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From Tantra to Zīj

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It is a pleasure to recall the times when Paul Kunitzsch came to my assistance in linguistic matters, saving me from embarrassing pitfalls, and so in return I offer an essay essentially about one of the common, but misunderstood, terms from medieval astronomy. The Arabic word *zīj* is the generic name for those astronomical handbooks which consist of groups of tables representing all the functions required in calculations of planetary longitudes and other quantities of interest. The tables are accompanied by a series of chapters which explain how the tables are to be used. There may also be further text giving more background information to the subject, but the dominant impression is created by the large number of tables. This is reflected in Nallino's etymology which saw the word *zīj* as a reference to the tabular format. He wrote as follows, expressing a view which has been accepted ever since,

> La parola zīǧ deriva della lingua pehlevica usata in Persia all'epoca dei re Sāsānidi. In questa lingua zīk significa l'ordito su cui viene tessuta la trama; i Persiani applicarono questa parola alle tavole numeriche, perchè le lore righe verticali somigliano ai fili dell'ordito.[1]
>
> The word *zīj* derives from the Pahlavi language used in Persia at the time of the Sasanid kings. In this language *zīk* means the warp on which came to be woven the weft; the Persians applied this word to the numerical tables because their vertical lines resembled the threads of the warp.

This explanation in terms of the lines defining the tables did not originate with Nallino, however, for it is found in Persian texts. John Greaves[2] in *Astronomica quaedam ex traditione Shah Cholgii Persae: una cum Hypothesibus Planetarum* (1652) quoted at length from the *Zīj-i Jāmiʿ* of Maḥmūd Shāh Khaljī (died 1469). In the opening of that work we have an explanation of the word, as follows,

> زیج معرب زیك است و آن عبارت است از ریسمانی چند که نقش بندان نقش جامها بر آن بندند و آن قانونیست جامه بف را در بافتن جامها ملون چنانچه زیج قانون است منجم را در استخراج تقاویم و اعمال موالید و خطوط و جداول زیج شبیه است بریسمانها زیك که در طول و عرض بهم کشیدة باشد
>
> Zīj is Arabic, from zīk; this expression is from the cord used by embroiderers by which they weave clothes of various colours, and also the guide (qānūn) for the weaver, used to arrange the variety. Thus a zīj is a guide (qānūn) for astronomers in deriving true

1 Nallino (1944), p. 120.

2 Greaves (1652). On Greaves' work as an Arabist and astronomer, see Mercier (1994).

positions and in making nativities; the lines and tables of a zīj are similar to the threads of the zīk, that are drawn in latitude and longitude.

No doubt it is through this work of Greaves that this interpretation came to be current in Europe.

There is however a compelling reason to reject this explanation. In a Pahlavi text, the *Epistles of Manušchīhr* (2.ii.9), which was indeed known to Nallino[3], there is a reference to *zīg ī hindūg*, *zīg ī šahriyārān* and *zīg ī ptlmyws* (Πτολεμαίος). It has become a habit to render zīg as 'astronomical tables', as we find not only in Nallino's reading, but everywhere else[4]. The term *zīg* is therefore used indifferently of Indian, Persian and Greek astronomical works. The problem with regard to the Sanskrit sources is that these works contain no tables.[5] They are in verse form, and all the numerical data and numerical procedures are provided within these verses, as mere lists. The prose commentaries likewise never employ the tabular format. It is necessary therefore to find another explanation for the choice of the word *zīg*.

In any case, he makes a conscious distinction between Indian and other sources. It is assumed here that the word was introduced in the first place when the Indian material was translated into Persian. Manušchīhr writes in the ninth century, and so it might be argued that he is not close enough to the period when the Sanskrit material was in the course of transmission, but at a time when Pahlavi was no longer a living language. It may be argued, however, that he used the older Sasanid expressions. Nallino[6] argued that because the Pahlavi transcription of Πτολεμαίος is *ptlmyws*, it must have been derived from the Arabic form *Btlmyws*, not directly from the Greek, because the short vowels *o*, *e* would have appeared in the Pahlavi transcription. On the other hand, this Pahlavi form could also have come from the pre-Islamic Syriac form *ptlmyws*, although admittedly this is only one of numerous variations in the transcription of this word.[7] Moreover, in Pahlavi the letters *p* and *b* are clearly distinguished, so the fact that Manušchīhr uses *p*-, rather than *b*-, argues that he did not work from an Arabic source.[8]

