Sarasvati River and Chronology: Simulations using Planetarium Software

B. N. Narahari Achar
Professor of Physics
University of Memphis, Memphis TN 38152 USA

I. Introduction

The theme of the conference is the ***Sarasvati*** River and Hindu Civilization. One aspect of the study in understanding the role of the great river is to develop some chronological markers. The ***Mahābhārata*** war was fought on the banks of this river[1] and the pilgrimage of ***Balarāma*** at the time of the war on the banks of the river ***Sarasvati*** provide some historical elements needed. References to astronomical events in the epic ***Mahābhārata*** have been recognized as observed and not computed. These astronomical events can be simulated using planetarium software and thus provide a basis for dating these astronomical events. The dating of the events in the ***Mahābhārata*** war correlates well with the dating of the archaeological explorations along the river. The paper presents the results of an ongoing research over the past few years regarding the date of the ***Mahābhārata*** war, the progress of the research has been reported in several publications including monographs. The present article is based on three stages of development represented in these publications[2].

Correlation can also be made with dating of astronomical events described in other Vedic texts such as ***saṁhita*** and ***brāhmaṇa*** texts. Astronomy is considered to be

[1] The boundaries of ***kurukṣetra*** are described in the verse: ***dakṣiṇena sarasvatyā uttareṇa dṛaṣadvatīṁ | ye vasanti kurukṣetre te vasanti triviṣṭupe*** || (Mbh. III. 81. 175)

[2] Narahari Achar, B. N.(2005), "Planetarium Software and the Date of the Mahabharata war" in *The **Mahābhārata:**What is not here is nowhere else*, Rukmani, T. S (Editor).,Munshiram Manoharlal Publishers, New Delhi, pp. 247-263. Proceedings of the International Conferenceheld at Concordia University, Montreal Canada 18-10, May 2001.

Narahari Achar, B. N., (2004), "Date of the Mahabharata war based on simulations using Planetarium software" in *The Date of the Mahabharata War Based on Astronomica Data*, Kamath, S. U., (Editor)*l* Mythic Society, Bangalore, International Colloquium on 5-6 January 2003.

Narahari Achar, B. N.(2006),"Planetary Configurations in the Epic Mahabharata: Revisiting an Exercise in Archaeoastronomy" in *Viewing the Sky through Past and Present Cultures"*, selected papers from the Oxford VII International Conference on Archaeoastronomy, Bostwick, T. W. and Bates, B (Editors) Pueblo Grande Museum Anthropological Papers 45, Phoenix, USA the foremost of sciences, and has played an important role in India since the Vedic times. Astronomy was essential in determining the proper times for performing the ritual ***yajña.*** It is generally accepted that the ***ṛgjyotiṣa*** (RJ) recension of ***Vedāṅgajyotiṣa***(VJ) is the earliest codified text of astronomy of India. This paper also addresses the state of Astronomy in India from the earliest times to ***Vedāṅgajyotiṣa.*** The accounts of history of astronomy in ancient India that are currently available[3] have to be modified in view of the developments discussed below.

II. *Vedāṅgajyotiṣa*

It is universally accepted that RJ is the earliest text of astronomy in Ancient India. The knowledge codified in this text is attributed to sage ***Lagadha***, but the composition of the text which has preserved this knowledge is attributed to ***Śuci,*** a disciple of ***Lagadga.*** RJ is more like a pocket reference rather than a detailed treatise of astronomy and gives all the knowledge of astronomy essential for the performance of Vedic rituals, codified in a form akin to the style of ***sūtra***s in 36 ***śloka***s, easy for memorization, but sometimes difficult for understanding. It is declared to be the science of time, as its primary purpose is to determine the proper time for the performance of Vedic rituals. Some of the important concepts of RJ include ***tithi, nakṣatra***(defined as a division of the Ecliptic), ***aṁśā, kalā, aṣṭaka*** and ***parvan***. Units of time, and measurement of time , ***ṛtu, ayana,*** and ***adhimāsa*** and a five year period called ***yuga.*** Pingree[4], in his eagerness to show that VJ was derived from Mesopotamian origin, assigned a date of ~400 BCE for it, while Sastry[5] and others had assigned a date of ~1200 BCE , based on the reference in RJ that the winter solstice occurred at ***Dhaniṣṭha,*** and on the identification of ***Dhaniṣṭha*** with β-Delphini. The author has argued[6] that every astronomical concept in RJ can be traced to ***ṛgveda*** and other Vedic texts. For the concept of ***tithi,*** for example, there are several well known quotations from ***ṛgVeda*** which show that the year nominally of 360 days is

[3] Sen, S. N.,(1971) "Astronomy" in : Bose, D. M., Sen, S. N., and Subbarayappa, B. V., (Ed) *A Concise History of Science in India*,Indian National Science Academy, New Delhi. Pp 58-135

[4] Pingree (1973)

[5] Sastry, Kuppanna, T. S.,(1985) ***Vedāñga Jyotiṣa of Lagadha,*** Indian National Science Academy, New Delhi.

[6] Narahari Achar, B. N. ,(1998a) 'On the Vedic Origin of the Ancient Mathematical Astronomy of India', Journal of Studies on Ancient India, **1-2**

divided into 12 months of 30 days each, thus alluding to ***tithi***, the 30th part of a lunar month:

dvādaśāraṁ na hi tajjarāya varvarti cakraṁ paridyāmṛtasya|

āputrā agne mithunāso atra saptaśatāni vimśatiśca tasthuḥ|| RV I.164.11||

The moon is the one who shapes the year: ***samānāṁ māsa ākṛtiḥ***|| RV X. 85.5 ||

Aitareya Brāhmaṇa (32.10) defines the ***tithi*** and the ***Taittirīya Brāhmaṇa*** gives the names of the fifteen ***tithes*** of the waxing phase:

etānuvākau pūrvapakṣasyāhorātrāṇāṁ nāmadheyāni || TB 3.10.1.1-3 ||

and the names of the fifteen ***tithes*** of the waning phase:

etānuvākā parapakṣasyāhorātrāṇāṁ nāmadheyāni || TB 3.10.1.2 ||

The concepts of equinoxes and solstices, the scheme of ***adhimāsa,*** the five year ***yuga*** system can all be traced to Vedic sources[7]. For example, ***Aitareya Brāhmaṇa*** (18.22) shows the knowledge of the equinox and the period between two solstices:

yathā vai puruṣa evaṁ viṣuvāmstasya yathā dakṣiṇo'rdha evaṁ pūrvo'rdho viṣuvatoyathottiro'rdha evamuttarā'rdho viṣuvatastasmāduttara ityācakṣate||

The practice of inserting an intercalary month is adduced to in

Veda māso dhṛtavato dvādaśa prajāvataḥ | vedā ya upajāyate || RV I. 25.8||

II. b *Nakṣatra* system is already known in *ṛgVeda*

Nakṣatras, variously translated as asterisms or lunar mansions with an enduring list of 27 (sometimes 28) in number have been the hallmark of Indian astronomy. They refer to stars, which lie near the path of the sun or the moon as markers, while in RJ they refer to the divisions of the ecliptic. Explicit mention of the names of only a few of the 27 ***nakṣatra***s is found in ***ṛgVeda*** although complete list of 27 (or 28) ***nakṣatra***s can be found in other ***saṁhita*** and ***Brāhmaṇa*** texts. This has led scholars to believe that not all the ***nakṇatra***s were known at the time of ***ṛgVeda*** and the development of the full list occurred later. The author has shown that the entire list of ***nakṣatra***s[8] can be found in ***ṛgveda,*** contrary to the scholarly pronouncements that such an entire list came to be recognized only at the time of ***taittirīya saṁhita.***

II. c. Names of the months *caitra* etc. already known in *ṛgVeda*

[7] Achar (1998a)

[8] Narahari Achar, B. N., (2002a) 'In Search of ***Nakṣatras*** in ***ṛgVeda***' in Bhu Dev Sharma (Ed), *Contemporary Views on Indian Civilization,* World Association for Vedic Studies, New Delhi, pp 361-370

One of the characteristic features of the Hindu calendar is the naming of the month on the basis of the ***nakṣatra*** near which a full moon may be taken to have occurred. These are the well known ***caitra, vaiśākha, jyeṣṭha*** etc. The names of the months in the Vedic texts, however, are ***madhu, mādhava, śukra, śuci, nabhas, nabhasya, iṣa ūrjā, sahas, sahasya, tapas and tapasya.*** Some scholars have conjectured that the names of the months based on the ***nakṣatra***s was not known during the ***saṁhita*** times, but came into vogue much later. In fact Dixit[9] surmises that this scheme came into vogue when the vernal equinox actually took place in ***caitra.*** Using the Planetarium software, the author has shown that there is no basis for this argument to establish a chronology. The scheme of naming the months called the ***caitrādi*** system has also been traced[10] to ***ṛgveda*** on the basis of the connection between ***Yajña*** and the important role of ***agni*** in it.

III. Time and its measurement

Astronomy is an observational science. RJ propounds a five year luni-solar year called the Yuga, comprising of ten ayanas, subdivided into ***ṛtu, māsa, ardhamāsa, ahorātra, kalā, muhūrta, kāṣṭā.*** These concepts can be traced to Vedic sources, for instance, in ***Mahānārāyaṇopaniṣat,***

kalāmuhūrtāḥ kāṣṭāścāhorātrāśca sarvaśaḥ
ardhamāsā māsā ṛtavassaṁvatsaraśca kalpantāṁ || MNU 1.2.3-4) ||

The method of measuring time with a water clock can be traced to Atharvaveda[11], and the method of Gnomon can also be traced to Vedic sources. In short, the entire astronomical knowledge of ***vedāṅga jyotiṣa*** is traceable to ***ṛgveda.*** The related question of ***kaliyuga, manvantara, kalpa etc*** will be discussed in a separate paper.

