in the present section, viz. Ibn Yūnis and al-Bīrūnī, are quite different from the sources used in Section 7, viz. our A, B, and Āryabhaṭa. Still, the results agree extremely well. All available evidence seems to support the conclusion that the latest *Zik-i Shatro-ayār* was preceded by an earlier redaction, composed about 450 and based upon the Persian system.

10. THE TABLES OF KHWĀRIZMĪ

Of the "Persian" zījes mentioned by Islamic astronomers, only one is extant, viz the zīj of Khwārizmī in the redaction of Maslama al-Majrītī, translated into Latin by Adelard of Bath.³⁵

Maslama's main contribution to this zīj seems to have been, according to Šā'id al-Andalusī, the use of the Hijra calendar. The original zīj of Khwārizmī used the Yazdigerd calendar.

Khwārizmī's zīj is sometimes classified as a Persian zīj, sometimes a Sindhind zīj. Both classifications are justified, for Ibn al-Qifṭī, informs us that Khwārizmī "based his tables upon the mean positions of the Sindhind, but deviated from it in the equations and the inclination (of the ecliptic). He fixed his equations according to the methods of the Persians, and the declination of the sun according to Ptolemy." In fact, Khwārizmī's mean motions are just those of the Brāhma-sphuṭa-siddhānta,³⁶ and his table of solar declination is just Ptolemy's.

The maximum equations of the planets in Khwārizmī's tables are nearly equal to those of the Zīj-i Shāh, as the following Table 1 shows. For comparison, we have also given the maximum equations of the Khaṇḍakhādyaka.

TABLE 1. Planetary equations

	Sun	Moon	Sat.	Jup.	Mars	Venus	Merc.
Shāh	2;14	4;56	9;37	5;6	11;12	2;13	4;0
Khwār.	2;14	4;56	9;36	5;6	11;13	2;14	4;2
Khaṇḍ.	2;14	4;56	9;34	5;6	11;10	2;14	4;28

For the sun and the moon, the three treatises agree: In fact, we know from Bīrūnī that these numbers "passed from India to the Persians."

³⁵ See note 14 and the "Survey" of E. S. Kennedy, *Trans. Amer. Philos. Soc.*, 46 (1956), notably p. 128 (no. 21) and 148 (§ 6), also Šā'id al-Andalusī, *Kitāb Ṭabaḳāt al-Umam*, transl. by R. Blachère (Paris, 1935), pp. 102 and 130.

³⁶ See note 18.

For Jupiter too we find perfect agreement, and for Venus the difference is only 1'. In the other three cases, we see that Khwārizmī follows the Zīj-i Shāh, with deviations of only 1 or 2 minutes.

The maximum values of the "equation with respect to the sun" or "*Ṣighra* equation," are displayed in Table 2:

TABLE 2. Second correction

	Sat.	Jup.	Mars	Venus	Merc.
Shāh	5;44	10;52	40;30	47;11	21;30
Khwār.	5;44	10;52	40;31	47;11	21;30
Khaṇḍ.	6;20	11;30	40;30	46;15	21;30

Here too, Khwārizmī follows the Shāh and not the Khaṇḍ., except in the case of Mars.

In the calculation of the true places of the planets, Khwārizmī follows the "method of the Persians" as Ibn al Qifṭī informs us. We may assume that this method was taught in the Zīj-i Shāh. For a detailed account of the method and its relation to Greek and Indian methods see B. L. van der Waerden, *Archive for Hist. of Exact Sci.*, 1, p. 107 (1961).

Still more important is the general form of Khwārizmī's zīj. The central part of this zīj is a *table of mean motions* in years, months, days and hours. Every Greek "Kanon" such as the "Handy Tables" of Ptolemy, and every Arabic zīj contains such a table of mean motions. In India no such tables are known. The Hindu treatises known to the Muslims and to us are either *Siddhāntas* or theoretical treatises without tables, or *Karaṇa treatises* such as the Khaṇḍakhādyaka, containing instructions for practical calculations. Neither kind contains tables of mean motions.

Hence, the Muslims could get the idea of such a table only from the Greeks or Persians, not from India. Now the earliest Arabic set of tables showing clear signs of direct Greek influence is the set called *Tabula Probata* (see footnote 30), written by Yaḥyā about 810. The zījes 2, 71, 30, and 100 of Kennedy's Survey (see footnote 35), based upon Indian and Persian methods, are about half a century older. Of these, the first two (2 and 71) are closely related to the zīj of Khwārizmī. They must have contained tables of mean motions. Hence, it seems that the Muslims got the idea of such a table set starting with mean motions not from the Greeks, but from the Persians. This is confirmed by the fact that the most usual word for such a table set, the word zīj, is derived from Pahlavi *zīk*.

