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Editor's Note

How could we better close out this second millennium CE than by a paper on astronomy and calendar calculations? This is, just like calendar reform, a perennial topic, and certainly so the matter addressed by the paper of Narahari Achar. Dating the Vedas with the help of astronomical observations referred to in the texts has engaged both scholars and the interested public for more than two centuries by now. Not always quietly and peacefully, and, as I will contend in a second brief paper appended to N. Achar's, not even justifiably so. For, too much emphasis seems to have been laid on taking the Vedic statements literally, as if they were made from a modern observatory. On the other hand, it is usually forgotten that even fairly primitive observations, such as marking the rising and setting points of the sun over the course of little more than one year, can set up a basic solar calendar, which then can be elaborated by a lunar one over the course of a little more than 5 years (coincidence of full moon and solar new year), or if wished, by a little more than 18 years (by observing the highest and lowest points in the course of the moon).

For an easily comprehensible introduction to these questions, chapter three of V. Aveni's book *Sky watchers of Ancient Mexico* (Austin, Univ. of Texas Press, 1980) is recommended; many of the relevant points for the Vedic period have also been described by A. Parpola in his book *Deciphering the Indus script* (Cambridge 1994). A. Aveni explains in simple terms how the sky can be observed "with the naked eye" and how basic astronomical facts can be determined from this.

An important innovation is that today everyone can check the correctness of the statements made in the two papers below by taking a look at some software described by N. Achar. (For Macintosh users, there is Voyager II and similar products.) No longer do we have to trust long and complicated calculations for some items that interest us, while we would have to go to our colleagues in astronomy for others that have not been made.

The crux remaining, however, is the interpretation of Vedic passages, as will be seen below. Just like the astronomical facts they cannot taken at 'first sight', that is, in astronomy forgetting about the changes due to precession (see below), or in Vedic studies forgetting about changes in the meaning words, concepts and cultural background: such observations have to be seen within the framework of other Vedic star lore, as discussed below. One cannot, as has

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so frequently been done even in the most recent books and papers, just quote an isolated sentence, e.g. the one from the ŚB discussed below, and build a complicated theory on it, especially if a closer reading of the passage in question does not bear out the original contention.

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I also thank all contributors and editors for their work and assistance, and I conclude with my best wishes to all readers for a happy and prosperous New Year, Century and Millennium!

M. Witzel (Dec. 24, 1999)

On Exploring the Vedic Sky with Modern Computer Software

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I. Introduction

As has been observed recently by Witzel,[1] the Vedic night sky has not received the full attention it deserves, and many Vedic passages, which allude to astronomical phenomena, have remained not yet fully understood. It is obvious that the sky as it appears to us now is quite unlike the sky that the Vedic people saw, and extensive calculations would have to be carried out before any meaningful comparison of the current sky with the stellar information in the Vedic passages can be made. However, in recent years there has become commercially available some very powerful astronomy software, the so-called Planetarium Software. These software products can generate and display on a personal computer, with a high degree of reliability, millions of stars and other heavenly objects as seen from any given location on earth and on any given date, all at the click of a mouse. These are used as tools in astronomical explorations with both conventional and automated telescope applications for determining when and in which part of the sky a particular object becomes visible. These computer programs, with the capability to generate and display the night sky at any date and place, can, therefore, be effectively used as research tools to generate and display the night sky as it was seen by the Vedic people. The Vedic passages describing the night sky can be studied in conjunction with such displays. It is to be expected that such an effort would lead to a better understanding of those Vedic passages. It is the purpose of this report to illustrate the application of a planetarium program, SkyMap Pro,[2], as a research tool[3] to study the Vedic sky in conjunction with Vedic passages,

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1 Witzel, M., "Looking for the Heavenly Casket", Electronic Journal of Vedic Studies, 1, 2,(1995). A longer version of this paper has appeared in Studien zur Indologie und Iranistik, 20; cf. also the discussion of the Milky Way and several asterisms in Vedic times in "Sur le chemin du ciel", Bulletin des etudes indiennes 2, 1984.

2 Marriott, C., SkyMap Software, 9 Severn Road, Culcheth, Cheshire WA3 5ED, UK (1993-1998). The latest version is called SkyMap Pro.

3 Achar, Narahari B. N., "The age of the Śatapatha Brāhmaṇa: a reexamination of Dikshit's theory", Indian Journal of History of Science, (in press). This paper, based on

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using as example some passages from *Śatapatha Brāhmaṇa* (ŚB). Another powerful program, PancAng2, developed by M. Yano and M. Fushimi[4] can calculate the *tithi* and *nakṣatra* for any date from 3100 BC onwards and is based on the *sūrya siddhānta*. This turns out to be a valuable tool in studying the Vedic rituals. Here it is used for identifying dates with a particular *nakṣatra*, *kṛttika*.

II. The passages in *Śatapatha Brāhmaṇa*

In the second *Brāhmaṇa* , the *Nakṣatra Brāhmaṇa* , of the first *adhyāya* of the second *kāṇḍa* of ŚB, occur the following lines:

> *kṛttikāsv agnī ādadhīta / etā vā agninakṣatraṃ yat kṛttikāḥ / tad vai saloma yo agninakṣatre agnī ādadhātai / tasmāt kṛttikāsv ādadhīta //* (II. 1. 2.1)
>
> He may set up the two fires under *kṛttikā*s; for they, the *kṛttikā*s are doubtless Agni's asterism, so that if he sets up his fires under Agni's asterism, (he will bring about) a correspondence (between his fires and the asterism): for this reason he may set up his fires under the *kṛttikā*s (tr. Eggeling[5])

> *ekaṃ dve trīṇi / catvārīti vā anyāni nakṣatrāṇi / athaitā eva bhūyiṣṭhāḥ yat kṛttikāḥ tad bhūmānam evaitad upaiti/ tasmāt kṛttikāsv ādadhīta //* (II. 1. 2.2)
>
> Moreover, the other lunar asterisms (consist of) one, two, three or four (stars), so that *kṛttikā*s are the most numerous (of asterisms): hence he there by obtains an abundance. For this reason he may set up his fires under the *kṛttikā*s (tr. Eggeling[5])

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an older version of the software SkyMapV2.2, argues erroneously for a site of observation far south of Delhi and is superseded by the present work.

[4] Yano, M. and Fushimi, M., Pancang2, a program based on *sūrya siddhānta*, available by ftp://ccftp.kyoto-su.ac.jp/pub/doc/sanskrit/

[5] Eggeling, J., The Śatapatha Brāhmaṇa According to the Mādhyandina School, Motilal Banarasidass, (Delhi, 1963), Part I, pp. 282-283.

[5] Eggeling, J., The Śatapatha Brāhmaṇa According to the Mādhyandina School, Motilal Banarasidass, (Delhi, 1963), Part I, pp. 282-283.

> *etā ha vai prācyai diśo na cyavante / sarvāṇi ha vā anyāni nakṣatrāṇi prāchyai diśo cyavante / tat prācyam evāsyaitad diśy āhitau bhavataḥ / tasmāt kṛttikāsv ādadhīta //* (II. 1. 2.3)
>
> And again they do not move away from the eastern quarter, whilst the other asterisms do move from the eastern quarter. Thus his (two fires) are established in the eastern quarter: for this reason he may set up his fires under the *kṛttikā*s. (tr. Eggeling[5])

The context is a discussion about the suitable time and *nakṣatra* under which it would be most auspicious to perform *agnyādhāna*, the establishment of the ritual fires for the first time by a householder. It is proposed that the new householder should establish the traditional *gārhapatya* and *āhavanīya* fires on the day of *kṛttikā nakṣatra*. For, the presiding deity of *kṛttikā* is Agni, the *kṛttikā*s alone consist of many stars and they never swerve from the east. He who performs *agnyādhāna* under *kṛttikā* , therefore, is blessed with abundance, and gets his household fires firmly established in the east. However, in the very next section arguments are presented against this proposition; for, the *kṛttikā*s were married to the *saptarṣis* who rise only in the north and hence are constantly separated from their spouses who rise in the east. "*amī hy uttarāhi saptarṣayaḥ udyanti pura etāḥ*". (II.1.2.4) This portends the same fate to befall the new householder, who establishes the household fires for the first time under *kṛttikā*. Hence, the day of *kṛttikā* is not to be considered suitable for performing this ritual. But counter arguments are presented later in the section, and finally, it is argued that *kṛttikā*s are the most auspicious for *agnyādhāna*; but, some other *nakṣatra*s, which may also be considered auspicious are suggested.