IV. Identification of the Vedic *nakṣatra*-s

Although in RJ the ***nakṣatras*** refer to divisions of the ecliptic, and the names of the divisions correspond to bright asterisms also known by the same names, there must have

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9 Dixit, S. B., (1969) ***Bhāratiya Jyitiṣaśāstra***, Calcutta.
10 Narahari Achar, B. N.,(2000) "On the Caitradi Scheme", Indian Journal of History of Science, 35.4 pp 295-310
11 Narahari Achar, B. N.,(1998b) "Measurement of Time Using a Water Clock : An interpretation of the Third Mantra of the Kala sukta of Atharvaveda (XIX.53.3), in Bhu Dev Sharma (Ed) *New Perspectives on Vedic and Ancient Indian Civilization,* World Association for Vedic Studies, New York, (2000), pp 157-165

been a time when only the asterisms and not the divisions of the ecliptic were used as the markers for the observation of movements of the sun and the moon. It is essential to identify the Vedic ***nakṣatras*** (the bright stars) with their modern names, for the lists that are available in the literature are not satisfactory, some of the asterisms being more than 30° away from the ecliptic and could not have been used as markers for the motion of the sun and the moon. The author has used the simulations using the planetarium software, SkyMap Pro, of nearly 900 new moons and full moons occurring around 2297 BCE, when ***kṛttikās*** (identified with Pleiades) were on the equator and around 2220 BCE, when the vernal equinox occurred at ***kṛttika***s and has produced[12] a table for identification of the ***nakṣatras,*** which is reproduced below. This identification is based on the view of the sky as the Vedic people themselves would have seen as simulated by the planetarium software. On the new moon days and full moon days, there is absolutely no question about the relative positions of the sun and the moon, and hence of the ***nakṣatra***, which describes the moon's position. The details of the identification procedure can be obtained from the reference cited above. The planetarium software produces the view of the sky by an extrapolation of the positions of the stars in a modern catalogue. The stars identified as a particular ***nakṣatra*** will therefore retain the identity. This is in contrast to the procedure adopted by Pingree[13], where the polar coordinates of stars given in a ***Siddhānta*** text is first converted to equatorial coordinates, then extrapolated to modern epochs to compare with the coordinates of stars in a modern catalogue and then make the identification.

The present list is believed to be the correct one as it is based on the view of the sky the Vedic people them selves would have observed. It agrees with most of the stars in the list given in the Report of the Calendar Reform Committee[14], but there are six cases, where there is disagreement. The new identification is based on stars, which are very close to the ecliptic and hence better suited as markers for the motion of the sun and the moon. Besides, the new identification easily explains a controversy [15]that had plagued the ***nakṣatra*** system, namely classification into ***deva and yama nakṣatra***s.

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[12] Narahari Achar, B. N., (2002b) 'On the identification of Vedic ***Nakṣatra***s' in: Bhu Dev Sharma (Ed) , *Contemporary Views on Indian Civilization,* World Association for Vedic Studies, New Delhi, pp 371-387
[13] Pingree, D., and Morissey , P.,(1989) "On the Identification of the ***yogatāras*** of the Indian ***Nakṣatras***", Journal for the History of Astronomy, **20,** pp99-119.
[14] Saha, M. N., and Lahiri, A. C., (1955) *Report of the Calendar Reform Committee,* CSIR, New Delhi
[15] Narahari Achar (2002b)

V. Date of *Vedāṅga Jyotiṣa*

The author has recently shown[16] that the date for the ***Lagadha*** recension of ***vedāṅga jyotiṣa*** must be revised to about 1800 BCE, rather than the previously accepted date of 1200 BCE. The date of ***vedāṅga jyotiṣa*** , as discussed by Sastry[17], is based on the calculation of the time when winter solstice occurred at ***Dhaniṣṭha.*** The date of 1200 BCE is based on the identification of ***Dhaniṣṭha*** with β-Delphini according to the old identification scheme derived from the ***yogatāras*** of the ***Siddhāntas***, and may not correspond to what the Vedic people themselves had observed. Based on the identification scheme proposed by the author in Table 1, ***Dhaniṣṭha*** corresponds to δ-Capricorni. Figure 1 shows the star map for Delhi on January 3, 1752 BCE, the day of winter solstice. It is clearly seen to be the month of ***Māgha*** in figure 2, as per the description in RJ verses 5 and 6. It can be noted that β-Delphini is more than 30° away from the Ecliptic and could not be a marker star, where as δ-Capricorni is right close to the Ecliptic and would be suitable as a marker star. Thus it follows that the date of ***Lagadha*** recension of ***Vedāṅga Jyotiṣa*** is to be dated around 1800 BCE. That there must have been versions of ***Vedāṅga Jyotiṣa*** much older than the ***Lagadha*** recension, as for example that followed at the time of the ***Mahābhārata*** war

[16] Narahari Achar B. N., (2000) "A Case for Revising the Date of ***Vedāṅga Jyotiṣa***" Indian Journal of History of Science, **35.3,** pp 173-183
[17] Sastry (1985)

Table 1. Identification of Vedic *nakṣatra*s[+]

*Nakṣatra*s	No. of stars	Identification of the Principal star		Presiding Deity
		RCRC	Present	
kṛttika	6	η-Tau	η-Tau	***Agni***
rohiṇi	1	α-Tau	α-Tau	***prajāpati***
mṛgaśira	3	λ-Ori	β-Tau*	***Soma***
ārdrā	1	α-Ori	γ-Gem*	***Rudra***
punarvasu	2	β-Gem	β-Gem	***Aditi***
puṣya	1	δ-Cnc	δ-Cnc	***Bṛhaspati***
āśleṣa	6	ε-Hya	ζ-Hya	***Sarpa***
makhā	6	α-Leo	α-Leo	***Pitṛ***
pūrvaphālguṇi	2	δ-Leo	δ-Leo	***aryamā***
uttaraphālguṇi	2	β-Leo	β-Leo	***Bhaga***
hasta	5	δ-Crv	γ-Vir*	***savitā***
citrā	1	α-Vir	α-Vir	***Indra***
svāti	1	α-Boo	π-Hya*	***vāyu***
viśākha	2	α-Lib	α_2-Lib	***indrāṇi***
anūrādhā	4	δ-Sco	δ-Sco	***Mitra***
jyeṣṭhā	1	α-Sco	α-Sco	***Indra***
mūla	7	λ-Sco	λ-Sco	***Pitṛ***
pūrvāṣāḍha	4	δ-Sgr	δ-Sgr	***āpaḥ***
uttarāṣāḍha	4	σ-Sgr	σ-Sgr	***Viśvedevāḥ***
śravaṇa	3	α-Aql	β-Cap*	***Viṣṇu***
dhaniṣṭha	5	β-Del	δ-Cap*	***Vasu***
śatabhiṣa	1	λ-Aqr	λ-Aqr	***Indra***
pūrvābhādra	2	α-Peg	α-Peg	***ajaekapāt***
uttarābhādra	2	γ-Peg	γ-Peg	***Ahirbudhnya***
revati	1	ζ-Pis	ζ-Pis	***Pūṣā***
aśvini	2	β-Ari	β-Ari	***Aśvin***
bharaṇi	3	41-Ari	δ-Ari	***yama***

[+] List taken from Achar (2002b)
[*] These identifications differ from the usual list. These stars are brighter and closer to the ecliptic and are natural choice as markers of the motion of the son and the moon.