In the extant Pahlavi texts the word *zīg* occurs a few times. The primary meaning is 'tether, tow-rope', that is a cord used for *binding*.[9] In one of these texts, the *Škand Gumānīk Vičār*, the context is astronomical, where the planets are said to be held by this 'tether' to the Sun and Moon. The word also occurs with the meaning 'astronomical text' in two passages, in the *Epistles of Manušchīhr*, as noted above,

3 Nallino (1922), p. 350.

4 Bailey (1943), p. 80; de Menasce (1945), p. 60; de Menasce (1958), p. 61. Note that we use the modern transcription *zīg*, except when quoting an earlier passage.

5 In commentaries of the tenth century and later, if one is to judge by arrangements adopted in modern editions, there is some very limited listing of parameters, sometimes placing degrees in one row, and minutes in the next row. In the much later Moghul period, certainly, tables in the usual sense are found.

6 Nallino (1922), p. 350.

7 Payne Smith (1910), p. 3089.

8 I owe this last point to François de Blois.

9 The Manichaean 'Book of the Giants': Henning (1946), pp. 59, 64; Skand Gumānīk Vičār: de Menasce (1945), pp. 52–3, and Zaehner (1955), p. 159. The Manichaean Šābuhragān: MacKenzie (1972b), line 327. The word is not included in MacKenzie (1971a); he gives only the closely related zīh, 'bowstring'.

and probably also in the *Dinkard*, Book III, Ch. 419. This last, however, is a most difficult passage which has been the subject of various translations.[10] MacKenzie, amending somewhat the version of de Menasce, suggests[11]

> 'The beginning (?) of the years, months and days (is (calculated?)) according to the *zīg* of the stars, <and> the birth of men, the year-count of kings, how many years have gone (by) from the creation (is) in the hands of the calculators.'

It is not absolutely clear to me whether *zīg* here means simply the 'binding' of the stars (to the Sun ?), or refers to some more abstract 'text' or 'rule'. The whole chapter is concerned with numerical details of the calendar and intercalation, and with the responsibility of calculators to maintain the (calculated – *ošmurtīk* –) year in step with the seasons, and to keep Nō Rōz at the Spring Equinox. Certainly the rule depends on the motion of the Sun, such as would be recorded in the usual astronomical text, Indian or otherwise, but the mention of *zīg* here may refer to nothing more than the need to follow the motion of the Sun in relation to the stars, which indeed is the sense of Nyberg's version, *Der Eintritt der neuen Jahre, Monate und Tage geschieht jedesmal gemäss der jeweiligen Stellung der Tierkreisbilder.* However elsewhere when *zīg* is a binding within the heavens, it is a case of planets bound to the Sun, not the Sun to the stars.[12] In any event, the translation of *zīg* by de Menasce as 'tables' certainly presumes too much.

Al-Bīrūnī, in his *Qānūn al-Mas'ūdī*, Book III, Ch. 1, offers his own explanation of the term *zīj*, which he bases on the Persian *zeh*.[13] He writes,

> ان هذه الصناعة اذا اريد اخراجها الى الفعل بمزاولة الحساب فيها فالاعداد مفتقرة الى معرفة اوتار قسى الدوائر ، فلذلك سمى اهلها كتبها العلمية زيجات من الزيق الذى هو بالفارسية زه اعنى الوتر، وسموا انصاف الاوتار جيوبا وان كان اسم الوتر بالهندية جيبا ونصفه جيبارد، ولكن الهند اذا لم يستعملوا غير انصاف الاوتار اوقعوا اسم الكل على النصف تخفيفا فى اللفظ،
>
> This art, if one wishes to put it into practice on the basis of careful calculation and preparation, requires knowledge of the chords of arcs of circles, and for this reason the practitioners of this art called their scientific books *zījāt*, from the [older] Persian *zīq*, which in [modern] Persian is *zih*, meaning 'bowstring/arc' (*watar*), and they called the halves of the arcs *juyūb*, this despite the fact that in the Indian language the name for the (whole) bowstring/arc is *jīva* and for its half *jīvārdha*, but the Indians, since they only used the halves of the arcs (in their calculations), transferred the name of the whole to the half as a way of simplifying the pronunciation.