III. Dikshit's theory

The lines given above are obviously of great astronomical importance and Shankar Balkrishna Dikshit[6] was perhaps the first one to use them to propose

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[5] Eggeling, J., The Śatapatha Brāhmaṇa According to the Mādhyandina School, Motilal Banarasidass, (Delhi, 1963), Part I, pp. 282-283.

[6] Dikshit, S. B., "The Age of the Śatapatha Brāhmaṇa ", Indian Antiquary, 24, 245-246, (1895).

a date for ŚB. Although many others[7] [8] [9] [10] have discussed this issue in the literature since then, none expresses more eloquently than Dikshit himself:[11]

> The statement that *kṛittikās* never deviate from the east implies that these stars always rise in the east, i.e., they are situated on the [celestial] equator or that their declination is zero. At present they do not appear to rise exactly in the east, but at a point north of east; this happens because of the precessional motion of the equinox. Assuming 50" as annual motion, the time when the junction star of the *kṛttikā*s had zero declination, comes to be 3068 years before Śaka and even 150 years earlier i.e., the approximate time of the commencement of Kali era, if 48" be adopted as the precessional annual motion. Calculating the declination of some other stars in this age, we find that the northernmost star of *rohiṇī* group, southern three of the *hasta* group, two from *anūrādhā*, one from *jyeṣṭhā*, and one from *aśvinī* were situated near the equator, only some one star from the *hasta* group (if at all) could possibly have been situated exactly on the equator, otherwise none. The statement about *kṛttikā*s rising in the east is made in the present tense and they cannot always do so because of precessional motion of equinoxes. In our time we find them rising to the north of east and they used to rise to its south in 3100 BS [before Śaka]. From this it can be inferred that the corresponding portion in Śatapatha Brāhmaṇa was written about 3100 years before the Śaka era.

Pingree[12] has argued that the phrase "never swerve from the east" cannot be taken to mean rise "heliacally precisely at the east point" as was done by Dikshit, who deduced that this could have occurred only when the Pleiades were on the equator in about 3000 BC. Pingree vehemently counters, "unfortunately for this theory [of Dikshit], parts of the *nakṣatra*s, *hasta*,

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7 Chakravarty, A. K., "The Asterisms" in History of Oriental Astronomy, (ed.) Swarup, G., Bag, A. K., and Shukla, K. S., Cambridge University Press, (Cambridge, 1987), pp. 23-28.

8 Kaye, G. R., "The Nakshatras and Precession", Indian Antiquary, 50, 44-48, (1921).

9 Kansara, N. M., "The Vedic Sources of vedāṅga jyotiṣa", in Issues in Vedic Astronomy and Astrology, (ed.) Pandya, H., Dikshit, S., and Kansara, N. M., Motilal Banarasidass Publishers Pvt. Ltd., (Delhi, 1992), pp. 273-296.

10 Sarkar, R., "Vedic Literature vis-a-vis Mathematical Astronomy" in History of Oriental Astronomy, (ed.) Swarup, G., Bag, A. K., and Shukla, K. S., Cambridge University Press, (Cambridge, 1987), pp. 29-32.

11 Dikshit, S. B., Bharatiya Jyotish Sastra, Government of India Press, (Calcutta, 1969), pp. 128-129.

12 Pingree, D., "Mulapin and Vedic Astronomy" in Dumu-E2-Dub-ba-a, (ed.) Behrens, H., Loding, D., and Roth, M. (Philadelphia, 1989), pp. 439-445.

viṣākhe, and perhaps *śravaṇa* were also on the equator in 3000 BC." According to Pingree, this fact would there by contradict the claim in Śatapatha Brāhmaṇa that only the *kṛttikā*s 'never swerve from the east'; hence, he doubts whether that phrase can bear the meaning attributed to it by Dikshit. One of the purposes of the present report is to establish the relative merits of these two claims by observing the sky-view generated by using the software "SkyMap Pro", in conjunction with the program "PancAng2". These views of the sky correspond to the latitude of Delhi and represent the sky as the Vedic people themselves might have seen.

IV. The sky at present

The SkyMap Pro software takes into account the precessional motion of the earth's rotation axis and produces the images of the entire sky at any location on earth and at any date from 4000 BC to 8000 AD. It is a very sophisticated mapping tool, which shows all the heavenly objects above the horizon at any given location at any given time within certain limits. It can display stars as faint as magnitude sixteen, and zoom in to a practically unlimited extent to produce area maps with greater details to any desired degree. Furthermore, the celestial coordinates, right ascension and declination,[13] and a host of other astrophysical data can be determined for any object for the epoch corresponding to a given date. The local rising and setting times for the object can also be determined. Figure 1 shows the sky as it appears at Delhi on September 1, 1999 AD, looking in the direction of east at 10:50 pm, a few minutes after the moon rise. The arc at the bottom represents the horizon. The coordinates in the map are the azimuth and altitude, with zenith at the top. The

[13] The coordinates right ascension and declination are the analogs of longitude and latitude, respectively, and are fixed on the celestial sphere. Right ascension is measured in hours (h.), minutes (m), and seconds (s), and has a range of zero to twenty-three hours.
Declination is measured in degrees (d), minutes (m), and seconds (s), and has a range from -90 degrees to +90 degrees, with the 0 degree being on the equator. The coordinates of a star when expressed in right ascension and declination are the same for all observers on earth. In contrast, azimuth and altitude, both measured in degrees, minutes and seconds are "local" coordinates for a given star, and differ from observer to observer.
Azimuth is measured from the North Point, for which it is zero all the way around to 360 degrees in a full circle along the horizon. Thus, it is 90 degrees for East Point, 180 degrees for the South Point, and 270 degrees for the West Point. Altitude is measured from the horizon to the zenith, which is 90 degrees.

azimuth angle of 90 degrees marks the East Point. Only stars brighter than magnitude 5 are displayed to avoid clutter. According to Panchanga, it is *kṛṣṇa saptamī* and *kṛttikā nakṣatra* on this day. As Sāyaṇa explains, '*yasmin dine candreṇa samyujyante tasmin dine*,' it is the day when *kṛttikā*s are joined with the moon. We take the Pleiades as *kṛttikā*s and eta-tauri as the representative for the group. One can see in the picture the waning (almost third quarter) moon and *kṛttikā* just above the horizon, and both are considerably to the north of east. The *kṛttikā*s are displayed in an Area Map in figure 2, which is an expanded view of the region whose boundaries are marked by the equatorial coordinates as shown. Figure 2 resolves the stars of the Pleiades group. *Taittirīya Brāhmaṇa* (TB 3.1.4.1, and earlier on, TS 4.4.5.1, MS 2.8.13, KS 40.4) give the names of the stars belonging to the group as *ambā, dulā, nitatnī, abhrayantī, meghayantī, varṣayantī*, and *cupuṇikā* (MS variant *bulā* for *dulā*, and *stanayantī* for *varṣayantī*). There is a spread of about 30 minutes in the declination coordinates of different members of the group. From the display in figure 1 it is determined that the moon has a declination of 13 degrees and 3 minutes, and an azimuth of 76 degrees and 43 minutes. Eta-tauri has a declination of 24 degrees and 6 minutes and an azimuth of 65 degrees. Thus it is clear that the moon rises at a point about 13.25 degrees north of east, and eta-tauri rises at a point about 25 degrees north of east. In fact, the latter is further north than the sun. This is exactly as described by Dikshit, with reference to the current position of *kṛttikā*. Figure 3 shows a view to the north and shows the *saptarṣis* rising at a point east of north. At the present time then both *saptarṣis* and *kṛttikā*s rise in the north, in agreement with Dikshit.[12]

[12] Pingree, D., "Mulapin and Vedic Astronomy" in Dumu-E2-Dub-ba-a, (ed.) Behrens, H., Loding, D., and Roth, M. (Philadelphia, 1989), pp. 439-445.