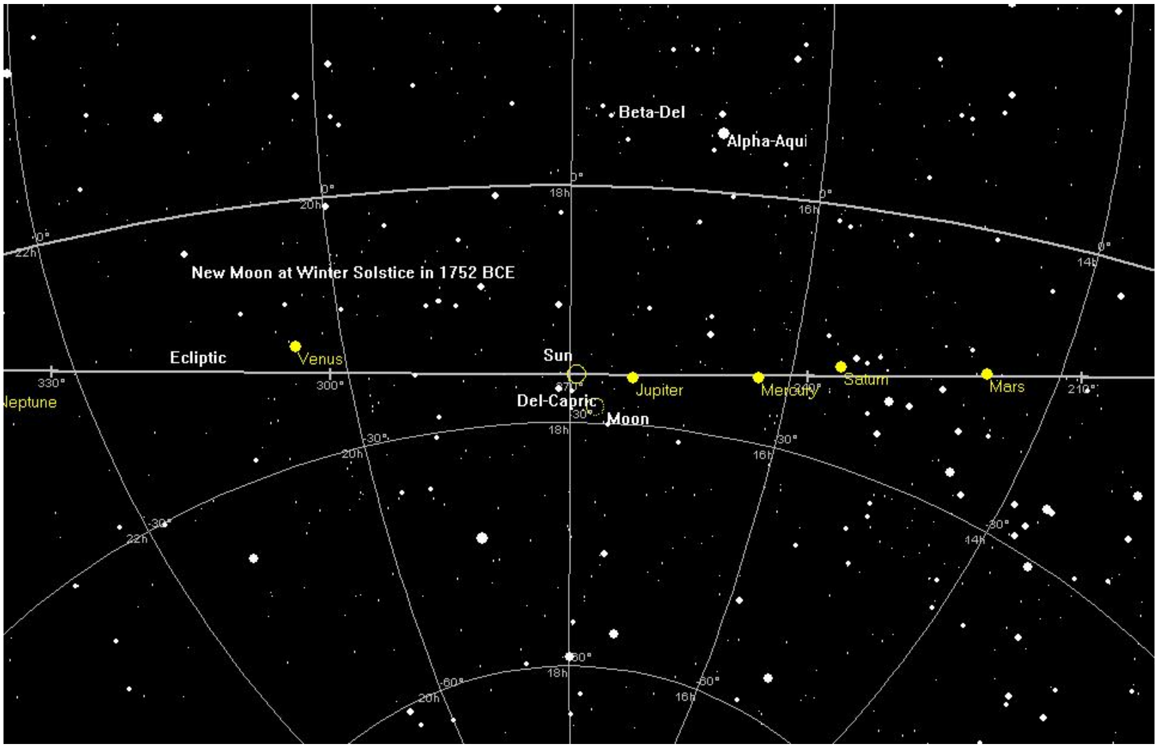

Figure 1. Winter Solstice in 1752 BCE

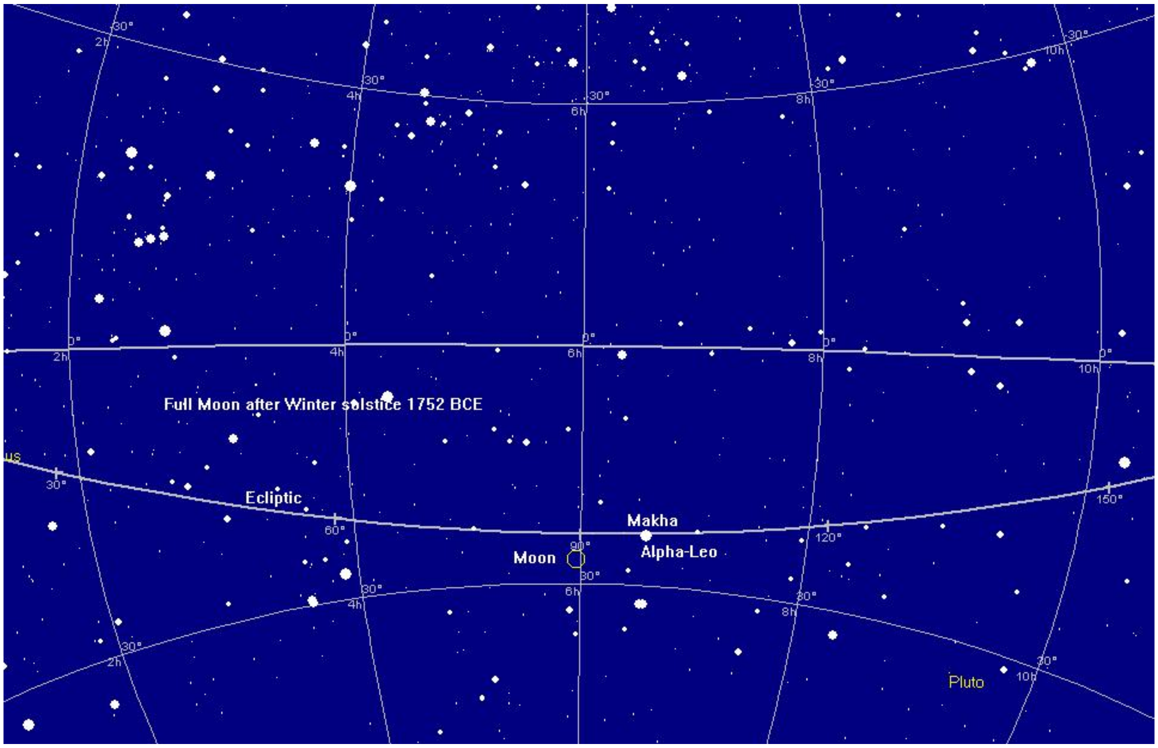

Figure 2. Full Moon after the Winter Solstice in 1752 BCE

VI. Date of *Śatapatha Brāhmaṇa*

It is a well known fact that there are many references to astronomical phenomena contained in the ***Brāhmaṇa*** texts and in fact these references have been used in the past by scholars such as Tilak[18] and Dikshit[19] to determine the dates of the events mentioned in these texts. A prime example of such investigations is the dating of the ***Śatapatha Brāhaṇa*** by Dikshi on the basis of the following lines referring to ***Kṛttikās*** :

etā ha vai prācyai diśo na cyavante… SB (II.1.2.3)

"and again they do not move away from the eastern quarter" (Tr. Eggeling[20])

amī hy uttarā hi saptarṣayaḥ udyanti purā etāḥ…..SB(II.1.2.4)

"these latter, the seven ***ṛṣi***s rise in the north and they (the ***Kṛttikā***s) in the east" (Tr. Eggeling[3])

These lines occur in the second ***brāhmaṇa*** of the first ***adhyāya*** of the second ***kāṇḍa*** of SB, in connection with choosing a suitable time for ***agnyādhāna***, the establishment of the ritual fires for the first time by a householder. It is suggested that the new householder should establish the traditional ***gārhapatya*** and the ***āhavaīya*** fires on the day of ***Kṛttika naṣatra***, for their presiding deity is ***agni.*** The ***Kṛttikā***s never swerve from the east and they alone consist of many stars. He who performs ***agnyādhāna*** on the day of ***Kṛttikā*** is blessed with 'abundance' and a 'steadfast family'. But, the second line quoted above argues against this proposition; for, ***Saptarṣi***s, who were married to ***Kṛttikā***s are constantly separated from the latter as they rise only in the east, while the ***Saptarṣi***s stay in the north, implying a similar fate befalling the new householder. However, counter arguments are presented and finally, it is argued that ***Kṛttikā***s are the most auspicious, but some other ***nakṣatra***s are also suggested as equally auspicious for the purpose of ***agnyādhāna***.

The astronomical importance of these lines was recognized by Dikshit, who interpreted "they do not move away from the eastern quarter" to mean that the ***'Kṛttikā***s rise exactly at the east point' and used this fact to determine the date of SB as ~3000

[18] Tilak, B. G., (1983) *The Orion,* Cosmo Publications, Poona
[19] Dikshit, S. B.,(1895) "The age of ***Śatapatha Brāmaṇa"*** Indian Antiquary ,**24,**pp 245-246
[20] Eggeling, J. ,(1963), *The* ***Śatapatha Brāhmaṇa*** *According to the* ***Madhyandina School***, Motilal Banarsidass, Delhi Part I, pp 282-283

BCE. With the advent of the so called planetarium software, Achar[21] reinvestigated this particular issue by simulations of the view of the sky and confirmed that Dikshit was essentially correct in his dating of SB.

VII. Date of the *Mahābhārata* War

The importance of the date of the ***Mahābhārata*** war as the sheet-anchor[22] for the chronology of ***Bhārata*** is too well known to be stated again. According to tradition, the war between the ***Kaurava***s and ***Pandava***s took place at the transition between ***Dwāpara*** and ***Kali yuga***s[23], around 3000 BCE. However, ever since Western Scholars showed interest some hundred years ago in the epic and began to discuss its 'historicity', a lively debate (or rather a war of dates!) has been going on. While some scholars[24] declare that the whole epic is a myth denying any historical truth to the story of the epic, many do believe[25] that the war actually took place, but are divided as to the magnitude of the event and as to the date when it actually took place. Some scholars portray the epic as an exaggerated account of a family feud. A plethora of dates ranging from before 5000 BCE to around 1000 BCE have been proposed[26] on the basis of estimates arrived at by using diverse methodologies and there appears to be no consensus for the date.

Among the diverse methodologies used, one methodology that is of special interest here is the one based on astronomical references (of which there are more than one hundred and fifty in number, and occur scattered throughout the epic). More than 40% of all the articles[27] (totaling more than 120 in number) dedicated to determining the date of the war, are based on the astronomical references. Although the astronomical references are scattered throughout the epic, most of them pertaining to the war occur in ***Udyogaparvan*** and ***Bhishmaparvan*** of the epic. Practically all scholars have

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[21] Narahari Achar, B. N., (2000) "On the Astronomical Basis of the Date of ***Śatapatha Brāhmaṇa***: A Reexamination of Dixit's Theory" Indian Journal of History of Science, **35 (1)**, pp 1-19

[22] Kota Venkatachelam,(1954)*The Plot in Indian Chronology*, Arya vijnana, Vijayavada

[23] ***antare caiva saṁprāpte kali dvāparayorabhūt***
samantapañcake yuddhaṁ kurupāṇḍava senayoḥ ||MBh. I.2.9||

[24] Sircar, D. C., (1969), "The Myth of the Great Bharata War", in *The Bharata War and the Puranic Geneologies*, University of Calcutta, pp 11-27.

[25] Gupta S. P. and Ramachandran, K. S.,(1976), (editors) *Mahabharata, Myth and Reality-Differing Views*, Agam Prakashan, Delhi;
Sathe, S.,(1983) *Search for thr Year of the Bharata War*, Navabharati Publications, Hyderabad.

[26] Vedavyas, E (1986), *Astronomical Dating of the Mahabharata War*, Agam Kala Prakashan, , Delhi. This is an exceptional book with an encyclopedic survey of literature on the topic. The date proposed in this work, 3138 BCE does not quite agree with the astronomical configurations as discussed here..

[27] Sathe (1983)

characterized the references in ***Bhishmaparvan*** as astrological omens[28] and inconsistent and not suitable for a 'scientific' analysis. The earlier works using the astronomical references were tedious and calculations were done manually and hence chose to use only a couple of the astronomical events out of the many available in the epic. More recent studies have used the computer software 'planetarium software' and consequently have considered a much larger number sample of astronomical references in the epic. Still, until recently there appeared to be no convergence of the dates[29]. Some scholars have introduced[30] ad hoc hypotheses in attempting to find some degree of coherence among the apparently 'inconsistent' astronomical references. It is clearly shown that the astronomical references are quite consistent and that such ad hoc hypotheses are totally unnecessary. The present article summarizes the results of a research conducted by the author over the past five years using planetarium software and the results have been published in several research publications. The research has shown conclusively that

(i) the astronomical references in the ***Bhishmaparvan*** are not merely 'astrological effusions fit for mother goose's tales' (as once characterized by Professor Sen Gupta), but follow a ***Vedic*** tradition of omens and describe mostly comets and not planets as generally assumed,

(ii) the few true planetary references in this parvan are identical to those in ***Udyogaparvan,***

(iii) These common references lead to a unique date for the war, 3067 BCE.