Our conclusion is that the Persian original of the Zīj-i Shāh contained a table of mean motions, followed by tables for computing corrections to obtain the true places of the planets according to the "Method of the Persians." This gives us a pretty clear idea of the general form of the tables. The

earlier redactions of the tables may have differed in the constants of the mean motions and in the maximum equations, but the general form of the tables must have been the same. Ultimately, the Persians must have got the idea of a Kanon from the Greeks.

RĀMĀYAṆA STUDIES I

THE KRAUṆCA-VADHA EPISODE IN THE VĀLMĪKI RĀMĀYAṆA

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THE KRAUṆCA-VADHA EPISODE, narrated in sarga 2 of the Bālakāṇḍa of the Vālmiki Rāmāyaṇa, is connected with the birth of the first śloka, uttered by sage Vālmiki when he was afflicted by grief, śoka, on hearing the piteable cries of a female *krauñcī*-bird, deprived from her mate.¹ Just as sargas 1 and 3 in the Bālakāṇḍa of the vulgate Rāmāyaṇa purport to "explain" why and how the Rāmāyaṇa came into existence, and which were the circumstances which induced Vālmiki to begin his great tale, so the Krauñca-vadha episode, in sarga 2, is supposed to account for the birth of the śloka, the principal metre used in the Rāmāyaṇa. This pretty tale appears at first sight as a kind of fancy, a flight of imagination due to one of the later rhapsodists who composed the Bālakāṇḍa. Scholars and translators in general did not attach much importance to the episode, and contented themselves with a passing remark on the

invraisemblance and fanciful character of the derivation śloka < śoka which seems to be hinted at in the episode, while crediting Vālmiki with having given its final form to the epic śloka, or having been the first to write an epic entirely in śloka.²

A closer examination of the Krauñca-vadha episode, however, suggests that the passage is not so meaningless as it appears and that it does not concern the origin of the epic śloka metre as such. It rather refers to an ancient tale or popular belief concerning the origin of lyrical poetry, which has a bearing on the origins of the Vālmiki Rāmāyaṇa itself.

PLACE OF THE KRAUṆCA-VADHA EPISODE IN VĀL. R. I. 2.

The Rāmāyaṇa scholars, Holzmänn, H. Jacobi, followed by C. Bulcke, have convincingly shown

¹ The episode is famous in Indian tradition, and is referred to in Āśvaghoṣa's *Buddhacarita*, Kalidāsa's *Raghuvamśa* and in the works of the Kashmirian poeticians, but the latter seem to have understood that it was the female bird which had been killed by the Niśāda, and the male bird which was lamenting its loss. (On the interpretation of this divergence, see G. H. Bhatt, "The Krauñcavadha in Dhvanyāloka and Kāvya-mīmāṃsā," *JOI* vol. IX (1959), p. 148 f., and Ch. Vaudeville, "A further note on Krauñcavadha in Dhvanyāloka and Kāvya-mīmāṃsā," *JOI* vol. XI (1961), p. 122 f.). The story was also famous outside India, as it is alluded to in a 7th century inscription found in a Vālmiki temple in Cambodia, cf. C. Bulcke, *Rāma-kathā*, Prayāg, 1950, p. 240, who refers to *BEFEO*, vol. 28, p. 147 and *JOI* vol. VI, p. 117.

Our references to the Vālmiki text of the Bālakāṇḍa are to the Baroda edition of the Vālmiki Rāmāyaṇa (Oriental Institute, Baroda, 1958).

² P. V. Kane, in *History of Sanskrit Poetics*, 1951, p. 320, note 1, is very affirmative: "Thus the Bālakāṇḍa states the origin of the classical Sanskrit śloka and also contains the germs of the *rasa* theory." H. Jacobi, in *Das Rāmāyaṇa*, Bonn, 1893 [English translation of the same by S. N. Ghosal, Baroda, 1960; our references are to the latter] says: "If this legend is based on any fact, the same appears to be that the epic śloka in its regular form first emerges in the poem of Vālmiki." (Jacobi, *o. c.*, p. 62). Jacobi's view seems to have been accepted by Winternitz (*A History of Indian Literature*, I, p. 480). Hopkins, in *The Great Epic of India*, p. 65, rejects the idea that Vālmiki is the "inventor" of the śloka: "We must let pass the statement of the Rāmāyaṇa itself that Vālmiki invented the śloka verse, though Vālmiki may have been the first to set out to write an epic in ślokas . . ." Also, in note 2 to the same page: "That Vālmiki could not have 'invented the śloka' is shown by the presence of an earlier form of śloka in the Brahmanic literature retained in the Mahābhārata."