2.2 THE ASTERISMS

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A system of 27 asterisms, or *nakṣatras*, plays an important role in Indian astronomy and calendrical science. The present convention is that the ecliptic is divided into 27 equal parts each $13^0 20'$ long commencing from one initial point. These arcs are called *nakṣatras*. Again a bright or prominent star of each division is called *yogatārā* bearing the name of the arc division e.g., *Kṛttikā* as *nakṣatra* means an arc division and as a *yogatārā* it means the star η Tauri of the Pleiades group.

The origin of this asterism system is very old. The names of these stars appear in Vedic litrature. The *Taittirīya, Kāṭhaka, Maitrāyaṇī Saṃhitās* and the 19th book of *Atharva Veda*, each has given a list of 27 *nakṣatras* (the last two have included an additional star, Abhijit (αLyrae), making a total of 28 *nakṣatras)*. All these lists always begin with the name *kṛttikās* (the star group Pleiades), and order of names of stars are more or less the same. Some of the stars changed their names in different hands; but they are always either star groups or single stars, and never arc divisions.

In some cases physical descriptions of the stars are given from which they can be identified, and some of these descriptions have astronomical significance which we shall now consider.

The *Kṛttikās* are described as consisting of seven stars (*Taittrīya Saṃhita* 4.4.5), many stars *(Satapatha Brahmaṇa)* and accordingly the *Kṛttikās* have been identified with Pleiades. The *Satapatha Brahmaṇa*(2.1.2.2-4) further states that the *Kṛttikās* do not shift from the east. The *Kṛttikās* rise in the east and the seven sages (Ursa Majoris) rise in the north.

Let us take this statement at its face value. If the *Kṛttikās* do not shift from the east, they must be on the equator; we suppose that at the time of observation of this tradition, the central star of Pleiades, η Tauri, had zero declination so that the *Kṛttikās* were seen to rise in the east.

Now, in 1967, latitude of η Tauri = $4^0 2'51''$ N (uneffected by precession), longitude = $59^0 31'53''$. Also, obliquity $\epsilon = 24^0 1'34''$ in 3000 B.C., and the average rate of precession between 3000 B.C. to 1967 A.D. = 49.7" per year.

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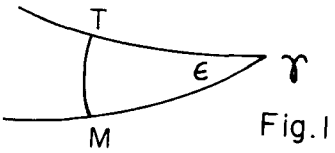

Fig.1

In Fig.1., let γ be vernal equinox, T = position of η Tauri on equator, $\angle\gamma$ MT = 90^0 so that TM = latitude (north) of η Tauri $4^0 2' 51''$ (proper motion of the star and other variations being neglected as they will not affect the result much). From ΔT Mγ,

$$\text{Sin } \gamma M = \frac{\tan TM}{\tan \epsilon} = .15871 \text{ or } \gamma M = 9^0 8'$$

$$\therefore \text{ Total precession} = 59^0 31' 53'' + 9^0 8' = 68^0 40'$$

Hence the epoch comes to about 3000 B.C. at the average rate of 49.7" per year, far before the accepted date of birth of Aryan civilisation in India. Hence we are inclined to believe that the tradition of *Kṛttikās* is very much earlier than the birth of Vedic literature; but anyhow this tradition was handed down to the compilers of *Brāhmaṇas* and *Saṃhitās* who recorded the tradition without any verifications. Our guess-work is that the source from where this tradition reached Aryan India was held in so high esteem that nobody questioned the validity of its truth i.e., it was beyond any question and the tradition was recorded in Vedic literature as a token of respect to the authority of the source.

There is of course a second view. In this opinion, the *Kṛttikās* have been named first in all the lists because of some preferential reason, and this reason is that the *Kṛttikās* at that age were on the equinoctial colure, i.e., vernal equinox was at the *Kṛttikās*. Of course, there is no express or explicit statement to this effect in Vedic literature; a few verses can only be unduly pressed to make out such a meaning. However, proceeding as before and taking η Tauri on the equinoctial colure, we get the epoch at nearly 2400 B.C., which is also earlier than the Vedic period. But in that case, its shift from East Point at rising becomes so much pronounced that it cannot escape any sky watcher's notice. We cannot correlate the statement "*Kṛttikās* rise in the east" and the supposition that the *Kṛttikās* were the vernal equinox. If there was any preferential reason for naming *Kṛttikās* first in the lists, it may be that the *Kṛttikās* rise in the east or that it contain many members or such special properties of it.