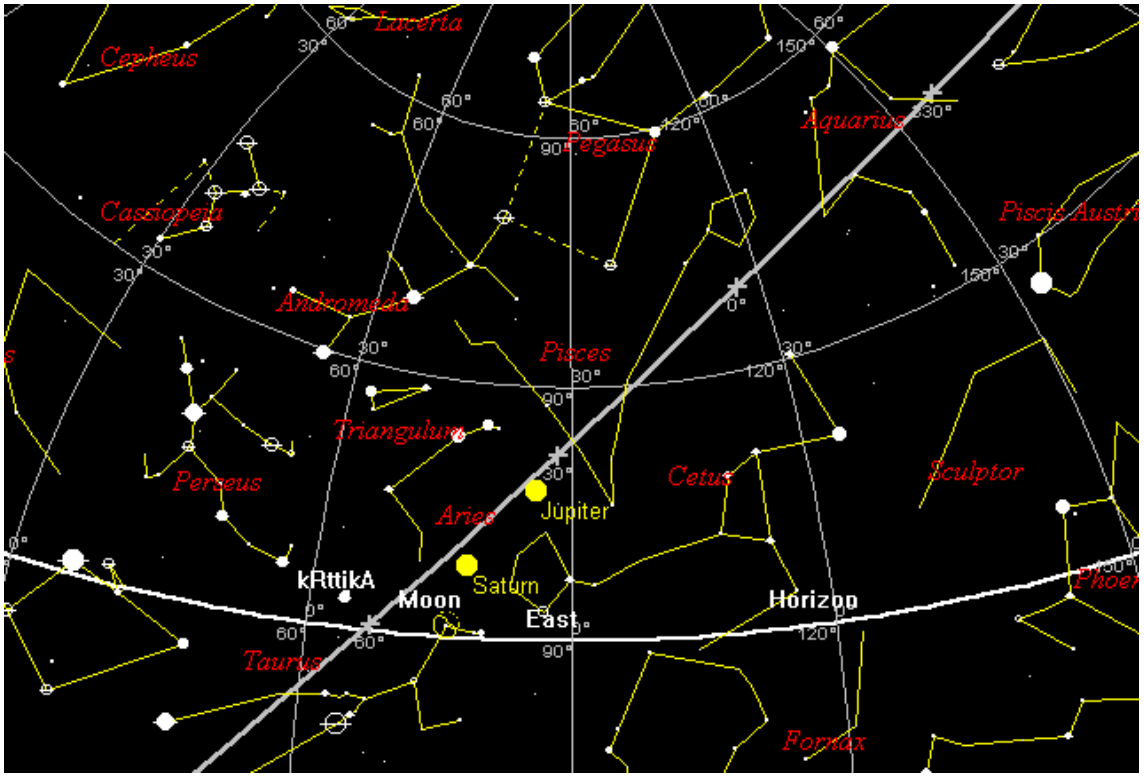
Lacerta
Cepheus
Pegasus
Aquarius
Cassiopeia
Andromeda
Pisces
Triangulum
Perseus
Aries
Jupiter
Cetus
Sculptor
kRttikA
Moon
Saturn
East
Horizon
Taurus
Fornax

Fig.1

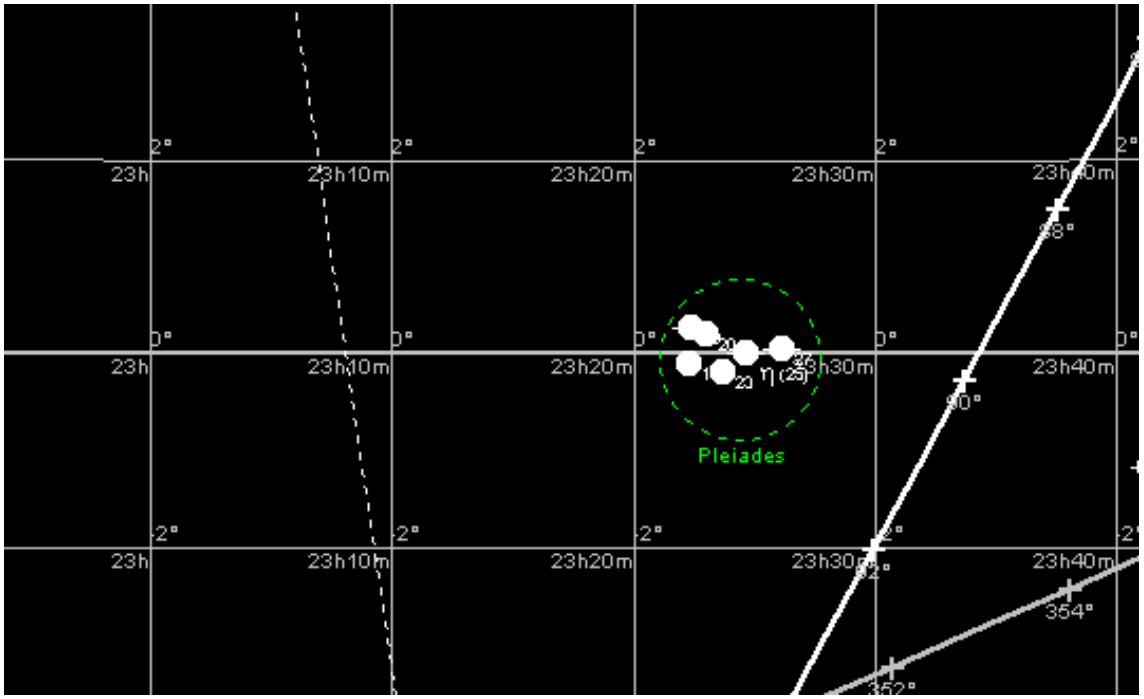
23h
23h10m
23h20m
23h30m
23h40m
Pleiades