(iv) all other astronomical references in the epic are consistent with the date

(v) The date agrees with the date given earlier by Professor Raghavan and is consistent with the traditional date~3000 BCE.

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[28]Sengupta, P. C., (1947) *Ancient Indian Chronology*, University of Calcutta, Calcutta.

[29] Kamath, S. U., (Bangalore, 2004), (Editor) The Date of the Mahabharata War Based on Astronomical Data, Mythic Society.

[30] It has been common to make ad hoc assumptions to fit whatever model one is proposing and to bring some degree of consistency in the astronomical references in the Epic. For example, Sengupta [14] assumed that the pair of eclipses had occurred two years before the war and later inserted into the text. Sharma (quoted by Iyengar in his paper in [15], p. 151) assumed that ***Vyāsa*** met ***Dhṛtarāṣṭra*** not just once on the eve of the war, but several times and the planetary positions refer to different times. Iyengar (in [15], p.167) assumed that part of the text in ***Bhiṣmaparvan*** actually belongs to ***sabhāparvan***.

(vi) Using the planetarium software, it can be easily demonstrated that all other dates proposed by different authors are inconsistent with the planetary configurations referred to in (ii) above.

VII a. Astronomical References in *Udyogaparvan*

Kṛṣṇa's mission for peace is so important that astronomical events in reference to that mission are recorded.

(i) ***Kṛṣṇa*** leaves for ***Hastināpura*** in the ***maitrī muhūrta*** in the month of ***Kārtika*** on the day of ***Revatī nakṣatra***.

(ii) On the way he halts at a place called ***Vṛkasthala*** and reaches ***Hastināpura*** on the day of ***Bharaṇī nakṣatra***

(iii) The meetings and discussions for peace go on till the day of ***Puṣya nakṣatra,*** when ***Duryodhana*** rejects all offers of peace. War becomes imminent.

(iv) ***Kṛṣṇa*** leaves ***Hastināpura*** on the day of ***Uttara Phālguni. Karṇa*** accompanies him in his chariot and has a long conversation with him.

(v) During the conversation ***Karṇa*** describes some omens he has seen that indicate a great harm to the ***Kuru*** family which include the following: ***śani*** is afflicting ***Rohiṇī, aṅgāraka*** has performed a retrograde motion before reaching ***Jyeṣṭhā*** and is prograde again having past ***Anūrādhā,*** the moon had lost all its luster on the full moon of ***Kārtika*** and a solar eclipse would appear to take place next new moon day.

(vi) At the end of the conversation, ***Kṛṣṇa*** sends a message to ***Bhiṣma*** and ***Droṇa*** through ***Karṇa*** that seven days from that day there is going to be an ***Amāvāsya*** at ***Jyeṣtha*** and that war rituals be started on that day.

Except for Professor Sengupta, these astronomical references are generally agreed to be genuine and pertinent by most scholars. Professor Sengupta does not have "faith in the astrological omens" described by ***Karṇa*** in (v) above. However, he does believe that the reference to ***'jyeṣṭha amāvāsya'*** is extremely important, but considers the reference to two eclipses occurring within thirteen days eclipses as interpolation.

VII b. Astronomical References in *Bhiṣmaparvan*

Sage ***Vyāsa*** meets with ***Dhṛtarāṣtra*** just prior to the war and describes the omens he has seen. Among these omens described in 76 verses in two chapters are some 40 astronomical references given in four different segments. These are some of the most misunderstood astronomical references. On a superficial reading, and assuming that the astrological references to ***graha*** pertain to planets as most scholars have done, the references appear to be confusing and contradictory. Since they also occur in four different segments, scholars have characterized them as unreliable and even as interpolations. But, by a careful analysis the author has shown that ***Vyāsa*** is very systematic in his description and follows a very genuine ***Vedic*** tradition of omens. The omens occur in four segments because, they pertain to four different aspects of the impending disaster: (a) an imminent war, (b) great harm to the ***Kuru*** family, (c) destruction of both armies and (d) disaster to the entire population. Most of the omens pertain to comets and not planets. The only true planetary positions are described in segment (b) as the omens describing harm to the ***Kuru*** family, they are identical to those described by ***Karṇa*** earlier in ***udyogaparvan.*** This is easily demonstrated, for example, by comparing the first segment of astronomical references in ***Bhiṣma parvan***: Chapter 2. verses 20-23 with some selected ***mantra***-s from ***AtharvaVeda Pariśiṣṭha.***

References in (MB VI.2. 20-23) ***Vyāsa*** tells ***Dhṛtarāṣtra:***	***'yuddhalakṣaṇa'***in ***Atharvaveda Pariśiṣṭha***.
"I observe the sun every day both at sunrise and sunset and have seen him as if encircled by long arms." "I see the sun surrounded by halos on all sides, halos which are tri-colored, dark in the middle and white and red towards the edge and accompanied by lightning." "I have been watching days and nights, the fierce sun, the moon and the stars shining incessantly and have been unable to distinguish between day and night. Surely this forebodes utter destruction." "On the full moon night of ***kṛttika,*** the moon with a fiery tinge was hardly visible, devoid of glory and the horizons were also of the same hue."	"(In predicting war) one should always consider the line of clouds and halos around the sun and the moon and observe whether they appear red in color or not."(64.5.7) "Which are blue and red towards the edges and dark in the middle and accompanied by lightning."(61.1.4) "Whenever the sun is surrounded at sunrise and sunset by tri-colored clouds, it indicates a great calamity to the earth and royal families."(61.1.15) "The color of the moon at the time of an eclipse indicates a battle if it is red and disaster to cities and villages if it smoky or fiery."(53.5.1-2)

It is clear that these are omens for an imminent war according to a Vedic tradition.

In the second segment, ***Vyāsa*** describes some omens, which forecast a great destruction, especially to the ***Kuru*** family:

> ***rohiṇiṁ piḍayanneṣa stitho rājan śanaiścaraḥ/***
>
> ***vyāvṛttaṁ lakṣma somasya bhaviṣyati mahadbhayaṁ***// MB(VI. 2. 32)
>
> "Oh King, Saturn is harassing Aldebaran and the spot on the Moon has shifted from its position. Something terrible will happen."
>
> ***abhikṣṇaṁ kampate bhūmirarkaṁ rāhustathāgrasat/***
>
> ***śveto grahastathā citrāṁ samatikramya tiṣṭati***// MB(VI. 3. 11)

"The Earth is experiencing tremors intermittently and Rahu (Moon's Node) has seized the Sun. ***śvetagraha*** has transgressed Spica."

These are identical to the omens described by ***Karṇa*** to ***Kṛṣṇa*** in ***udyogaparvan.***

Vyāsa describes in the third segment further indicators, in the form of comets, of the calamity to the entire army (***senayoraśivaṁ ghoraṁ…***). He names specifically a number of comets, ***śveta, dhūmaketu, mahāgraha, paruṣa, pāvaka, dhūma, lohitāṅga, tivra, pāvakaprabha, śyāma, ghora, and dhruvaketu,*** as can be seen from the original Sanskrit verses. All these names can be found in the list of comets given by ***Varāhamihira***[31].

The word ***graha*** (from the root ***grah***=to grasp or to seize) refers to any heavenly object, which can move and hence can 'grasp' or 'seize' a star. Thus, it can refer to a planet or to a comet. It is true that nowadays in Indian astronomy, the word ***graha*** denotes only a planet. But, ***Vyāsa*** leaves no doubt to the fact that in ***Bhiṣmaparvan,*** the word ***graha*** refers to a comet:

"grahau tāmrāruṇaśikhau prajvalitāvubhau" MB (VI. 3. 24)

'the two ***grahās*** blazing with coppery red hair'.

The heavenly object ***graha*** blazing with red hair in the context here can only refer to a comet. It may be noted that the word comet itself derives from the Greek word for hair.

Vyāsa refers to son of Sun, ***sūryaputra***, explicitly, but he also refers to the comets by the name of the parent planets, i.e., Jupiter to indicate the comet son of Jupiter. While this is quite according to the Sanskrit grammar, it is this notation that has caused so much confusion and most scholars have interpreted them literally as referring to planets alone (instead of the comets which must have been meant). This has resulted in inferring conflicting planetary positions, when in actuality no planetary position is indicated.

In the final segment, ***Vyāsa*** describes the omens, which indicate the destruction of the entire population:

caturdaśīṁ pañcadaśīṁ bhūtapurvāṁ ca ṣoḍaśīṁ/

---

[31] M. Ramakrishna Bhat, ***Varāhamihira's Bṛhatsaṁhitā***, Part I. Edited with English translation. (Delhi : Motilal Banarsidass, 1981). According to ***Varāhamihira***, the ancient Indian astronomers ***Parāśara*** and ***Garga*** had observed hundreds of comets and regarded the comets as indicators of impending calamities.

imāṁtu nābhijānāmi amāvāsyāṁ trayodaśiṁ// MB(VI. 3. 28)

candrasūryāvubhau grastāvekamāse trayodaśiṁ/

aparvaṇi grahāvetau prajāḥ saṁkṣapayiṣyataḥ// MB(VI. 3. 29)

"I know New Moon coinciding with fourteenth, fifteenth and also on the sixteenth day, but I have never known it coinciding with the thirteenth day. In one and the same month, both the Sun and the Moon are eclipsed on the thirteenth. These ill-timed eclipses indicate destruction of the people."