10 The text is available in a facsimile of one manuscript, Dresden (1966), p. 518. Nyberg (1934), pp. 34, 68, gives a transcription, translation and various notes. He recalled Nallino's theory, but rejected it, adding that he regarded zīg simply as a technical term in astronomy. De Menasce (1972), p. 375, gives a translation and notes, but for this chapter indeed he acknowledges Mary Boyce as the source of the translation with its notes. Apart from these I am indebted to Prof MacKenzie for correspondance about this passage.

11 Private correspondance.

12 In his discussion of the 'binding' of the planets to the Sun and Moon by means of zīges, Zaehner brings together a number of passages from the Škand Gumānīk Vičār, the Bundahišn, and elsewhere.

13 Bērūnī (1954), Vol. 1, 271.

Much of this is correct, since we know that *zih*, as in the earlier Pahlavi, means bowstring or chord, that the Arabic *juyūb* is the plural of *jīb*, the Arabic transcription of the Sanskrit *jīva*, chord, and that *jīvārdha* is the Sanskrit for half-chord, that is 'sine'. Clearly *zīq* is his Arabic orthography for the Persian *zīg*. However, in saying 'from the [older] Persian *zīq*, which in [modern] Persian is *zih*', he has somewhat simplified the position, for while in Pahlavi *zīg* meant a stretched cord, *zih* meant a bowstring; while the two words are very closely related, there was a difference in meaning. In any case, the point of al-Bīrūnī's argument seems to be just that the work came to be called *zīj* because it contained an account of sines and chords. Incidentally, he was not concerned that there should be a *table* of sines.[14] However important the calculation of sines may be in these astronomical works, it seems to be stretching a point to argue that they are named as class after the word for 'sine'.

In early modern Persian, one finds *zīj* and *zīč* (not *zīg*, at least in the printed edition) in the Persian Epic, *Shāhnāmeh* of Firdausī, in the sense of an astronomical text. This is qualified occasionally as *kuhan* ('ancient'), *hindī* or *rūmī*[15]. Mohl always translated the word as 'table astronomique'.

The word *zīj* is glossed according to a Persian source in the late thirteenth century, as recorded in the Greek version of the *Zīj al-ʿAlāʾī*.[16] Although this was an Arabic *zīj* it came into Greek use with the aid of the Persian Shams Bukharī who supplied oral instructions. Here the sense of 'weaving', 'loom' was apparently provided by this Persian informant.

> Ζῆζι οὖν λέγεται τὸ βιβλίον τοῦτο κατὰ Πέρσας ἐπειδὴ δικὴν ἱστου ὑφαίνονται οἱ ἀστέρες ἐν τούτῳ καὶ τάττονται, δι᾽ ὧν ὑφασμάτων παντοῖα εἴδη δείκνυνται ἐκ μεταφορᾶς τῶν ἱστῶν· ὃν γὰρ τρόπον ἐν τούτοις μετὰ τὸ ὕφασμα ἡ ποικιλία τῶν ἀσκουμένων διάφορος δείκνυται, τὸν αὐτὸν τρόπον καὶ ἀπὸ τοῦ τοιούτου ἐπιστημονικοῦ βιβλίου κατὰ μέθοδον κρείττονα ὑφανθέντος ἡ ποικιλία καὶ ἐναρμόνιος πλοκή τε καὶ τάξις ἀναφαίνεται τῶν ἀστέρων.
>
> This book then is called a Ζῆζι (*zīj*) according to the Persians because, like a loom, the stars are woven on it and arranged in the weaving, and thanks to such weavings all sorts of forms are shown, according to the metaphor of the looms. Indeed, from the manner in which, in the latter, after weaving, the variety of worked materials appears different, in the same way also, thanks to such a scientific book, woven in the best way, the variety and the harmonious twisting and arranging of the stars becomes evident.

