2.3 VEDIC LITERATURE VIS-A-VIS MATHEMATICAL ASTRONOMY

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INTRODUCTION

The present paper restricts to the analysis of some passages from the Vedic literature, viz. *Śatapatha Brāhmaṇa* and *Vedāṅga Jyautiṣa*, from the view point of mathematical astronomy.

The *Śatapatha Brāhmaṇa* in 2.1.2.1 to 2.1.2.5, refers to some ritual in which some fire has to be set up. It recommends *Kṛttikā* as the *nakṣatra* or the lunar asterism under which to set up the fire. For, there are some special features that *Śatapatha-Brāhmaṇa* obviously considers as good points. According to the text, one good point about *Kṛttikā* is that it is 'the most numerous'; secondly, it rises 'in the east'.

Following the time-honoured practice initiated by outstanding Indologists, we can, of course, take *Kṛttikā* to mean Eta Tauri and the stars in its immediate vicinity, that collectively form the 'open cluster' Pleiades. It has six stars visible to the naked eye without much of an effort and some more under good seeing condition. That explains its being described as 'the most numerous'.

But what one may possibly imply by saying, about some stars, that they rise 'in the east'? All stars (that rise) rise in the east. Why then specially mention it about *Kṛttikā*? The conclusion perhaps is inescapable that, in the present instance with reference to *Kṛttikā*, the word 'east' has not been loosely used. Here it implies precisely the 'east point' itself or points very close thereto. In fact, in the present situation, it should have the second, alternative broad implication; because *Kṛttikā* refers to a star-cluster rather than to a single star. But does any of the stars of *Kṛttikā* - say Eta Tauri - really rise at the east point. Now, it does not today. Did it do at any time in the past? Let us examine.

Due to what is known as 'precession of the equinoxes', the celestial longitude of any star keeps on systematicaly increasing. The rate of increase is not uniform. In 2000 A.D. the figure would be 50".279 and in 2000 B.C. it was 49".391. Let us take the mean of these two last-mentioned values. In other words, for our historical purpose, let the rate be 49".835 per year. Now, in 1985, the celestial longitude of Eta Tauri is about $59^0 47' 24''$. But $59^0 47' 24'' \div 49''.835 = 4319$ approxi-

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mately. Therefore we conclude that about 4319 years back from now, its celestial longitude must have been zero and therefore it would more or less coincide with the vernal equinox. So it could rise at the east point or almost there.

The expressions 'almost there', that has been used here, is not unwarranted. In fact, for Eta Tauri, the celestial latitude is now about $4^0 2'58"$ and because this co-ordinate can change only very minutely for any star (for Eta, by the way, it is now increasing at the rate of only about 0".377 per year), it could have been only very slightly different for Eta Tauri 4319 years back. In other words, in 2334 B.C., Eta Tauri would rise not exactly at the east point but at a point a little to its north - say, 3^0 to 4^0 away.

A deviation of 3^0 - 4^0 is arguably small - so small as to have been ignored by the ancient people. Another way out is provided by the fact that *Kṛttikā* comprises several stars, of which Eta Tauri happens to be just one. Some other star of the group, more to the south than Eta, might fit the bill exactly and there is nothing in the text to indicate that it was Eta Tauri that was particularly chosen for consideration and not any other star.

The upshot of all this is that circa 2334 B.C., *Kṛttikā* rises "in the east" was a particularly significant statement to make - more significant than at any other earlier time in the history of human civilization.

The *Vedāṅga Jyautiṣa*, in verse 8, indicates that the greatest duration of day-time is 18 *'muhūrtā's* (and the shortest is 12). Let us take this statement for scrutiny keeping in mind that, in ancient India, a full day was looked upon as consisting of 30 muhurtas (so that 1 muhurta = .8 hour)

Let us confine ourselves to the northern hemisphere which was the abode of the Vedic people. We know that, for that part of the globe, the higher the latitude, the greater can be the duration of the day-time. Also higher northern declination of the Sun goes with longer day-time. Now, the latitude may be as high as 90^0 N but the highest solar declination possible is much less. This extreme value of solar declination is subject to some slow periodic change - pendulating from $21^0 59'$ to $24^0 36'$. Currently the value is about $23^0 27'$ but in this historical analysis we shall do well to use the mean value of $23^0 17'.5$.

