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Date of *Mahābhārata* War Based on Astronomical References—A Reassessment

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Abstract

Mahābhārata, the great Sanskrit epic of ancient India, contains numerous references to celestial phenomena such as eclipses, solstices, planets and Indian calendar along with description of prevalent seasons. In the past, various scholars have worked out different dates for *Mahābhārata*, ranging from 5600 BCE to 400 BCE, often based only on a few cyclic events and on interpretations beyond what the text states. The most widely used date is determined as 32nd century BCE using the link between *Bhārata* war and the *Kali Yuga Era*. Going by this date, one finds serious contradictions with description of the corresponding seasons, location of equinoxes and many other astronomical events. This prompted us to undertake an in-depth analysis of astronomical references in *Mahābhārata* in order to determine its date accurately. Different versions of the text do exhibit self-contradictory statements leading one to believe that interpolations and modifications to the original have taken place. We have used astronomical events that are consistent with each other. These are taken from 52 verses covering 10 different *Parvas,* yielding dates, which fall in the given sequence almost with the precision of a day. The verses provide sufficient information to help locate autumnal equinox and winter solstice along with a sequence of other events including eclipses to determine a unique date of the epic. An attempt has been made to resolve the internal inconsistencies in the planetary positions pointed out by earlier scholars. Modern softwares, mainly Planetarium Gold 4.1 and Stellarium 0.10.6.1 have been used for simulation of the sky after examining their suitability for the work. In this paper, it is shown how the dates of various events described in *Mahābhārata* have fitted during earlier part of the 18th century BCE and that the Great War began on 14 October 1793 BCE (Gregorian reckoning).

Key words: Ancient Indian Astronomy, Archaeo-astronomy, Astronomical dating, Ethno-astronomy, Indian Calendar, *Kali* Era, *Mahābhārata, Uttarāyaṇa*, Winter Solstice

1. Introduction

Many Sanskrit texts of ancient India contain frequent references to astronomical phenomena (Shukla, 1987, pp. 9-14) and natural environment. Besides these, the great Indian epic *Mahābhārata* also has numerous references to celestial events. It is among the oldest Sanskrit compositions, but determining its age remains a challenge to the modern mind. Here the astronomical references in *Mahābhārata* have been examined for determining its age accurately.

1.1. The *Mahābhārata* composed by sage Vyāsa, consists of 18 *Parvas* (Volumes or books) containing over 100,000 *ślokas* or couplets. It is the longest epic poem ever written. The narration adopts a nested structure of 'story within a story'. Central to the story is the dynastic conflict between Kauravas and Pāṇḍavas leading to the Great War at Kurūkṣetra. The epic is among the most widely researched texts of ancient India and holds an extremely important position in understanding the development of culture and civilization in the

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Indian sub-continent. Researchers believe that the text was conceived/composed in three stages. *Jayā,* the original, consisted of some 8000 verses. The next, known as *Bhārata* contained 24000 verses, which continued to be expanded over time to the present versions of *Mahābhārata* containing about 100000 verses (Pandey, 1965, Preface, p. 2*; ādi parva* 1/101-109). The three versions are now inseparable in spite of serious attempts to reconstruct them from the existing version. There is evidence (Pandey, 1965, Preface, p. 2*; ādi parva* 1/101-109) that no additions were perhaps done from the first century CE. Various editions of the epic are extant in Sanskrit with translations in English and other regional languages of modern India. In this study, we have made use of the Critical Edition (Sukthankar et al., 1919-1966) and the Calcutta Edition of *Mahābhārata* and its English translation by Ganguli (Ganguli, Eng. Tr., *The Mahābhārata of Krishna-Dwaipayana Vyāsa,* 1883-1896) available online. Hereinafter, we shall refer to *Mahābhārata* as **MB.** All references to **MB** *ślokas* in this paper correspond to the Critical Edition.

1.2. Astronomical content: Dixit (1968, Part I, pp. 107-128) has summarized and discussed 65 astronomical references in **MB**. There are many more, totaling at least 150, but not all may be directly helpful in deriving the date, although they may throw some light on the state of understanding of the astronomical phenomena during that period. One may classify the references as:

- Calendric- providing details of *nakṣatra*, Moon's phases, clues to *tithi* and count of days/ nights, years and months for a given event
- Solstices, equinoxes and seasons
- Eclipses of the Sun and the Moon
- Planetary positions with reference to *nakṣatras* for astrological purpose
- Comets, Meteors and atmospheric phenomena and
- Cosmological time scales

There is no mention of the 12 *rāśis* (the Indian zodiacal constellations) in **MB**.