The entry zīg in the Persian dictionary *Burhān-i Qāṭiʿ*, written 1062/1636 by Muḥ. Ḥusain b. Khalaf al-Tabrīzī, known as Burhān, dedicated to the Shīʿī King of Gol-

14 For example, he translated the Sanskrit work Karaṇa Tilaka into Arabic, giving it the name Ghurrāt al-zījāt, although as a typical Sanskrit astronomical work, it contained no tables, only verses; Rizvi (1965).

15 The detailed references to the passages in Mohl's edition are as follows. These are based on Wolff (1934), s. v. zīj, zīč.
Zīj: 2 p. 232, ll. 450, 453; 4 p. 34, l. 369, p. 252, l. 2923, p. 564, ll. 2437, 2440, 5 p. 284, l. 225.
Zījhā-i Kuhan: 7 p. 112, l. 1303.
Zīj-i Hindī: 4 p. 232, l. 2686, p. 704, l. 4105.
Zīč: 1 p. 328, l. 1404; 7 p. 278, l. 3290.
Zīčhā-i Kuhan: 7 p. 112, l. 1306.
Zīč-i Rūmī: 5 p. 494, ll. 38, 41; 6 p. 346, l. 2243

16 Pingree (1985), Part 1, p. 36.

conda, Abdullāh Quṭb Shāh, is a remarkably close echo of the *Zīj-i Jāmi'* of Shāh Khaljī, and the foregoing Greek text.[17]

تارهایی باشد که استادان نقشبند نقش جامهایکه بافند بدان بندند· وکتابیکه منجمان احوال و اوضاع نجوم و افلاك را از جداول آن معلوم کنند و همچنان که آن قانونی است جامه بافان را در بافتن نقشهای جامه این کتاب نیز دستوری است منجمان را در شناختن احوال و اوضاع فلکی، وهمچنانکه کیفیت نقوش جامها از آن تارها پیدا می شود، کمیات و حرکات کواکب از جدولهای این کتاب ظاهر میگردد، و معرب آن زیج است

(*Zīg*) may be the cords to which the masters of design bind the design of a garment which they are weaving. It is a book from which are made known to astronomers the states and conditions of the stars and spheres from its tables. Just as the former is a guide for the weavers in weaving the design of a garment, so this book also is a guide for astronomers in recognizing the states and conditions of a sphere. And as the manner of the design of a garment is made known from those cords, the forms and motions of the stars are made apparent from the tables of this book. In Arabic it is *zīj*.[18]

The cords (tārhā') in question would seem to be the warp of the loom on which the weaving is done. The *Burhān-i Qāṭi'* does not name a source, but evidently it was an explanation which had circulated since the 13th century. Without a quotation from a text the sense 'loom' cannot of course be considered as absolutely certain, and it may after all be a ghost.

We may summarise the position then, by saying that *zīj* has been explained in Arabic and Persian sources as arising

1) from the fact that the knowledge of sines and chords is central to the work (al-Bīrūnī);
2) from a resemblance between weaving a pattern on a loom according to a fixed rule, and the calculations of astronomical positions from a set of rules (*Zīj al-'Alā'ī* and the *Burhān-i Qāṭi'*);
3) from a resemblance between the warp and weft of a loom and the lines defining an astronomical table (Shāh Khaljī).

The last interpretation finally invokes the actual shape of the table, with its horizontal and vertical divisions, the only argument which has circulated among European scholars down to Nallino.

Sanskrit origins

Since the word *zīj* arose in connection with an astronomical text at the time when Indian works came to be known in Iran, that is in the late Sasanid period, it may

17 Vullers (1855), s. v. zīg. The Burhān-i Qāṭi' is a fundamental work which has appeared in several editions, both European and Persian, for example by Th. Roebuck, Calcutta, 1818, 1834, and Tehran, Mo'īn (1962). It is much quoted by Vullers and Desmaisons (1910). For an account of the work see the Introductory volume of the Loghat-Nama, Mo'īn (1959), vol. 1, pp. 199 seq.

18 The passage continues as follows, 'Name of a small bird, smaller than a sparrow, ash-gray, red underneath, with very good and melancholy song. Name of a tribe of Kurds inhabiting the Gīlūye mountain (Arabic Jīlūya, Turkish Cilu Dagh)'.

well have been as a literal translation of a Sanskrit word. In the sense 'cord' it may have rendered *sūtra*, and in the sense of stretched cord, *tantra*. Both these words have strong literary associations, and the latter is particularly relevant to astronomical texts of the sixth century.