Fig. 2

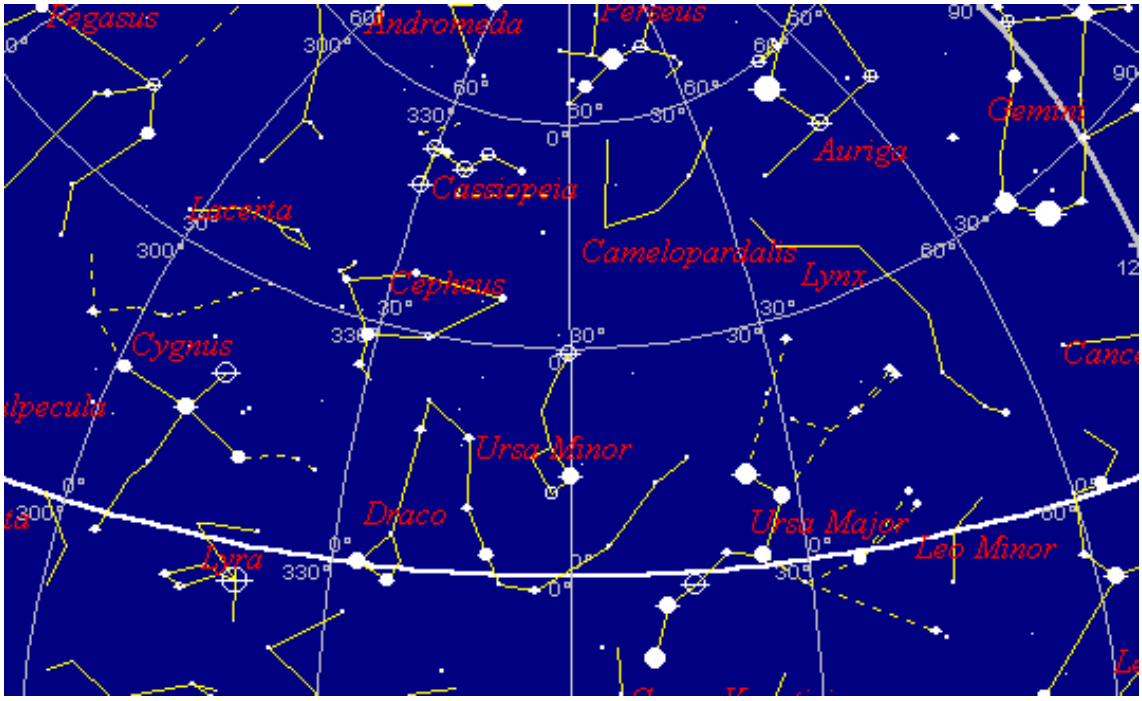

Fig. 3

V. *kṛttikā*s on the celestial equator

Using the software SkyMap Pro, we can determine the date when eta-tauri was at a position of zero declination. At that time it would be exactly on the equator and would rise exactly at the East Point. Since there is a spread of about 30 minutes in declination of the different members of the Pleiades group, the other members will not be technically exactly on the equator at the same time and hence would not rise exactly at the east. However, this small spread in declination would have been hardly noticeable. In fact, for a couple of centuries on either side of this date, the *kṛttikā* group would still be seen as rising in the east. Figure 4 shows the view of the sky for Delhi on July 8, 1200 BC. According to pancAng2, It is *śrāvaṇa aṣṭamī* in *kṛṣṇa pakṣa*, and it is *kṛttikā nakṣatra*. The picture shows the view of the sky to the east soon after moonrise and *kṛttikā* is also seen just above the horizon. On this date eta-tauri has a declination of 9 degrees and 41minutes, and rises at a point about 10 degrees north of east. Obviously, the event described in ŚB occurred much earlier than 1200 BC. Figure 5 is a sky map corresponding to August 16, 2927 BC, when *kṛttikā*s (actually, just eta-tauri) rise exactly in the east. With *kṛttikā*s rising in the east, the Vedic people watching the sky would declare, "*etā ha vai prācyai diśo na cyavante*."

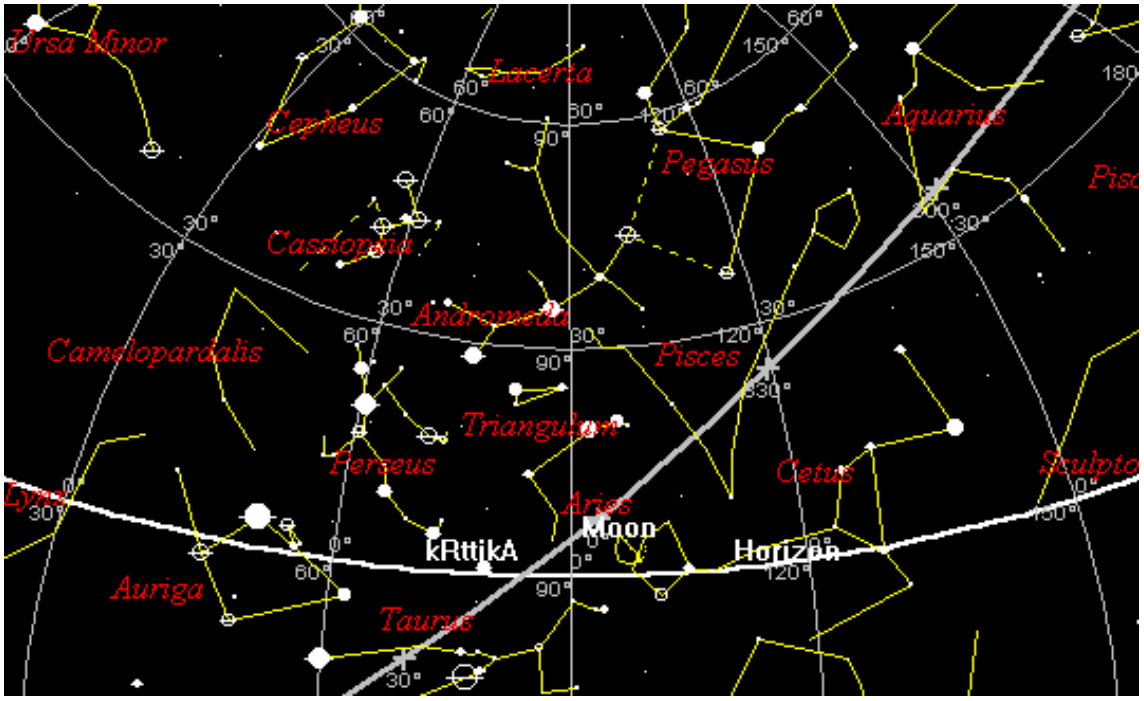
Ursa Minor
Lacerta
Cepheus
Aquarius
Pegasus
Cassiopeia
Andromeda
Camelopardalis
Pisces
Triangulum
Perseus
Cetus
Aries
Moon
kRttikA
Horizon
Auriga
Taurus

Fig. 4

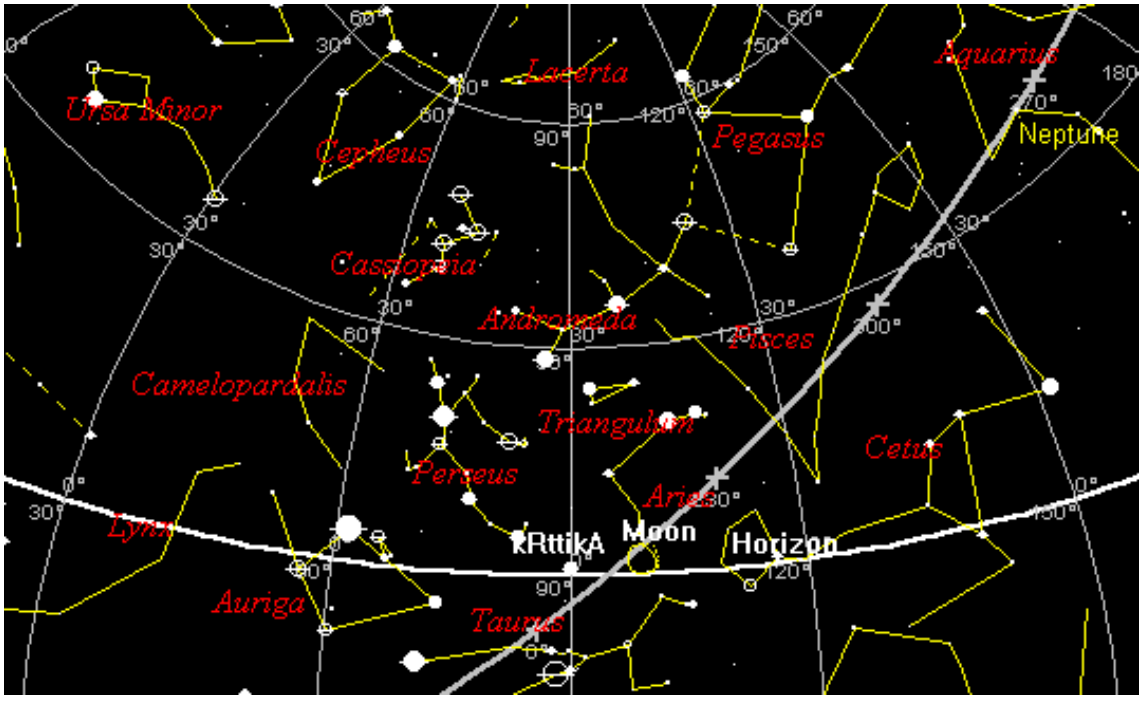
Lacerta
Aquarius
Ursa Minor
Pegasus
Neptune
Cepheus
Cassiopeia
Andromeda
Pisces
Camelopardalis
Triangulum
Cetus
Perseus
Aries
Moon
kRttikA
Horizon
Auriga
Taurus

Fig. 5

VI. Other *nakṣatra*s on the equator

Pingree has questioned the interpretation, that the phrase "never swerve from the east" means "they always rise exactly at the East Point". For, according to Pingree, parts of *nakṣatra*s*, hasta, viśākha*, and perhaps *śravaṇa* would also be on the equator on this date and this would contradict ŚB's claim that only *kṛttikā*s "never swerve from the east." We have generated sky maps for Delhi for this date, August 16, 2927 BC, facing east and separated by six hours in time interval so that the entire sky for right ascension from 0-23 hours near the equator region could be presented. Table 1 presents, as obtained from these maps, a list of stars, which are brighter than magnitude 4 and lie close to the equator by 2 degrees or less. The table also gives the values of their magnitude, right ascension and declination for the epoch 2927 BC. It is seen that there are about a dozen stars close to the equator. Of these, three are 30 minutes or less away from the equator, and four more are less than a degree away. There are additional four stars at about 1.5 degrees and the last one is about 2 degrees away from it.