1.3. Earlier work on dating MB: There is a wide range of dates worked out earlier for **MB** using astronomical references. Āryabhaṭa's (5th century CE) calculation of *Kali* era beginning seems to inspire many determinations placing the date around 3000 BCE. Others are clustered around 1500 BCE and 800 BCE. The recent ones include 1478 BCE by Iyengar (2003) and 3067 BCE by Achar (2003). Iyengar (2003) has handled the most challenging part of the astronomical references in the epic, namely, the description of planets in *Bhishma Parva* in an ingenuous manner constraining the same with eclipse references. The diversity in the determinations by various authors is the result of (i) scanty coverage of events that are cyclic without putting proper constraints such as imposed by equinox or solstices (ii) ambiguous interpretation of the verses (iii) random selection of events belonging possibly to different layers of time in the available text.

In this study, we picked up 52 verses containing references to astronomical phenomena described in *Parvas* 1, 3, 4, 5, 6, 8, 9, 12, 13 & 16 of **MB**. These events hold important clues to the time of their occurrence. Interpolations or modifications to the original astronomical statements are not ruled out. Although, we have attempted to include maximum number of available references in our analysis, but if a given statement does not at all fit into the scenario, we have given our reasons to exclude it. As far as possible, we have tried to include the references related to the main characters in the story ignoring the general statements in the form of astronomical principles that may have come down as legends.

We have applied latest computations of eclipses, general precession and planetary orbits to identify the events in these verses. We have used modern computer software to simulate the sky to verify the events and determine their time of occurrence. We use BCE (Before Common Era) and CE (Common Era) notations. The year 1 BCE is followed by the year 1 CE. Where we used astronomical notation with a minus sign before the year instead of BCE, the year 0 corresponds to 1 BCE, year -1 corresponds to 2 BCE and so on. *All dates with BCE or CE suffixes, mentioned in this paper are in Gregorian reckoning unless otherwise stated.*

2. Modern Tools of Investigation

Computer software, commonly known as planetarium software, has replaced tedious astronomical computations during the past two decades for simulating the sky on home computers. The time simulated by most of these software can be set at any point up to a few thousand years in the future or past to generate views of the sky. The input data on planetary orbits used by most of these software provide positional accuracies of 0.1 arcsec to 1 arcminute within a few thousand years of the present day (2000 BCE to 6000 CE). We have further examined the uncertainties in these software packages as discussed below.

2.1. Sky Simulation Software: We list below some commonly available software packages for generating the sky views over any place and time:- *Stellarium, Planetarium Gold, Celestia, Voyager, SkyMap Pro, Starry Night, Cartes du Ciel, Digital Universe Atlas, RedShift, TheSky, Universe Sandbox, XEphem* etc. The accuracy of given software would depend on the input data and the computing schemes used by it. In order to ensure their suitability for this study, we examined the software Stellarium (0.10.6.1)[1] and Planetarium Gold (4.0/4.1).[2] These programmes claim to make use of high precision data on positions of stars from HIPPARCOS[3] Catalogue published by the European Space Agency and the Guide Star Catalog (GSC) (Lasker, et al. 1990) of the Association of Universities for Research in Astronomy (USA). One expects accuracies of at least 1 arc-second in star positions over the entire precession cycle. They claim to compute orbital data and solar system ephemeris based on one of the following: DE200/HORIZONS[4] of JPL, NASA, USA and VSOP87 (Bretagnon & Francou, 1988) of France. Stellarium (Stel) is a kind of public domain software with a Free Documentation License and provides information on its precision. It calculates the variation in position of the planets over time by using VSOP87 method. It claims the precision as 1 arc-second for Mercury, Venus, Earth-Moon barycenter and Mars over the years -2000 to +6000 and the same precision for Jupiter and Saturn over the year 0 to 4000.