Bentley(1823) has given another interpretation of the *Kṛttikā* myth which we shall consider next. In a later section we shall see that there are indeed some evidences, not stated in terms of *Kṛttikās*, which relate to the epoch 2400 B.C.

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The astronomy branch of Vedic literature is contained in a small text, the *Vedāṅga Jyautiṣa*. Therein the winter solstice has been placed at β Delphini (Dhaniṣṭhā) which refers to the epoch 1400 B.C. But the period of composition of the text is now supposed to be 600 B.C.

In this text, *nakṣatras* are arc divisions only, and no longer stars or stargroups. The lunar zodiac is divided into 27 equal parts each $13^0 20'$ long commencing from β Delphini (Dhanistha). Lunar positions, *ayanas* etc. are always given in terms fractions of these divisions. *Nakṣatras* are assigned a new meaning arc divisions, and in this scale, winter solstice falls at the beginning of the Dhaniṣṭhā division. The vernal equinox then falls, in this scale of division, at 10^0 of Bharani, i.e., $3^0 20'$ west of the beginning of *Kṛttikā* division.

Bentley's assumption is that at the time of *Śatapatha Brāhmaṇa*, the vernal equinox coincided with this beginning-point of *Kṛttikā* arc division and since then, upto the epoch of *Vedāṅga Jyautiṣa*, there has been a precession of $3^0 20'$, which occurs in 240 years. Accordingly Bentley supposed that the *Satapatha Brahmaṇa* was composed around 1700 B.C.

But we are unable to understand it. The main purport of the text, that the *Kṛttikās* rise in the east, does not hold true under this assumption and also, *nakṣatras* are stars and not arc divisions in this text.

We are nowhere told in the Vedic literature the specific purpose for which the asterism system was developed or devised, but there are indications that measures of year, months and fixation of auspicious days were related to many of these stars. Terms like Citrā full-moon-day, or day of Phalgunīs etc. indicate a relationship of a day with one or another star(Taittirīya-saṃhitā,7.4.8) Although the exact purport of the term Citra full moon is not clear, it may mean the day when the full moon disc is visible near the star Citrā in the night sky, or the full moon day in the month of Caitra, yet an attempt of calendarisation of the asterisms is discernible here. It is not known whether the system was devised as a framework for calendar or once the system was ready at hand its services were used for calendrical purposes. But undoubtedly the calendrical scheme was based on this system of asterisms.

Again, we have the following record in the *Maitrī Upaniṣad* (Chap.6) "The Sun makes its southern course from the beginning of Maghā to middle of Sravisthā (i.e. Dhanisthā)". Very clearly, Magā and *Dhaniṣṭha* here are arc divisions, and not stars. Now, in the *Vedāṅga Jyautiṣa* scale, summer solstice falls at middle of *Aślesā*, and this point is at 4^0 east of the star ε Hydrae. Also from middle of *Aslesā* to beginning of Maghā it is $6^0 40'$. Assuming this $6^0 40'$ to be total precession between the records of the *Vedāṅga Jyautiṣa* and *Maitri Up.*, the epoch corresponds to the date 1800 B.C. nearly.

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But surely the *Maitrī Up.* did not use the scale of the *Vedāṅga Jyautiṣa* which was formulated some 400 years after it just as an inscription cannot be dated in B.C. years. The text must have used its own zodiac or one formulated before it.

We take this zodiac to have commenced from the star Maghā (Regulus). This initial point cannot be the winter solstice or vernal equinox because then we get a period when human civilisation did not develop. Hence this was the point of summer solstice. The total precession then becomes, between this text and the *Vedāṅga Jyautiṣa*, $13^0 29'$ = Arc betweeen ε Hydrae and Regulus ($=17^0 29'$) minus 4^0 The corresponding epoch of the tradition of text becomes about 2400 B.C., a period when the text itself was not compiled.

We now get a highly interesting result. In this case, the vernal equinox was at η Tauri (as it is $89^0 50'$ behind Regulus). Here we have an indirect reference to the fact that the vernal equinox occurs at *Kṛttikās* though no explicit reference to the vernal equinox occuring at *Kṛttikas* is available, as stated earlier.

We thus see that transformation of *nakṣatras* from stars to arc divisions and calendarisation of the system were complete around 2400 B.C. This tradition was also handed down to Aryan India who, without questioning the authority, recorded it in Vedic literature.