Stars	**Magnitude**	**Right Ascn.**	**Declination**		
41-Arietis	3.70	22h	31m	1d	28m
epsilon-Pegasi	2.50	17h	38m	-1d	23m
theta-Aquilae	3.40	15h	56m	-1d	7m
zi-Serpentis	3.60	13h	14m	1d	21m
delta-Scorpi	2.50	11h	38m	0d	57m
sigma-Librae	3.40	10h	46m	0d	23m
nu-Hydrae	3.30	6h	46m	1d	12m
lambda-Hydrae	3.80	6h	6m	1d	54m
pi-Hydrae	3.50	9h	53m	-0d	10m
alpha-Hydrae	2.20	5h	21m	0d	48m
beta-Corvi	2.80	8h	29m	1d	5m
epsilon-Corvi	3.20	8h	7m	0d	41m
Eridanus	4.00	4h	18m	-1d	27m

Table 1. Stars located close to the equator in 2927 BC (epoch: 2927 BC)

Based on Pingree's own scheme of identifying stars,[14] *hasta, viśākha*, and *śravaṇa* correspond to delta-Corvi, iota-Librae, and alpha-Aquilae respectively. From the star maps, it is determined that none of these stars are really close to the equator in 2927 BC, and hence, are not found among those listed in table 1. In fact, the declinations of these stars are 7 degrees 49 minutes, 5 degrees 38 minutes, and 9 degrees 41 minutes respectively. Therefore, these stars would rise noticeably far from the East Point. None of the stars in table 1 can be identified with the junction stars or the *yogatārā*s themselves. It is true however, that there are stars in table 1, which may be considered to be other members of the groups associated with some junction stars, i.e., asterisms. For hasta, it is beta-Corvi, with a declination 1 degree 5 minutes, and epsilon-Corvi, with a declination of just 41minutes. For *viśākha*, it may be sigma-Librae with a declination of mere 23 minutes; and/or delta-Scorpi with a declination of 57 minutes, and perhaps *uttara proṣṭhapada*, epsilon-Pegasi, with a declination of -1 degree 23 minutes. Hence, these could also be described as "rising exactly in the east", or "not swerving from the east." Except for these, no other stars in table 1 can be regarded as belonging to the traditional list of *nakṣatra*s. Pingree's point (namely, ŚB's statement that only *kṛttikā*s never swerve from the east cannot have the meaning that they rise exactly in the east) would appear to be well taken since, *hasta, viśākha* and even *uttara proṣṭhapada*, are also on or near the equator, just as the *kṛttikā*s.

However, this objection does not really have any efficacy when one examines carefully the context under which that statement is made, namely, choosing the most auspicious *nakṣatra* for performing *agnyādhāna*. If the ritual of *agnyādhāna* is to be done under *kṛttikā*s because, "they never swerve from the east", then, Pingree's point would be equivalent to stating that the same ritual could be performed equally well under *hasta, viśākha*, and even *uttara proṣṭhapada*. For, they also would "never swerve from the east." In fact, hasta is considered as an alternate auspicious star for *agnyādhāna*, as discussed later in the same section in ŚB. *Āśvalāyana sūtra* (II.1. 10) permits both *viśākha* and *uttara proṣṭhapada* for the same ritual. Pingree might have scored a point, had these *nakṣatra*s been denied the status of being auspicious for performing *agnyādhāna*. While "never swerving from the east" may be a criterion for selection as a suitable *nakṣatra* for the ritual, there may be other reasons why *kṛttikā*s are preferred, such as the presiding deity being Agni. Thus the phrase

[14] Pingree, D. and Morissey, P., "On the Identification of the yogatārās of the Indian *nakṣatra*s", Journal for the History of Astronomy, xx, 99-119, (1989).

"never swerve from east" cannot mean anything other than "rising heliacally exactly at the East Point", for, ŚB itself declares: "*udyanti pura etā[ḥ]*" "they rise in the east." On this point, Sāyaṇa also says in his exegesis "*śuddha-prācyam evodyanti*" "they rise in the true east."

VII. *Saptarṣis* in the north

It was mentioned earlier that at the present time all members of group the *saptarṣis*, except alpha-Ursa majoris rise (and set) in the north as observed from Delhi (figure 3). However, in 2927 BC, it can be seen in figure 6, that Thuban is the pole star (later on called *dhruva*)and that all members of the *saptarṣis* are circumpolar and are quite to the north. Hence the *saptarṣis* would neither rise nor set. We have verified that the *saptarṣis* remain circumpolar at Delhi from about 4500BC to about 100 BC, at which time only one star of the group, eta-Ursa majoris, becomes non-circumpolar and rises and sets. It is only at about 600 AD that a second member of the group becomes non-circumpolar at Delhi. If they are all circumpolar as seen in Delhi at about 3000 BC, what is the meaning of "they rise in the north"? In order to see at least one of them rise and set, one would have to observe from a place south of Delhi. In fact, beta-Ursa-majoris, (declination: +66 degrees 8 minutes) could be observed as rising or setting from a place whose latitude is about 24degrees N, compared to Delhi's 28 degrees 22 minutes N. One would have to be at latitude of about 10 degrees N to observe all of *saptarṣis* to rise and set. Then what is the real meaning of *amī hy uttarāhi saptarṣayaḥ udyanti pura etā[ḥ]* (ŚB II.1.2.4)? Eggeling translates it as "for the latter, the seven ṛṣis, rise in the north, and they (the *kṛttikā*s) in the east." We feel that the confusion arises because, "*udyanti*" is associated with both "*saptarṣayaḥ*" and "*etāḥ*." The sentence should be broken as *āmī hy uttarāhi saptarṣayaḥ / udyanti pura etāḥ* /, associating *udyanti* with *etāḥ* only. The first part would simply state "*amī hy uttarāhi saptarṣayaḥ (santi)*". As Sāyaṇa explains, '*āhi ca dūre*', (PS 5.3.37) *iti*. *-āhi* is a *pratyaya, uttarāhi* would mean '*dūradeśe uttaradigbhāge'* 'at a far off place in the north'. Thus, ŚB (II.1.2.4) would mean "for these seven *ṛsis* indeed (stay) far to the north and they (the *kṛttikā*s) rise in the east." There is even a hint of the circumpolar nature of the *saptarṣis*, by the absence of 'rising'!

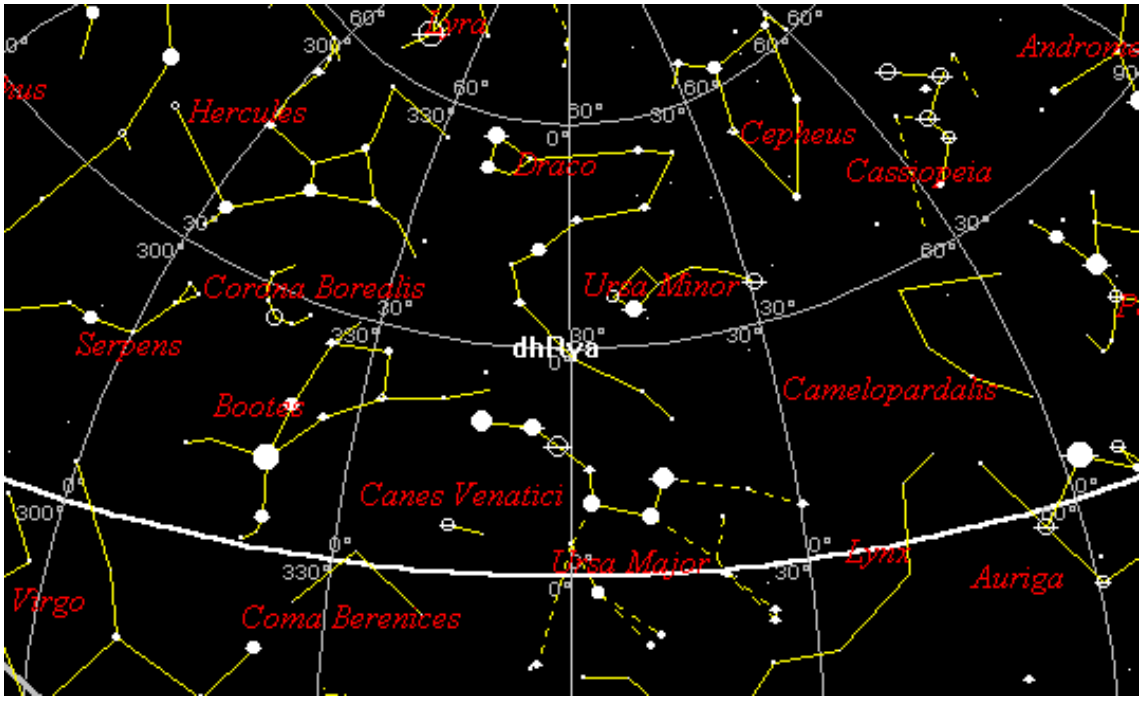

Fig. 6.