Planetarium Gold (Pl G) includes star positions based on Guide Star Catalog from NASA. It provides limited information about the precision obtained. Therefore, we made a comparative study by simulating the time of astronomical event of Vernal Equinox (VE) over New Delhi (28°.614 N, 77°.209 E) over the past 5000 years by determining the instant when both programme codes show Sun's Right Ascension (RA) as zero. We also recorded position of five naked-eye planets and the Moon at those instants as shown by the two programmes. We give the results in Table 1(A) and Table 1(B) below.

From Table 1 (A) and (B), we find that the date of Vernal Equinox remains nearly fixed around 21–22 March in Planetarium Gold over millennia; it keeps drifting in Stellarium from 21 March during 2015 – 1583 to 17 April in -3000. One can thus infer that Planetarium Gold uses the

[1] Stellarium User Guide, Matthew Gates, Free Software Foundation Inc., Boston, USA (2009)

[2] *Planetarium* User Manual, JC Research Inc., (1997-2001).

[3] http://archive.ast.cam.ac.uk/hipp/hipparcos.html

[4] http://ssd.jpl.nasa.gov/?horizons

Table 1(A). Comparison between Stellarium and Planetarium Gold results

Event: Vernal Equinox (sun's RA = 00h 00m.00)				Right Ascension (RA)							
Stellarium (Stel)		Planetarium Gold (Pl G)		Mercury		Venus		Mars			
Date d m y	Time h m s	Date d m y	Time h m	Stel h m s	Pl G h m	Stel h m s	Pl G h m	Stel h m s	Pl G h m		
21.3.2015	04 08 00	21.3.2018	04 08	22 57 59	22 57.9	02 07 34	02 07.5	01 21 04	01 21.6		
21.3.1583	11 27 48	21.3.1583	11 30	00 59 46	00 59.8	00 13 45	00 13.8	07 00 31	07 00.5		
11.3.1582#	05 30 48	21.3.1582	05 30	00 07 50	00 07.8	02 47 00	02 47.0	21 52 47	21 52.8		
10.3.1581	23 43 48	21.3.1581	00 00	23 11 35	23 11.6	21 57 23	21 57.4	05 29 06	05 29.2		
23.3.0001	10 13 48	21.3.0001	06 00	22 40 17	22 39.7	00 32 44	00 33.9	03 37 57	03 38.2		
31.3(-) 1000	07 37 50	20.3(-) 1000	22 15	22 26 15	22 25.8	02 46 26	02 46.4	00 19 17	00 19.7		
08.4(-) 2000	15 00 50	21.3(-) 2000	22 15	22 32 42	22 31.7	22 46 52	22 45.9	04 20 57	04 21.6		
17.4(-) 3000	01 50 50	22.3(-) 3000	00 30	22 41 37	22 39.7	02 46 38	02 46.0	16 33 05	16 34.5		

Table 1(B). Comparison between Stellarium and Planetarium Gold results[5]

Event: Vernal Equinox (sun's RA = 00^h 00^m.00)				Right Ascension (RA)					
Stellarium (Stel)		Planetarium Gold (Pl G)		Jupiter		Saturn		Moon	
Date d m y	Time h m s	Date d m y	Time h m	Stel h m s	Pl G h m	Stel h m s	Pl G h m	Stel h m s	Pl G h m
21.3.2015	04 08 00	21.3.2015	04 08	09 03 35	09 03.4	16 13 24	16 14.2	00 30 26	00 29.9
21.3.1583	11 27 48	21.3.1583	11 30	22 51 00	22 50.8	23 09 38	23 10.5	21 42 31	21.44.8
11.3.1582#	05 30 48	21.3.1582	05 30	21 02 09	21 02.1	22 28 35	22 29.2	12 52 45	12 51.5
10.3.1581	23 43 48	21.3.1581	00 00	19 01 56	19 02.0	21 47 02	21 47.5	04 42 07	04 44.7
23.3.0001	10 13 48	21.3.0001	06 00	12 23 47	12 23.3	04 38 34	04 43.1	07 51 58	07 42.8
31.3(-) 1000	07 37 50	20.3(-) 1000	22 15	02 02 23	02 02.4	04 15 58	04 22.0	16 32 44	16 19.5
08.4(-) 2000	15 00 50	21.3(-) 2000	22 15	18 44 03	18 43.6	04 47 58	04 55.3	11 17 30	10 46.5
17.4(-) 3000	01 50 50	22.3(-) 3000	00 30	09 30 43	09 32.6	05 18 19	05 24.9	05 07 22	04 04.4

#see note 5.

tropical length of the year, resulting in calendar dates that remain almost fixed with reference to seasons. On the other hand, Stellarium seems to use Julian calendar dates before 1582, the year of Gregorian calendar reform, resulting in longer year. The calendar dates in Stellarium in remote past would not indicate the same season as they do now, but may conform to the Julian calendar dates used before 15 October, 1582. However, one must take into account the fact that Gregorian reform was enforced in different parts of the world on different dates.