Sūtra is literally 'thread', or 'cord' but came to be used in the sense of a guiding thread through a subject, a collection of aphorisms, and can sometimes be rendered 'guide'. Sūtra texts, such as the work of Pāṇini, are collections of concise formulae, suited to memorising. In the astronomical context we have Āryabhaṭa's *Daśagītikāsūtra*, the opening part of the work which we commonly know under the title *Āryabhaṭīya*.

Tantra is a derivative from the root *tan*.

tan: to extend, continue, stretch, weave, prepare the way, accomplish, compose;
tantra: loom, warp, leading part, model, system, doctrine; class of works dealing with magic.

Among related derivatives,

tanti: cord, line, weaver
tantu: thread, cord; continuity.

Although *tantra* is most commonly used now in the context of Tantric practices, including forms of black magic, associated with the worship of Śakti, that sense is relatively late, perhaps later than the seventh century.[19] In the Ṛgveda the word simply means 'loom', while for Pāṇini and his early commentators it meant also a 'collection of procedures'. In the astronomical context, in the sixth century, we know that both works of Āryabhaṭa (i. e. the so-called sunrise and midnight systems) were referred to as *tantras*.[20] In the following I give a list of the uses of *tantra*, both referring to Āryabhaṭa, and in a generic sense.

Bhāskara[21], *Mahābhāskarīya* –

I,3: *sphuṭatantramāśmakam*, the perfect treatise of the Āśmaka (Āryabhaṭa)
I,21: *laghutantra*, short treatise (of Āryabhaṭa)
II,8: *tantrajña*, knowing the *tantra* (composed by Āryabhaṭa)
V,78: *sarvatantravit*, knowing all the treatises
VII,33: *tantrāntara*, the other treatise (of Āryabhaṭa, i. e. the midnight system)

Varāhamihira, *Bṛhatsamhitā* (I.9)[22] –

> jyotiḥ śāstramanekabhedaviṣayam skandhatrayādhiṣṭhitaṃ tatkārtsnyopanayasya nāma munibhiḥ saṃkīrtyate saṃhitā
> skandhe'smin gaṇitena yā grahagatistantrābhidhānastvasau horā'nyo'ṅgaviniścayaśca kathitaḥ skandhastṛtīyo'paraḥ
> The Jyotiḥśāstra, treating of several subjects, is contained in three branches. A complete course of it is termed by the Seers Saṃhitā. In one branch are to be found the motions of the heavenly bodies, as determined by calculation: this is called Tantra, or

19 Kane (1962), p. 1031 seq.
20 Billard (1971), pp. 6, 25, 80, 91, 110, 122.
21 Shukla (1960).
22 Kern (1865), (1913).

doctrinal part. The second branch is Horoscopy, or the casting of the horoscope. There is a third branch, different again.

Brahmagupta, *Brāhmasphuṭasiddhānta* –
XI, (entitled) *tantraparīkṣā*, examination of treatises, referring especially to Āryabhaṭa.

Haridatta (A.D. 683), *Grahacāraṇibandhana* –
III,46: Bhaṭatantra, referring to Āryabhaṭa's work.[23]

It is clear that for Āryabhaṭa and the period immediately following him the general name of an astronomical treatise was *tantra*. It was only in later centuries that this came to be replaced by *siddhānta*.

Al-Bīrūnī, in his *India*, has a note on the words *karaṇa*, *tantra*, and *siddhānta*.[24] He remarks that works of the first two types do not reach the standard of the *siddhānta*, and that there are two famous *tantras* by Āryabhaṭa and Balabhadra.[25]

> In the course of the transmission of Sanskrit works to Iran in the sixth and seventh centuries it was natural therefore to search for a Persian equivalent of the word *tantra*, and the proposal here is that *zīg* was chosen for this purpose.

The alternative would have been a transcription, but I can see no indication that *tantra* was ever transcribed. In Tibetan translations from Sanskrit *tantra* and *tantu* are both translated by *rgyud*, from the verb *rgyud-pa*, 'to file on a string', another instance of a literal translation.[26] In Soghdian Buddhist literature, on the other hand, the word *sūtra* was transcribed as *swtr*, *swttr*.[27]

The words *zīg* and *tantra* are linked at an elementary level in the sense of 'stretched cord', and also, if we accept the Burhān-i Qāṭi', with one of the principal meanings of *tantra*, 'loom'.