VIII. Some comments on the computer software

SkyMap Pro and Pancang2 agree with each other remarkably well even though one is based on *sūrya siddhānta* and the other is modern astronomical software. For example, on spot-checking the occurrence of new moons and full moons over a period from 3100 BC to 3000 AD, there is a difference of utmost a day (sometimes two). This difference arises mainly because of the convention for assigning *tithi* at sunrise and also because the program Pancang2 does not give the time when a *tithi* or *nakṣatra* begins or ends. Moreover, there are "*kṣaya*" and "*vṛddhi*" *tithis*. Nevertheless, this difference did not cause any serious difficulty in selecting the days of *kṛttikā nakṣatra*. There are a number of planetarium-type software available for PCs: The Sky, Red Shift, and Starry Night, just to mention a few. While they may perform more or less equally well for telescopic applications, there were some difficulties in using them for the present application. For example, on extrapolating to BC years, there was general agreement with the coordinates of stars, but not for the phases of the Moon. In fact, there was a difference of about eight days for full moon between the SkyMap Pro and The Sky in the year 2500 BC. In the case of Red Shift and Starry Night, sometimes the star map did not display the correct coordinates for the stars, even though the calculated coordinates were correct.

IX. Conclusions

A simulation using the software SkyMap Pro in conjunction with Pancang2 has been used to verify that the statements in ŚB about the *kṛttikā*s never swerving from east and about *saptarṣis* rising in the north point to events that could have been observed around 3000 BC. The fact that there are other *nakṣatra*s besides *kṛttikā*s which also do not deviate from the east appears to have been recognized, for, these other *nakṣatra*s have been suggested in the *śāstras* as alternate choices for performing the *agnyādhāna* ritual. The simulation also helps to understand better the statement about the *saptarṣis* being in the far off north.

X. Acknowledgement

This work has been supported in part by a University of Memphis Faculty Research Grant.

Abbreviations

ŚB *Śatapatha Brāhmaṇa*

PS *Pāṇini Sūtra*

The Pleiades and the Bears viewed from inside the Vedic texts

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N. Achar and his predecessors of the past hundred-odd years, definitely have a point when they state that several *nakṣatra* ('moon houses') can be viewed as being exactly situated on the eastern horizon at their various times of rising in the course of the night (and of the year), and that *Śatapatha Brāhmaṇa* 2.1.2.1 seems to describe the time when the Pleiades (*kṛttikāḥ*) were rising due east (at c. 2900 BCE). That means the Pleiades were rising in the east at nightfall at fall equinox, while the sun rises against their background at the spring equinox (heliacal rising at vernal equinox). The question here will be how to interpret this passage and how to place it against the background of Vedic star lore.[1]

Investigating these basic facts is of special importance as a wide range of claims has been made for the Vedas, from the observation of planets (see, however, M. Yano, forthcoming) to that of precession, the 'wobbling' of the celestial north pole (now close to our Pole Star, Polaris) around the northern region, on a path that takes some 28,000 years for one turn. Understanding this particular item is important for any evaluation: the situation in 2900/2300 BCE is no longer the one we can observe today. Stars on/near the ecliptic (our Greek-Babylonian zodiac signs, and the Vedic *nakṣatra*s) have moved on — for example the point where the sun rises at equinox on March 21 — in a generally east-northeastern direction, by some 47°. Our equinox now closer to the sign of Aquarius, compared to the situation in 2900 BCE when it was in Aries, close to Taurus .

Such detailed astronomical knowledge which can be gained only by very long term observations over the course of many hundreds if not thousands of years, is not to be expected, a priori, for the Vedic period.[2] The Vedic

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[1] It has to be noted that lore about the (heliacal) rising point of the *kṛttikā*s, Sirius, etc. is old; cf. for example Hesiod (Erga 383 sqq.) about the rising of the Pleiades as indicator for the right time to plough, or Sirius as the harbinger of the yearly flood of the Nile in old Egypt; for such data in Indo-Iranian and Indo-European, cf. Witzel 1984.

[2] Unless some very old and outdated astronomical observations had been transmitted, unchanged, over a long period of time and were then actively compared with contemporaneous observations.

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statements about the rising point of certain *nakṣatra*s thus must be viewed with circumspection, and most importantly of all, the ancient situation can by no means directly be compared with our modern night sky. On the other hand, it is important to note that the situations of 2900 or 2300 BCE do not differ that much from the one in 1000 BCE, as the situation of 2900 BCE differs from ours in 2000 CE, some 5000 years later! This point is usually lost in the discussion, and therefore stressed below.

The Vedic texts usually, though not exclusively, speak about the *nakṣatra*s in connection with the moon. The moon, supposed to live with his 27(?) wives (KS 11.3) or 33 wives (TS 2.3.5.1-3),[3] that is the goddesses in the *nakṣatra*s. However, he loved *rohiṇī* (Aldebaran in Taurus) best and stayed only with her; he therefore was punished by the *yakṣma* disease of 'consumption' (i.e. the waning of the moon). Since then, he has to dwell each night of the month in another 'moon house' (*nakṣatra*). The same situation, of course, occurs when we look at the position of the full moon over the course of the year: it is in one of the 27 or 28 *nakṣatra*s. (The sun, due to its opposition to the moon, always rises in the same *nakṣatra*s where the moon sets, but six months earlier/later. The heliacal rising in *kṛttikāḥ* of the sun thus took place in c. 2927 BCE at the vernal equinox in March. The Vedic texts, however, are more concerned with establishing the lunar calendar for sacrifices and festivals).[4]

II. The rising point of the KRttikās, the Pleiades

While the ŚB quotation discussed by N. Achar and his predecessors indeed seems to point to a situation where kṛttikā *nakṣatra* was situated at true east at the equinox, i.e. in 2927 BCE. However, the exact wording of the sentence just indicates that the *kṛttikā*s do not move away (*na cyavante*) from the east (*prācyai diśaḥ*). The Pleiades, just like any other *nakṣatra* close to the ecliptic, do of course rise in the east (during the course of one night or of the year), move upwards towards the south and set in the west. However, the Pleiades, even when the gradual changes effected by precession are taken into account,

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[3] Cf. also TS 3.4.7.1, KS 18.14, VS 18.40, ŚB 9.4.1.9, SB 3.12, etc.

[4] For a summary of older opinions on the origin of *nakṣatra* system (Babylonian, Chinese, Arab) see Macdonell and Keith, 1912, s. v. *nakṣatra*, p. 409-431; for a recent discussion (origin in the Indus Civilization), see Parpola 1994, p. 201-206, 241-246. Needless to say, the concept can be older than either the Indus or the Babylonian and Chinese astronomy and may go back to the often surprisingly sophisticated observations of the Neolithic.

move very little indeed from the eastern direction over many centuries after the above date.[5] This is important. From 2900 to c. 1500, a period framing the whole of the Indus civilization, (2600-1900, thus with a margin of a few centuries before and after it), and even from 1500 to 500 (the usual date of the Vedic period), the *kṛttikā*s indeed were situated close to the equator (see below).

We should not, as is always done, compare the (pre-)Vedic situation of 2900 BCE with today's, instead, we must investigate the difference between the starting point of this system at c. 2900 BCE, in the early copper/bronze age,[6] with that of the ŚB, which is, after all, an iron age text. The iron age starts in India at c. 1200 BCE at the earliest, but the general linguistic, spiritual, social and political developments of the ŚB points to a time frame shortly before the lifetime of the Buddha (around the middle of the millennium, traditionally 563-483 BCE, or even only around 400 BCE).