This segment contains the famous reference to sequence of two eclipses within an interval of thirteen days and in fact, almost identical to the omens described in ***Atharvaveda Pariśiṣṭha*** :

yadi tu rāhurubhau śaśibhāskarau

grasati pakṣamanantaramantataḥ|

puruṣaśoṇitakardamavāhinī

bhavati bhūr naca varṣati mādhavaḥ|| (AP 53.3.5)

The important planetary configurations

The important references to planets consist of those that are common to both ***Udyoga and Bhiṣmaparvan-***s and include the following

(i) conjunction of ***śani*** with ***rohiṇī***

(ii) retrograde motion of ***aṅgāraka*** just before reaching ***jyeṣṭhā***

(iii) a lunar eclipse on the ***kārtika pūrṇima*** ,followed by

(iv) a solar eclipse at ***jyeṣṭha***.

These events lead to a unique year for the war. All other references in the epic are consistent with this date.

VIII. Simulations using Planetarium Software and the date of the war

A search is made for the years in which there is a conjunction of Saturn (***śani***) with Aldebaran (***Rohiṇī***) between 3500 BCE and 500 CE. As Saturn takes an average of 29.5 years to go around the sun once, the event also repeats with the same period. There are 137 such conjunctions during the interval specified above. A search is then made for those years from among these 137 dates when Mars (***aṅgāraka***) is retrograde before reaching Antares (***Jyeṣṭhā***). Since the retrograde motion of Mars repeats with the same period as its synodic period, a spread of two years on either side of each of the dates was considered in the search. The search reduced the set to just seventeen: 3271 BCE, 3067 BCE, 2830 BCE, 2625 BCE, 2388 BCE, 2183 BCE, 1946 BCE, 1741 BCE, 1503 BCE, 1299 BCE, 1061 BCE, 857 BCE, 620 BCE, 415 BCE, 28 CE, 233 CE and 470 CE, when Saturn was near Aldebaran and Mars executed a retrograde motion before reaching Antares. A search is then made for those years in which there is a lunar eclipse near Pleiades (i.e., on the ***KārtikaPūrṇima*)*.** This reduces the set to just two, 3067 BCE and 2183 BCE. It turns out that in both of these years the lunar eclipse is followed by a solar eclipse at ***jyeṣṭha.*** A sequence of 'two eclipses within a period of 13 days' also occurs in the two eclipse seasons. When one considers the fact that ***Bhiṣma*** passed away on the ***Māgha śukla aṣṭamī***, after the occurrence of winter solstice, a unique date results, for the winter solstice in January 13, 3066 BCE occurred on ***śuklapañcamī,*** where as the winter solstice in 2182 BCE occurred on ***kṛṣnacaturthi***.

Thus a unique date of 3067 BCE for the date of the war emerges. The author has shown that this date is consistent with all the other astronomical references in the epic in several publications with the help of copious illustrations of star maps generated by Planetarium software. Some of them will be included as part of this essay by way of illustration

VIIIa. Illustrations

The star maps in figures 3-10 show that the astronomical events are reproduced. In figure 3, the day ***Kṛṣṇa*** starts on his diplomatic mission, it is clearly seen that moon is near ***revati,*** and ***śani*** is at ***rohiṇi.*** Figure 4 shows the full moon in ***kārtika***, it also happens to be a lunar eclipse day. At this time, ***Kṛṣṇa*** is busy with the peace talks in ***Hastināpura.*** In figure 5, ***Kṛṣṇa*** rides with ***Karṇa*** after the failure of the peace mission, it is ***uttaraphālguṇī***. Seven days from that day, it will be ***amāvāsya*** at ***jyeṣṭha***. ***Kṛṣṇa*** sends the message to ***Bhīṣma*** and ***Droṇa*** to start the war rituals that day. Figure 6 shows the star map for that that day, which is also a solar eclipse day. The retrograde loop of Mars in that year is also shown in the figure. The retrograde motion of Mars before reaching ***Jyeṣṭha*** had occurred several months earlier. Figure 7 shows the day the war starts: moon is at ***bharaṇi.*** Figure 8 shows the fourteenth day, when the war continues until the wee hours of the morning and stops when the moon rises. Figure 9 shows the last day of the war, it is ***śravaṇa nakṣatra*** and ***Balarāma*** returns. Figure 10 shows the day of ***Bhīṣma***'s expiry: ***śukla aṣṭamī, rohiṇī nakṣatra.***

. The sheer volume of astronomical data and the consistency of the astronomical references reinforce conclusively the traditional belief that the war took place about five thousand years ago, and that the astronomical references are not clever interpolations of some latter day astronomer.

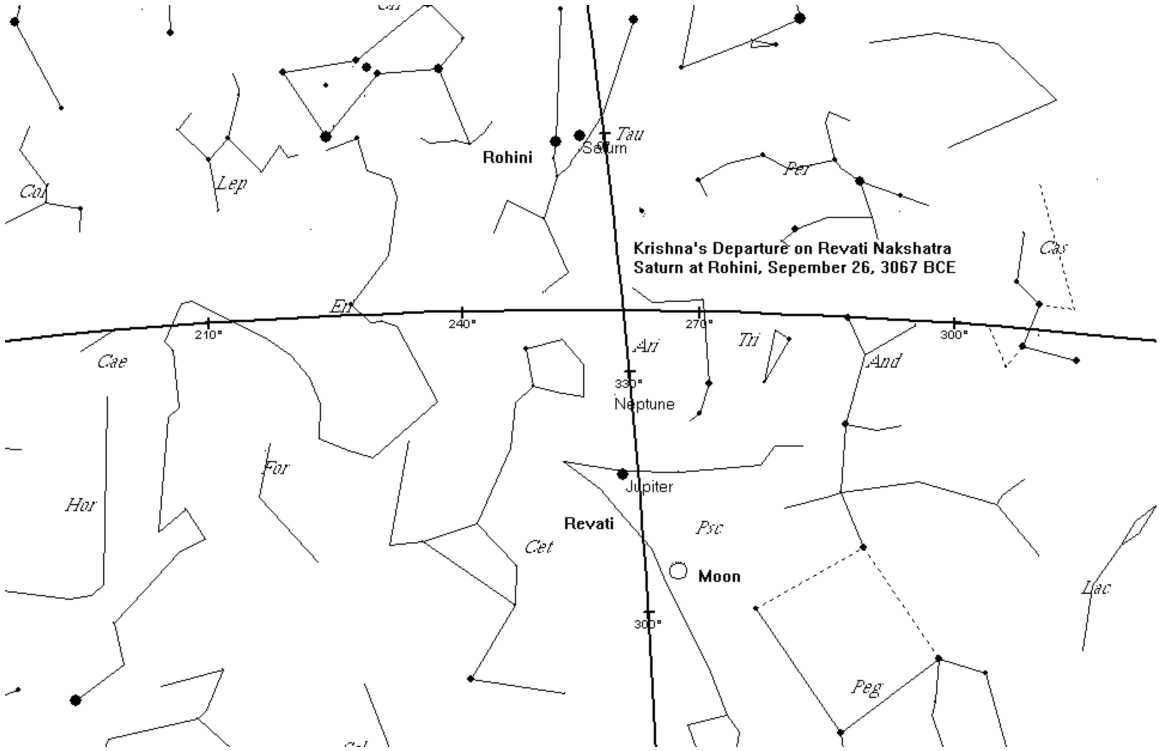

Figure 3. ***Kṛṣṇa's*** Mission for Peace: Departure on September 26, 3067 BCE.