While ranging beyond the Persian and Sanskrit texts of immediate interest, we may note that the metaphor between 'something woven' and 'something written' is by no means confined to these languages. After all, the English words 'textile' and 'text' have a common origin in the Latin 'texere', meaning 'to weave'; consider the common expression 'to weave a tale'. In Latin itself 'textum' meant both 'textile' and 'text'. In Post Biblical Hebrew 'Maseket' מסכת meant not only a 'web on the loom', but 'tract' (as in the Talmud), both derived from נסך to 'weave'.[28] In Chinese, jīng 經, also has this ambivalence, 'That which runs lengthwise; the warp in a loom. ... The "Canon" of Confucianism. The *sūtras* of Buddhism and Taoism', (Giles' *Dictionary*, no 2122).[29]

23 Sarma (1954), p. 20.
24 Sachau (1910), I, pp. 155–6.
25 Balabhadra was a ninth-century commentator on the works of Varāhamihira and Brahmagupta, much used by al-Bīrūnī, and known to us through commentaries by Pṛthūdaka.
26 Jäschke (1881), pp. 111–2.
27 Benveniste (1940), p. 271.
28 I am obliged to Jill Butterworth for this example.
29 It remains unclear to me whether the metaphor refers to the mental act of arranging one's thoughts in order, or to the physical act of writing out lines of text.

Implications

If we accept this proposal, then, it follows that works in Persian or Arabic of the *zīj* type, especially those of Sanskrit origin, need not necessarily contain material in tabular format. This observation would pertain especially to the *Zīg-ī šahriyārān*, which would seem to have been the first stage in the translation from Sanskrit to Persian. This is apparently the antecedent of the later Arabic work *Zīj al-Shāh*. These works are not extant, but we have some information about them from al-Bīrūnī and others.[30] It is altogether likely that these were simply texts arranged in verse like the Sanskrit originals. We know at least of imitations of such verses by al-Fazarī, quoted by al-Bīrūnī.[31] Other works of *zīj* type may also have been without any tabular format, for example the lost *zījes* of Abū Ma'shar, and Māshā'allāh.

Further, if *zīj* was used to render *tantra*, this would support the view that the *Zīg-ī šahriyārān* was based in fact on *the* Tantra, the work of Āryabhaṭa. Finally since al-Bīrūnī remarks[32] that in the *Zīg-ī šahriyārān* the day was measured from midnight, not sunrise, it would follow that the Persian translation is based not on the *Āryabhaṭīya*, but on the lost *tantra* by Āryabhaṭa, which used the midnight system. However we know enough about the parameters of the original midnight system and about the *Zīg ī šahriyārān* to be sure that changes had taken place, at least in the details of the planetary equations.[33] It is interesting to note Manušchīhr's remarks on the three *zījes*, *šahriyārān*, *hindug*, and *ptlmyws* (Πτολεμαίος), since he reports that these were accurate for the Sun and Moon, for Saturn, and for Mars respectively, so that he certainly distinguished between the Indian original and the Persian version.[34]

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30 Kennedy (1958), further work being reported in Kennedy (1959) and Kennedy (1976).

31 Kennedy (1976), vol. 1, p. 190, vol. 2, p. 118.

32 Sachau (1879), p. 6.

33 Apart from Kennedy (1958), one should consult Kennedy (1959) for the details of the Zīj al-Shāh as known to al-Bīrūnī. The magnitudes of some of the equations differ from those known from the Sanskrit sources of Āryabhaṭa's midnight system, such as the Sūrya Siddhānta of Varāhamihira.

34 West (1892), p. xlvii. Although this is an old translation, notable indeed as a correction to an earlier translation of West's, there is not likely to be any quarrel with this reading from it.

35 A recent study by Panaino (1998), which came to my notice when this paper was completed, surveys discursively the role of *zīg* as a 'planetary binding', exploring numerous texts, mainly Iranian. He evidently regards this sense of *zīg* as sufficient reason for its use in the sense of 'astronomical handbook'.

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