Our guess-work is that the practice of determining the nearness of the moon to one or another star by eye-estimation was not considered a reliable method. To avoid any dispute, the stars were replaced by arc divisions, and the eye-estimation method was replaced by a computational method using moon's motion, of course, at its mean rate. We are, however, unable to identify the original source from which Aryan India received these conventions.

We can make a rough estimate of the region from where the above traditions were observationally correct.

The star Svātī (α Bootes) has been described as an outcast (for being far away from other stars) traversing the northern sky (*Mahābhārata, Śānti-Kalpa* 3 - *nityam uttaramārgagam*). The declination of Svātī works out to be $45^0 3'$ in 3000 B.C. (using the transformation formula $\sin\delta = \cos\varepsilon \sin\beta + \sin\varepsilon \cos\beta \sin\lambda$) and the second to it in declination was α Lyrae, declination being $43^0 38'$. As Svātī had rising and setting, the latitude of the place of observation must be, with some marginal allowances, less than 40^0 It may be noted here that the declinations of these two stars, by 2400 B.C., were $42^0 29'$ and $42^0 4'$ resp. i.e. they were equally northward stars. It is likely that Abhijit was recognised as an additional star around this period, although it was not assigned any arc division.

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Again, the record that the seven sages rise in the north seems to bear an inner meaning. By 3000 B.C. α Draconis was the pole star (within tolerable limit of accuracy) and the stars ε and ζ Ursa Majoris were circumpolar almost throughout India, and βU. Majoris had highest co-declination among the seven sages. If we assume that the purport of the text was that all seven sages were then nearly circumpolar or that βU. Majoris was seen just to touch the north point on the horizon at rising, then the latitude of the place should be, after marginal allowances, greater than 30^0; in other words, these traditions were observed from a region within a latitude belt of 30^0 to 40^0.

We explain another tradition in favour of this assumption.

The *Vedāṅga Jyautiṣa* (Yājuṣa, verse 8) has measured the length of the longest day as 14 hours 24 minutes. The unit used in the text is 18 *muhurtas* where 30 *muhurtas* = 24 hours. A rough estimation of the place can be made thus:

Half-day = 7 hours 12 minutes = 108^0, declination of sun on longest day = ε = $23^051'42"$ (in 1400 B.C.). Hence, from cos H = -tan φ tanδ, we get $\phi=35^0$. But this result is unreliable, as effect of refraction has not been considered here. The Indian system is that day begins when the sun is just visible on the horizon. Now, horizontal refraction is 35', and sun's radius is 16'. Hence, at apparent beginning of day, sun's centre will be $90^051'$ below the horizon. Now consider the spherical triangle ZPS, where S is centre of sun, Z and P are zenith and pole, and hour angle H is 108^0. Then we get, using cosine rule on ΔZPS, $\phi = 33^012'$, which we take as 33^0. We neglect dip because any height favourable to development of high civilisation will affect our result very slightly. Thus the tradition of the *Vedāṅga Jyautiṣa* also conforms to our estimation of the latitude belt.

The third and final reformation of asterism system was done in the 6th Century A.D. after which it assumed its present shape where the *nakṣatras* appear both as arc divisions and stars, but as single stars only and not star groups. All astronomial texts of high authority reckon the initial point of these arc divisions from the star ζ Piscium (Brahmagupta, *Bhāskarācārya* and others) or from a point 10' east of it (*Sūrya Siddhānta*). A detailed discussion of this final shape of the system is outside the scope of the present paper.

We have considered so long only such astronomical references from the Vedic literature which are stated in explicit terms and have carefully avoided statements having doubtful or ambiguous meaning, and our finding is that the convention of asterism system was developed before birth of Aryan civilisation in India. This was handed down to Indian Aryans who in turn recorded it in Vedic literature as unquestionable truth. Vedic social life was also adjusted to this convention. We are, however, unable to trace or even to make a guess-work as to how Aryan India received this sytem of asterism; what we know is that the antiquity of this convention has been faithfully preserved in Vedic literature.

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DISCUSSION

J.N. Nanda : If the declination angles are 46^0, possible geographical place may be inside India. Any comments.

A.K. Chakravarty : The treatises have not been identified in the pre-Aryan era. The calculated latitude will be the maximum and thus location could be south of the possible 44^0 N.