Table 1 (A) and (B) further show that the difference in position (RA) of planets computed by the two programmes for the common instant of Vernal Equinox gradually increases as we go back in time. Mercury, Venus, Mars and Jupiter differ by about $\pm 1^m$ and Saturn by about 7^m by the year -3000. Moon's position, however, differs by 31^m in -2000 and 63^m by -3000. Notably, we find

[5] In the reformed (Gregorian) calendar, October 15 followed October 4, 1582, skipping 10 days. Pl G does not have this discontinuity in its dates.

that Moon's RA at the common events of full moon and new moon shown by the two programmes differs very little, eg. at the full moon on September -1792, it differs by $2^m.2$ and at the new moon in October -1792 by $2^m.5$ only. Both software will thus show the *Nakṣatra* of the Full Moon and the New Moon phases accurately. They may differ by ±1 *Nakṣatra* for other phases if we go before the year -3000. As we are dealing with references in the epic to such conjunctions and positions in the background of *Nakṣatra*, each spanning more than 13° in the sky, the above uncertainties in the computed positions are not serious. In any case, the simulations would be far more accurate than the manual computations tried during the past two centuries to determine the date of **MB**.

We have simulated various events narrated in **MB** using Planetarium Gold 4.1 as it indicates the prevailing season directly with its tropical calendar dates throughout. We have crosschecked the sky configuration with Stellarium 0.10.6.1 wherever necessary.

3. Time of *Mahābhārata* War

3.1. Kali Era and *Mahābhārata*

There are many internal references to *Kali Yuga* in MB (1.2/9, 3.148/37, 9.59/21), for example,

> *antare caiva saṃprāpte kalidvāparayor abhūt|*
> *samantapañcake yuddhaṃ kurupāṇ dvasenayoḥ||*
>
> **MB** 1.2/9
>
> 'In the interval between the *Dwapara* and the *Kali Yugas*, there happened at Samanta-pañcaka the encounter between the armies of the Kauravas and the Pāṇḍavas'.
>
> *prāptaṃ kaliyugaṃ viddhi pratijñāṃ prāṇḍavasya ca|*
>
> *ānṛṇyaṃ yātu vairasya pratijñāyāś ca pāṇḍavaḥ||*
>
> **MB** 9.59/21
>
> 'Know that the *Kali* age is at hand. Remember also the vow made by the son of Pandu! Let, therefore, the son of Pandu be regarded to have paid off the debt he owed to his hostility and to have fulfilled his vow!'

The references at **MB** (16.1/1, 16.2/2, 16.3/18, 16.5/21,22, 3.148/37 and 9.59/21) describe destruction of Vrishnis and *Mahānirvāna* of Kṛṣṇa in the thirty-sixth year after the war, an event identified with the beginning of *Kali Yuga.* However, by itself this information does not give any clue independently about the times of both **MB** and the beginning of *Kali Yuga*.

Āryabhaṭa (Sharma, 2008, *Gītikāpāda*.5, p.23; *Kālakriyāpāda*.10, p. 153) (499 CE) mentions the time elapsed since the beginning of the *Kalpa* upto the time the *Bhārata* battle ended. He also states that 3600 years of *Kali* had elapsed when he composed *Āryabhaṭīyam* at the age of 23 years. Dixit (1968, Part II, p. 55) has worked out the time of *Āryabhaṭīyam* as 421 Śaka or 499 CE. The year of *Kali* era beginning thus works out as 3102 BCE. Saha and Lahiri (1955) have shown that Āryabhaṭa defined the above *Kali* Era beginning based on the assumption of a grand conjunction of the Sun, the Moon and five planets at the initial point of *Meṣa* (Aries). Āryabhaṭa made calculation of the same using the planetary elements then known to him. In reality, such conjunction did not occur and his date of *Kali* Era beginning is only a mathematical extrapolation. However, it has become part of Indian astronomical tradition over the centuries to compute time (*Ahargana*) just like the Julian Day numbers in modern astronomy. We have shown further under Section 5 that close passes of bright planets are not very rare. Such an assemblage in the past may not serve as a unique identifier for the *Kali Yuga* beginning. Nevertheless, we examined the dates around the year 3102 BCE to 3140 BCE to verify the events, both astronomical and related to seasons (equinox), but came across contradictions as discussed below.