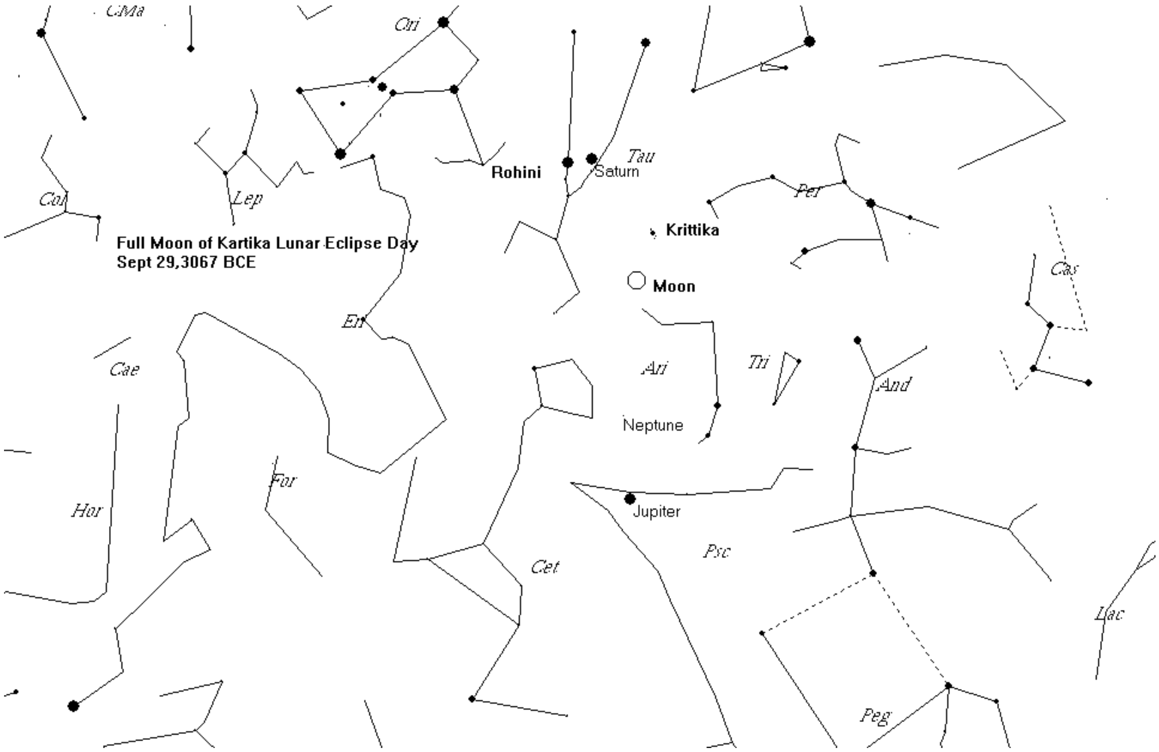

Figure 4. Full Moon of ***Kārtika.*** Lunar eclipse Day September 29, 3067 BCE

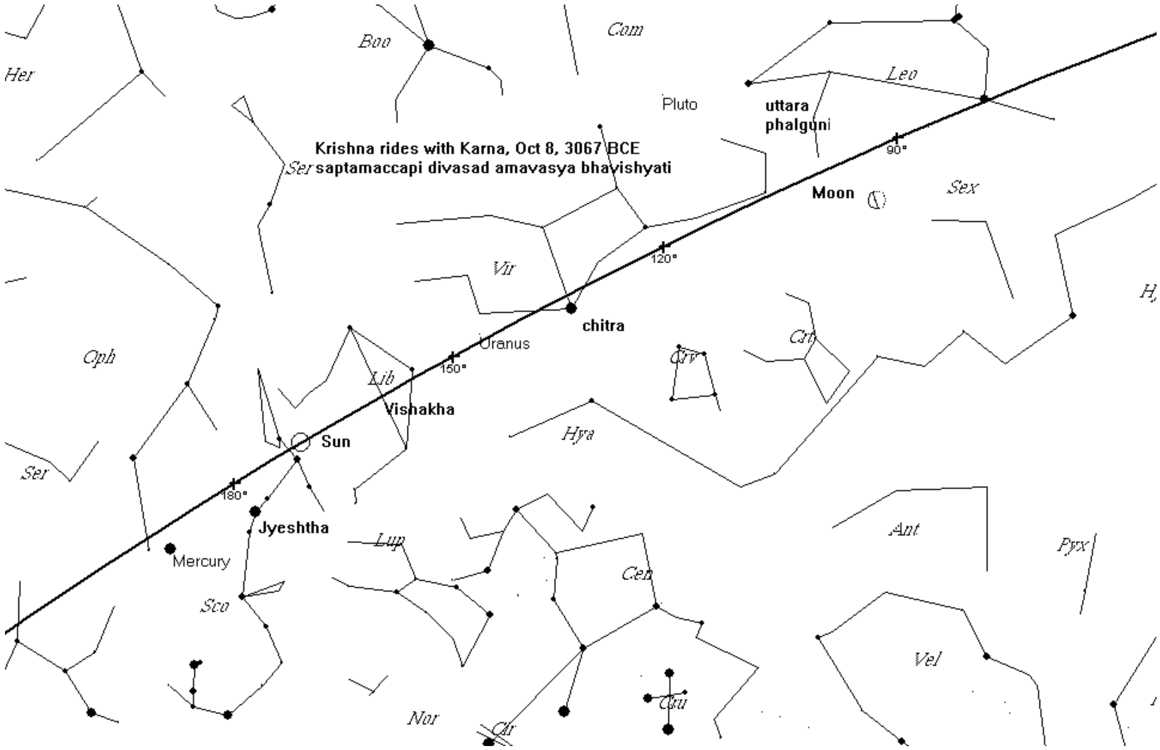

Figure 5. ***Karṇa rides with Kṛṣṇa uttara phālguni nakṣatra*** October 8, 3067 BCE

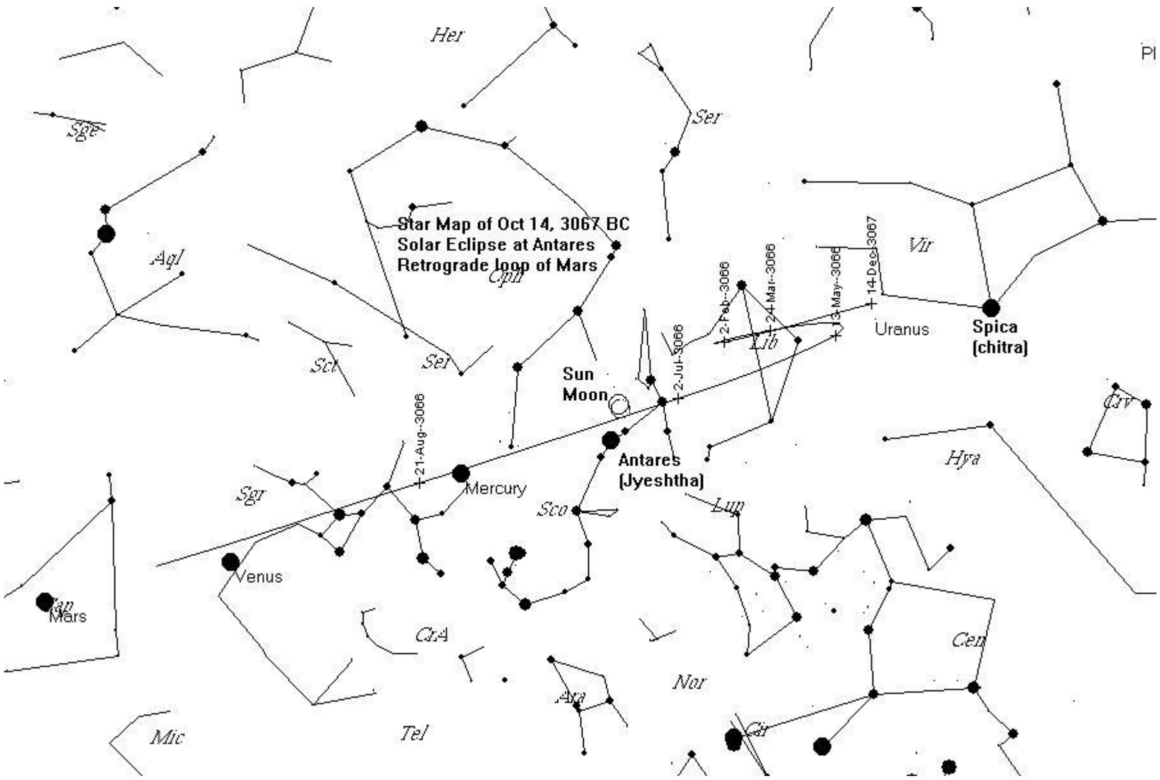

Figure 6. ***Jyeṣṭha amāvāsya*** solar eclipse day.October 14, 3067 BCE.; Retroloop of Mars