Let us examine the issue from different angles by admitting different poosible meanings of 'Sun-rise' and 'Sun-set'.

I WITHOUT CORRECTION FOR REFRACTION

Ordinarily, the Sun is considerd to have risen when it has just wholly come up on the eastern horizon and similarly to have set when it has just wholly gone down below the western horizon.

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If the declination of the Sun is δ and the latitude of the place of observation is ϕ (both measured northwards) then (by calculating its 'hour-angle' both at the time of its rise and set) one can write, for its duration of stay above the horizon in terms of hours, the expression $2/15^0 \cos^{-1}(-\tan\phi\tan\delta)$, where the angle denoted by the inverse circular function is assumed to be an angle in degrees.

Putting the stipulated value of δ for the Sun, we then get, according to *Vedaṅga-jyautiṣa*,

$$\frac{2}{15^0}\left[\cos^{-1}(-\tan\phi\,\tan 23^0 17'.5)\right]^0 = 14.4$$

($\because$ 18 muhūrtas = 14.4 hours)

This yields $\phi^0 = 35^0.66$ nearly.

II WITH CORRECTION FOR REFRACTION

If the effect of refraction is considered, the length of day-time involves apparent Sun-rise and apparent Sun-set. Taking the value of 34' for 'horizontal refraction', the equation in this case changes to

$$\frac{2}{15^0}\left[\cos^{-1}(-\tan\phi\,\tan 23^0 17'.5)\right]^0 + 2 \times 34/60 \times 1/15 \times \frac{1}{\sqrt{\cos(\phi+\delta)\cos(\phi-\delta)}} = 14.4$$

And if this equation is solved for ϕ, by putting $\delta = 23^0 17'.5$, the computer yields $\phi = 34^0.5$ nearly.

III TAKING THE SUN'S UPPER LIMB FOR THE SUN ITSELF

The Sun, unlike a star of the nocturnal sky, does not appear to be a point of light. It looks like a disc whose angular diameter is about 32' : Sun-rise or Sun-set is not an instantaneous phenomenon.

What is to be done then? There are two distinct procedures. One is to choose any specific part of the Sun. Usually, it is the centre of the solar disc that is chosen. When this chosen part of the Sun rises or sets, then the Sun (as a whole) is considered to have risen or set. The other alternative is to choose what is called the 'upper limb' of the Sun and treat it as representative of the Sun. But in this case, the upper limb does not signify the same part of the Sun throughout: in the eastern sky the point of the Sun first to appear on the horizon is referred to as the upper limb, while in the west the last point to disappear is given that appellation. It is by far the more popular stand: to people in general, as soon as a bit of the Sun is seen, it is day begun; as long as the last bit of it is seen, the day is still on.

If we adopt the first procedure, which in fact is the more rational of the two, we are de facto treating the Sun as a star of the night-sky and therefore the equation and the solution of II hold in toto.

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If, on the other hand, we assume that the observers of *Vedāṅga-jyautiṣa* took the usual or popular view, then to them the day-time got unduly lengthened. If we want to correct for this error, our equation becomes

$$\frac{2}{15^0}\left[\cos^{-1}\left(-\tan\phi\,\tan 23^0 17'.5\right)\right]^0 + 2 \times (34+16)/15 \times 1/60 \times \frac{1}{\sqrt{\cos(\phi+\delta)\cos(\phi-\delta)}} = 14.4$$

Replacing δ by $23^0 17'.5$ and then solving this equation for ϕ by means of computers, one gets $\phi^0 = 34^0$ nearly.

CONCLUSION

The results stemming from the aforesaid analysis and calculations are somewhat astonishing. For, modern scholars, by and large, do not associate Vedic literature with the third millennium B.C., which is considered rather to be the flourishing period of the Indus valley civilization. Also, Vedic people are geographically associated with lower northern latitudes.

A plausible conclusion is that the relevant astronomical observations were made much earlier and their narration in literary form took place later. The Aryans probably observed while they were still in the process of emigration, or they carried the information from their earlier settlements, or else they got it from the Harappan people.

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