The same is indicated the internal chronology of the Vedic texts, e.g. by quotations in ŚB from the RV (a text without iron); the RV is first followed by the Yajurveda Saṃhitā mantras (iron is attested) and their slightly later explicatory prose (in the same Yajurveda texts), to whose discussions ŚB often answers; these texts are, again, followed by the earlier and later Brāhmaṇas (Aitareya Br., Jaiminīya Br., Vādhūla Br., Baudhāyana ŚS etc.) with whom ŚB shares many cultural and linguistic characteristics. Indeed, the very phrase *prācyai diśo na cyavante* (also found in BŚS) gives itself away as a formulation of the post-Ṛgvedic period. The genitive/ablative in *-ai* of stems in *-ī* does not occur before the Taittirīya Saṃhitā (and a few cases in *śaunaka Atharvaveda*);

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[5] As N. Achar, indeed, also mentions in passing, and as I have done in a paper that was to be published in India in a popular science journal some two years ago, along with some papers by specialists on the Veda and the Indus civilization; this project seems to have been abandoned by now; my paper will now be published in a volume on the Aryan question, ed. by Bryant /Patton (forthcoming).

[6] For hints of an old system starting with *rohiṇī* (Aldebaran), see Macdonell and Keith 1912 and Parpola 1994. — Incidentally, many of the names of the *kṛttikā*s are 'foreign' i.e. *ambā, dulā (bulā*, MS), *nitatnī, cupuṇīkā*, while some others are connected with rain, e.g. *abharayantī, meghayantī (stanayantī*, MS), *varṣayantī* (cf. Parpola 1994; used as names of bricks in the Agnicayana) — which fits very well the location of KS, MS, TS in Haryana/U.P., where the rainy season starts only in mid-July (Delhi ~ MS, at c. 1000 BCE). A 'rainy' *kārttika* at c. 2900 BCE, however, makes no sense for the Indus civilization (in the Greater Panjab and Sindh), where there is no real monsoon. At any rate, even for Delhi, the rainy season begins in mid-July and ends in September/October. (Note also the relationship between the Pleiades star *cupunīkā* (YV) and *ni-cumpūṇa* in RV, KS, MS, *ni-caṅkuṇā* in TS, apparently 'effusion, bubbling, water spirit').

it is typical for the central north Indian (TB) and eastern texts (such as ŚB) of the Brāhmaṇa period, while it disappears in post-Vedic Sanskrit (Witzel 1989).[7] In short, we have a statement, perhaps first made in c. 2900 BCE, in an iron age text that is close to the middle of the first millennium BCE (750-600 BCE?)

However, both Pingree and Achar do not undertake the important test, a countercheck to investigate how the Vedic people might have looked at the night sky of the very late Vedic period ŚB belongs to. D. Pingree, justifiably in is context, only looks at the situation in c. 2900 BCE and rightly indicates that several *nakṣatra*s other than the Pleiades also are on the equator and thus "do not swerve from the east" when their heliacal rising point is observed in the course of a year and when it is compared with the many *nakṣatra*s that are situated more off the equator. On the other hand, N. Achar has indeed noticed that the Pleiades do not divert much from the eastern direction for the next few centuries,[8] but one needs to follow through for a late Vedic text such as ŚB (composed around 750-600 BCE).

On checking with similar astronomical software (Voyager II), we observe that during the years from 3000 BCE down to 500 BCE, i.e. close to the approximate date of ŚB, the Pleiades move very little from the eastern direction at their position at Spring Full Moon. At vernal equinox in 2900 BCE the *kṛttikā*s were at 90° Azimuth, i.e. due east according to Achar, while at 1527 BCE they were at 81° 43", at 1027 BC at 74° 47", and at 500 BCE at 77° 38". These data were calculated for the Pleiades star Maia on Full Moon day; today they are off from the point of the vernal equinox (near lambda Piscis, phi Aquarii) by some 54° 23'; that means they are seen in the northeast.

The 'traditional' Vedic situation, thus, holds out for long enough that ŚB still can speak of the Pleiades as 'rising in the east' — maybe not true east, but 'east enough' at some 8-13° off true east. It must be underlined that the text

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[7] Further, the text must be viewed in context; other *nakṣatra*s (*rohiṇī, mṛgaśīrṣa, phalgunī, hasta, citra* in ŚB*, citra/svāti, śravaṇa* in BŚS, etc.) are discussed for various reasons, some of which include the usual 'etymology' based ones of Brāhmaṇa style discussions. It is, however, significant that some of the *nakṣatra*s identified by Pingree as being on the equator (*hasta, viṣākhe, śravaṇa*) are preferred by BŚS (hasta, *śravaṇa*); cf. also the list of equatorial *nakṣatra*s mentioned by Achar, above in section III (*rohiṇī, hasta, anurādhā, jyeṣṭhā, aśvinī*), and the partly corresponding list of ŚB (*rohiṇī, hasta*). Clearly, equatorial *nakṣatra*s were preferred.

[8] Cf. the position of the *kṛttikā*s and the full moon on his map of Delhi as late as July 1200 BCE.

actually does not speak of 'true east', — that is only Sāyaṇa's interpretation (14th c. CE), i.e. of someone living just some 500 years before our own times. Instead, the observation made above, just as the contemporary ones of the Baudhayāyana Śrautasūtra 27.5 (cf. *mānava* ŚS 10.1.1.3)[9] refer to certain prominent *nakṣatra*s or even to their stars, all of which allow to fix the eastern direction for a particular ritual purpose, i.e. the orientation of a hut on the offering ground.

III. East, North East, South East

This point becomes important when we investigate what "east" actually means in the Vedic texts. First of all, and obviously so, the eastern direction (*pūrvā diś*) of the sky, that is true east. However, the matter is more complex. While the older Vedic texts do not speak of intermediate directions of the sky (northeast, southeast, etc.), this distinction begins to emerge in the post-RV texts (*avāntaradiśā* MS, KS, TS, *avāntaradeśa* ŚB, *antardeśa* AV, *upadiśā* KS). One of the earliest cases is AV 15.5.1 sqq. where the southeastern region is described as *tasmai prācyā diśo 'antaradeśāḍ* ... "from the intermediate direction of the East", the SW as '*dakṣiṇāyā diśo*...', etc.[10] Again, we can decide the question on basis of contemporary texts.

By the time of the ŚB 11.6.1.2 we get such circumscriptions as: *etayoḥ pūrvayor uttaram anv avāntaradeśam vrajatāt* "then go to the upper (northern) one of the two eastern intermediate regions!"[11] We should translate (*ava-*)*antaradeśa* as 'intermediate region' (between N and NE, NE and E, etc.) and

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[9] It must be underlined that ŚB, BŚS, MŚS 10.1.1.3 have alternative dates for the setting up of the sacred fires, e.g. BŚS 27.5 (Karmānta) "The *kṛttikā*s do not move from the eastern quarter; after their complete appearance he should measure (the offering hut), that is one possibility. After the appearance of *śravaṇa* (Alpha of Aquila), that is the next; between *citrā* (Ear of corn, in Virgin) and *svāti* (Arcturus), that is one more." They are all located on the equator, and could serve as alternative points which clearly provide options three or six months later than the (ancient) equinox. However, these dates have nothing to do with the rules established for the *kṣatriya* and *vaiśya* in ŚB: spring for Brahmin, Summer for *kṣatriya*, Rainy Season for the *vaiśya*. This does not coincide with the BŚS locations.

[10] The oldest cases of intermediate directions are found in the explicatory prose of the Yajurveda Saṃhitās, with e.g. *uttarataḥ purastāt prāyaṇa-* 'the northeastern entry' (of the hut), MS 3.6.1: 60.13.

[11] Actual compounds such as N-E, S-W are late Vedic, e.g. SB 2.10 *prāg-udāk-prāyaṇa*, etc. For details on all types of circumscriptions and actual compounds for the intermediate directions, see Witzel 1972: 179-180

distinguish it from **avāntara-diś* 'intermediate direction' (NE, etc.). The northern and the southern *avāntaradeśas*, situated north and south of true east, form the eastern *deśa* (later, and nowadays, meaning 'province, country'). In other words, Vedic 'east' comprises the area between northeast and southeast, or to be more specific, the area (starting from E = 90°), between 90° and +45° (northeast), and -45° (southeast).