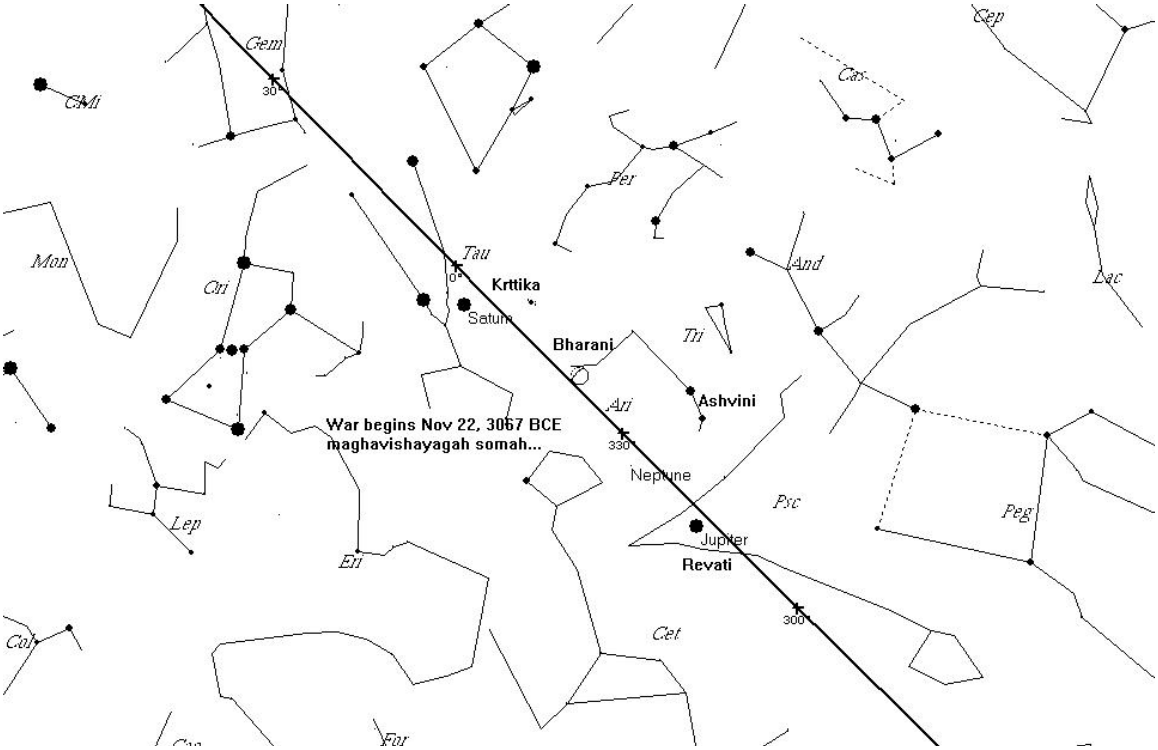

Figure 7. War begins November 22, 3067 BCE. It is ***Bharaṇi*** day

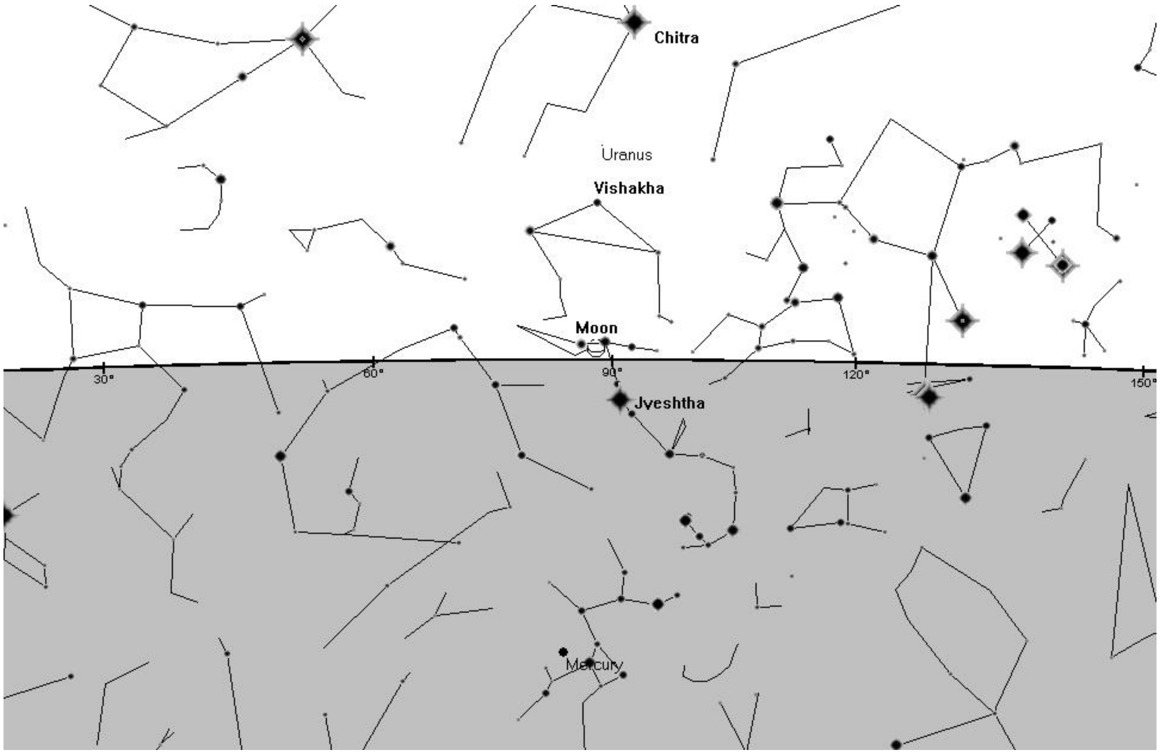

Figure 8. Fourteenth Day of War. Moon rising at 2:30 am seen just above the horizon

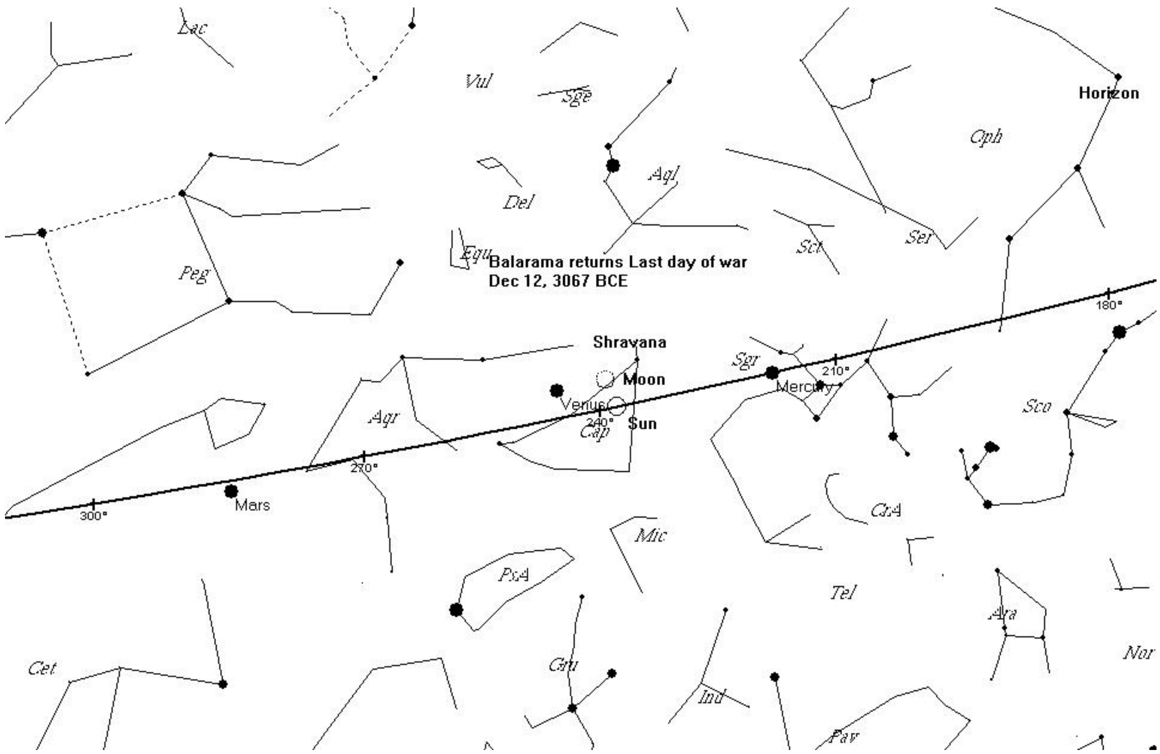

Figure 9. Last day of the war. Balarama returns on the ***śravaṇa*** Day.

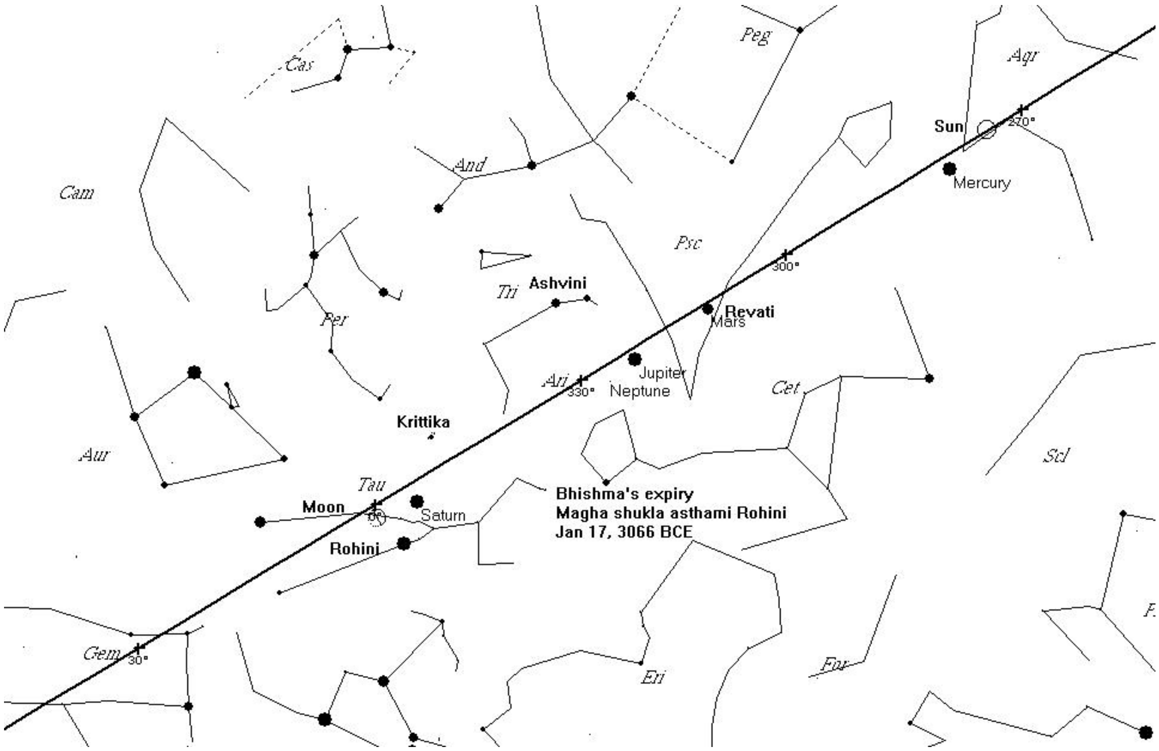

Figure 10. ***Bhiṣma's*** Expiry. ***Māgha śukla aṣṭami rohiṇi nakṣatra.*** January 16, 3066 BCE

IX. Consistency with the dates of other Vedic texts

It will be interesting to verify astronomical information contained in other Vedic texts and determine the dates based on simulations using planetarium software and to see if these dates are consistent with the date of ***Mahābhārata***.

For example, based on the astronomical information from ***Rgveda,*** Sengupta[32] inferred a solar eclipse on July 26, 3928 BCE. Figure 11 shows the star map for this date. As verified by the software RedShift, it is a central solar eclipse, which occurred two days after the summer solstice that year, as per Sengupta's conjecture. However, some caution must be exercised. As has been discussed in detail by the author, in the planetarium software, the positions of the planets and the stars are computed using the latest theories and information available and they are highly reliable. However, there are uncertainties when it comes to determining eclipses on dates extrapolated to 4000 BCE. These uncertainties which may amount to about 15 minutes when extrapolated to dates around 1000 CE, jump to more than 12 hours for the time of the occurrence of the eclipse when extrapolated to 3000 BCE, and even more when taken to 4000 BCE. The exact location of the eclipse and the exact time of visibility are uncertain, but the occurrence of the eclipse itself is certain. As a consequence, determining the date on the basis of eclipse data alone is risky. However, the eclipse data can be used as secondary information to confirm that it occurred on a particular date.