I therefore submit that all positions of the Pleiades (*kṛttikāḥ*) at vernal equinox during the Vedic period (c. 1500-500 BCE) fell well within this limit; they are indeed much closer to true east than the northeast (-45°) which is reached only in c. 650 CE. In short, the *kṛttikā*s did not swerve (much, 8-13°) from the eastern direction (*pūrva diś*) and remained well within the eastern *deśa* and its two *avāntaradeśa* (NE-SE)![12]

However, the ŚB passage has another surprise in store, when viewed against the background of the extant Vedic texts.

IV. The Seven *ṛṣi*s

Curiously, discussants of the ŚB passage in question have not paid close enough attention to the phrase a few lines later, ŚB 2.1.2.4, which speaks of the Seven *ṛṣi*s, the Great Dipper (Ursa maior, the great bear/wain). The Seven *ṛṣi*s are said to have been called *ṛkṣāḥ* "formerly" (*saptarṣīn u ha sma vai pura rkṣā ity ācakṣate*). This name of the Big Dipper is found just once before ŚB, at the RV 1.24.10.[13]

This evidence strongly indicates that ŚB authors, after the passage of up to a thousand years after the RV, still had a good 'traditional' memory of the rare, old Ṛgvedic name. Indeed the name is much older, it is (pre-?)IE, cf. Latin Ursa maior the great bearess', Greek *arktos* 'the bearess' with her cubs, etc.[14]

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[12] Note also the Old Iranian system as preserved in the Avesta, with four *karsuuar* 'climes' covering the same areas as in Vedic, i.e. from NE-SE, SE-SW, SW-NW, NW-NE, but with the later(?) additions by an eastern and a western sector, see Witzel (forthc. in Münchener Studien zur Sprachwissenschaft, 2000).

[13] The RV line is quoted once more, verbatim, in another—very late—Vedic text, TA 1.11.2: *ṛṣayaḥ saptātriś ca yat | sarve 'trayo agastyaś ca | nakṣatraiḥ śaṃkṛto 'vasan | atha savituḥ śyāvāśvasyāvartikāmasya | amī ya ṛkṣā nihītāsa uccā |* The last *pāda* seems to refer back to RV verse 7 which describes the *nyagrodha* tree. For the date of TA 1 see Witzel 1972.

[14] This seems to reflect stone age mentality, cf. Schadewaldt 1970, Scherer 1953; later on, with the advance of technology, the 'Bear' was also called 'wagon, Wain' (Witzel 1972). In Avestan, the asterism is called *haptO iringa* (acc.) 'the seven signs', which

So, why can the ŚB authors not have transmitted another piece of traditional knowledge, that about the exact rising point of the *kṛttikā*s, — astronomical lore that dates back to the third millennium BCE?[15]

V. Conclusion

The combination of the two observations from the same text, —actually from the same section of ŚB— are powerful arguments for giving a straightforward, and not a very involved astronomical interpretation to both passages in ŚB 2.1.2 : that is, the retention of traditional (pre-)Ṛgvedic lore about the *saptarṣi*s (Ursa maior) and the observation that the *kṛttikā*s do not swerve from, i.e. rise, in the east or closely nearby for a very long period (c. 2900 BCE down to even 500 BCE and beyond). The first is about a traditional rising point of the Pleiades at a certain moment in time, the memory of which was preserved;[16] the second, a traditional name of an important asterism, the marker of the northern direction, 'up there' (*uttara*, Witzel 1972), where the (great) bear(s) are found. Both passages are traditional priestly lore, orally transmitted over many centuries; they were used in ŚB at the precise moment when a particularly important ritual[17] was discussed and performed, that is, the first setting up of one's sacred fires.

In sum, it simply cannot be maintained, with the confidence B. Dikshit once had and that some of his successors still have, "that the corresponding portion in *Śatapatha Brāhmaṇa* was written about 3100 years before the Śaka era" (i.e. about 3043 BCE). First, there was no S. Asian writing at the time, except for the enigmatic Indus script which has not been read with confidence, a script that certainly did not reflect Vedic Sanskrit (see the last number of EJVS).

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would be Vedic **sapta* **lingā(ni),* but the identification with the Seven (Ṛgvedic) *ṛṣi*s is only Indo-Aryan and not even found everywhere in Vedic yet (see above).

[15] Whether its source is Indo-European star lore, as is the case of the *ṛkṣāḥ* ('the bears' = Ursa maior), cf. Scherer 1953 and Schadewaldt 1970, or whether it stems from the observations of the Indus people as Parpola 1994 maintains, or whether from some other possible source, e.g. the Bactria Margiana Archaeological Complex (2100-1800/1700BCE) which seems to have influenced both the Old Iranians as well as the Indo-Aryans (for linguistic evidence, see the last number of EJVS).

[16] Though for practical purposes and for other classes such as the *kṣatriya* and *vaiśya*, the rising points of other asterisms were used as well, see above note 9 and cf. the treatment in ŚB 2.1.2, BSS, MSS etc.

[17] Note that the *agnyādheya* is, from the point of view of the development of the solemn *śrauta* ritual and its texts, a late ritual.

Second, the very form of the sentence (using the middle/late Vedic form *prācyai*) betrays the phrase as having been composed in iron age time, and, with the rest of the ŚB, fairly close to the time of the Buddha. The original observation about the Pleiades, however, can go back to the third millennium BCE.

Retention of such outdated data in ritual is not unusual; to use a contemporary item, the time for Annual Meeting of the American Oriental Society depends on the date for the Christian Easter festival, which is determined as the first Sunday after the Full Moon in Spring (after March 21) and thus is based on a remnant of the lunar calendar; the basis for this date ultimately goes back much further in time, to the date of the ancient Hebrew Passover festival.[18]

VI. Some further notes.

Additionally, a few stray remarks may be appended that are connected with the preceding discussion. During the Indo-Iranian period, the 'bears' (*ṛkṣāḥ*) were not, of course, always visible in the night sky and rise from a partial position below the horizon (especially if we think of a BMAC or of a still more northern location): that would not be possible even for most of the Panjab, and is only possible South of Delhi, below c. 30° N.

The present tense of *ud i, udyanti*, however, which would point, in some scholars' opinion, to c. 3000 BCE, is easily explained, when we actually look at the Big Dipper when it appears in the early evening even today; it moves towards the north pole, surpasses it and sets in the west, (see sky maps in Witzel 1996).

This observation solves N. Achar's problem of the Ursa maior "rising" in the North. It actually rises, when it gets dark, in the north (nowadays with its easternmost stars from below the horizon, for late Vedic times cf. ŚB 13.8.1.9); Ursa maior then turns upwards, and is, after a few hours actually higher than the north pole (now situated at c. 30° in the southern Panjab/Delhi)... So why

[18] Note for example that our present Gregorian calendar is only some five hundred years old (and was not accepted in Russia until well after the October revolution, which actually took place in November); it was preceded by the Julian calendar which was in force for some 1500 years. Caesar's reform was instituted because the date of the Roman calendar had become out of tune with the seasons, just as a *kṛttikā* date for spring would be nowadays.

can the Vedic texts not speak of '*ud-yanti*', especially so, as the north is also called *ut-tara* ('situated on the side of *ud* "up"'), and as the northern direction includes all regions from to 45° = NE to 90° = E and 315° = NW.

Generally speaking, the use of the actual term 'to rise' (*ud i*) is not strange at all, as the stars close to the north pole move 'upwards' towards the pole (thus northwards), while the stars not so close to the pole, such as the *kṛttikā*s and other *nakṣatra*s on the equator, move in the opposite direction, towards the zenith (thus southwards). This explains the Brāhmaṇa story of a separation between the seven *ṛṣis* and their six wives (the *kṛttikā*s), while only *arundhatī* (Alcor in Ursa maior) remains with them (cf. Parpola 1994).

Abbreviations

AV	*Atharvaveda Saṃhitā*
BŚS	*Baudhāyana Śrautasūtra*
JB	*Jaiminīya Brāhmaṇa*
KS	*Kaṭha Saṃhitā*
MS	*Maitrāyaṇi Saṃhitā*
MŚS	*Mānava Śrautasūtra*
RV	*Ṛgveda Saṃhitā*
TS	*Taittirīya Saṃhitā*
SB	*Ṣaḍviṃśa Brāhmaṇa*
VādhB	*Vādhūla Brāhmaṇa*
VS	*Vājasaneyi Saṃhitā*
ŚB	*Śatapatha Brāhmaṇa*
YV	*Yajurveda*

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