[32] Sengupta (1947) p. 120.

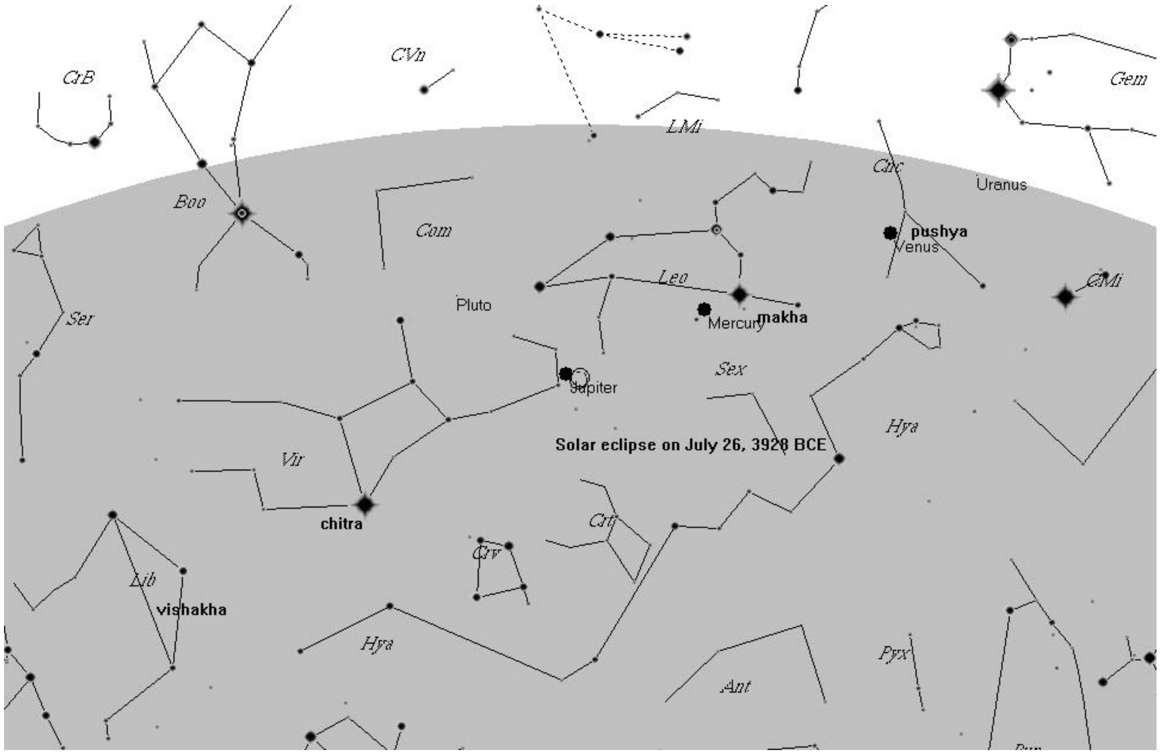

Figure 11. Solar eclipse on July 26, 3928 BCE.

However, there are other astronomical data available in the ***brāhmaṇa*** texts. As already mentioned, ***śatapatha brāhmaṇa*** refers to ***kṛttikā-*** s rising exactly in the east. On the basis of simulations using the planetarium software[33], the date of the event referred to has been shown to be 2925 +/- 100 BCE, quite in agreement with Dikshit.[34] Considering that this text is attributed to ***Yājñavalka,*** a disciple of ***Vaiśaṁpāyana***, who is an important narrator of the epic, the date of 3067 BCE for the war is consistent with the date of ***śatapatha brāhmaṇa.*** As shown[35] earlier (also on the basis of simulations using the planetarium software) that ***Lagadha***'s ***vedāṅga jyotiṣa*** should be dated to be about ~1800 BCE. The astronomy followed at the time of the ***Mahābhārata*** war is ***vedāṅga jyotiṣa***, but is very much pre-***Lagadha.*** The date of ***Lagadha'*** s ***vedāṅga jyotiṣa*** is also consistent with the date of the war. It may be noted in passing that ***śatapatha brāhmaṇa*** mentions both ***Parikṣit and Janamejaya.*** This is an independent check on the date of the war. A passage in the ***pañcaviṁśa brāhmaṇa*** (XXV. 15.3) connects ***Janamejaya*** with the ***sarpayāga*** and has been referred to by Raychaudhuri.[36] The date of a solar eclipse mentioned in the ***pañcaviṁśa brāhmaṇa*** text has been determined by Sengupta[37] to be September 14, 2451 BCE. This date is consistent with the date of the war and the date of the other ***brāhmana*** texts and confirmed by the star map for this day in Figure 12.

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[33] Narahari Achar, B. N., (2000) " On the Astronomical Basis of the Date of Satapatha Brahmana: A reexamination of Dikshit's Theory", Indian Journal of History of Science, 35(1),pp. 1-19.
[34] Dikshit, S. B.
[35]Narahari Achar, B. N., (2000), "A case for Revising the Date of Vedanga Jyotisa,", Indian Journal of History of Science, 35.3, pp 173-183.
[36] Raychaudhuri, H. C., (1923), Political History of Ancient India, University of Calcutta, Calcutta, p.10.
[37] Sengupta (1947), p.

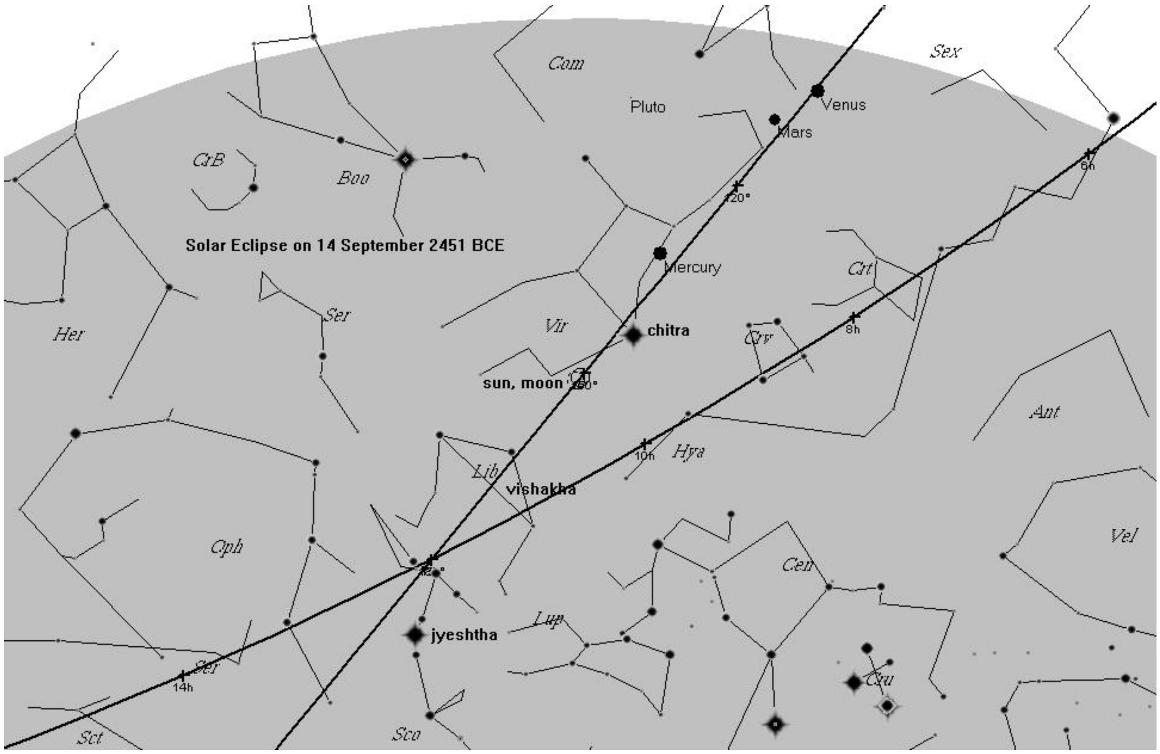

Figure 12. Solar Eclipse on September 14, 2451 BCE

.X. Conclusions

Many of the prevalent notions about Vedic astronomy have been reexamined and are found to be modified. All the ***Nakṣatra***s have been known since ***ṛgVeda***, and not just a few. There is not a chronological development in the list of ***Nakṣatra***s. The scheme of naming months on the basis of the full moon occurring near a ***Nakṣatra*** also goes back to ***ṛgVeda.*** That means the astronomical knowledge is truly ancient. A new set of identification for the Vedic ***Nakṣatra***s has been carried out. The newly identified bright stars are closer to the ecliptic and are better suited to act as markers for the paths of the sun and the moon. These ***Nakṣatras*** in conjunction with astronomical information from the Vedic texts can be used to determine the dates. The date of ***Śatapatha Brāhmaṇa*** as determined confirms Dixit's theory. A unique date for the ***Mahābhārata*** war as determined agrees with Professor Raghavan's. The date of ***Pañcaviṁśa Brāhmaṇa*** as determined by Sengupta has been confirmed and is consistent with the other dates discussed in the paper.These provide the elements of chronological background in our quest to understand the role of the river ***Sarasvati*** and its influence on Hindu civilization.

List of Abbreviations

AP *Atharvaveda Pariśiṣṭha*

MB Mahabharata Critical Edition

MNU *Mahānārāyaṇopaniṣat*

RJ *ṛgjyotiṣa*

SB *Śatapatha Brāhmaṇa*

VJ *Vedāṅgajyotiṣa*

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