3.2. Seasons and their variation with sidereal Luni-solar calendar

The calendar used in **MB** is clearly the sidereal type deriving the names of the lunar months from the *nakṣatra* (asterism) in which the full moon of the month is seen to occur. We know that the equinoxes and the solstices, and consequently the seasons, keep slowly shifting with reference to the dates of the sidereal (*Nirāyaṇa)* luni-solar Indian calendar due to general precession. We have seen under Section 2.1 above that dates of equinoxes and solstices and consequently the seasons remain nearly constant over millennia in the 'Planetarium Gold' software because of tropical length of the year of its calendar.

This helps us to connect the dates used in this software directly with the seasons in the remote past, unlike other similar software that use Julian calendar before the Gregorian reform (effective 15 October 1582 CE). In **MB***,* the following verses from *Vana Parva* highlight vividly the connection between 'autumn' and Kārtika month during Pandavas' *Vanavāsa* (exile) period, especially the description of Kārtika full moon. A modern astronomer can appreciate the description of post monsoon, dust free sky in northern India for a short period in autumn, when 'astronomical seeing conditions' are the best.

tathā bahuvidhākārā prāvṛṇ meghānunāditā|
abhyatītā śivā teṣāṃ caratāṃ marudhanvasu|| 9 ||

krauñca haṃsagaṇākīrṇā śara tpraṇihitābhavat|
rūḍdha kakṣavanaprasthā prasannajalanimnagā|| 10 ||

vimalākāśa nakṣatrā śaratteṣāṃ śivābhavat|
mṛgadvijasamākīrṇā pāṇḍavānāṃ mahātmanām|| 11 ||

paśyantaḥ śāntarajasaḥ kṣapā jaladaśītalāḥ|
grahanakṣatrasaṃghaiś ca somena ca virājitāḥ|| 12 ||

teṣāṃ puṇyatamā rātriḥ parva saṃdhau sma śāradī|
tatraiva vasatām āsīt kārtikī janamejaya|| 16 ||

MB 3.179/9,10,11,12,16

'Thus while the Pāṇḍavas were roaming about in the deserts and sandy tracts, the happy season of rain, so various in aspect and resounding with clouds passed away. Then set in the season of autumn, thronged with ganders and cranes and full of joy; then the forest tracts were overrun with grass; the river turned limpid; the firmament and stars shone brightly, and the autumn, thronged with beasts and birds, was joyous and pleasant for the magnanimous sons of Pandu. Then were seen nights, that were free from dust and were cool and beautified by myriads of planets and stars and the moon'.

'And, O Janamejaya, the holiest night that of the full moon in the month of Kartika in the season of autumn was spent by them while dwelling there!'.

Then, the verse below from *Udyog Parva* on Kṛṣṇa's peace mission to Hastinapur to avert the war gives the month as Kaumuda *(*Kārtika*)*, under Revatī *Nakṣatra* and the season in transition from autumn to winter.

kaumude māsi revatyāṃ śarad ante himāgame|
*sphītasasya sukhe kale kalyaḥ sattvavatāṃ varaḥ||*7||

MB 5.81/7

'In the month of Kaumuda (Kārtika), under the Revatī constellation, after the passing away of autumn, and in the dewy season, and at a time when the earth had an abundance of crops on it, that foremost of men of prowess…'

We tried to simulate the sky for the years -3101 to -3137 (36 years) to see whether the events mentioned in **MB** 3.179/16 and 5.81/7 could be reproduced to establish a connection of the war with the dates of *Kali Era* in use today. In the year -3101 (3102 BCE), *Kārtika Purnima* occurred on 31 August (**Fig. 1**) and Revatī *Nakṣatra* on 29

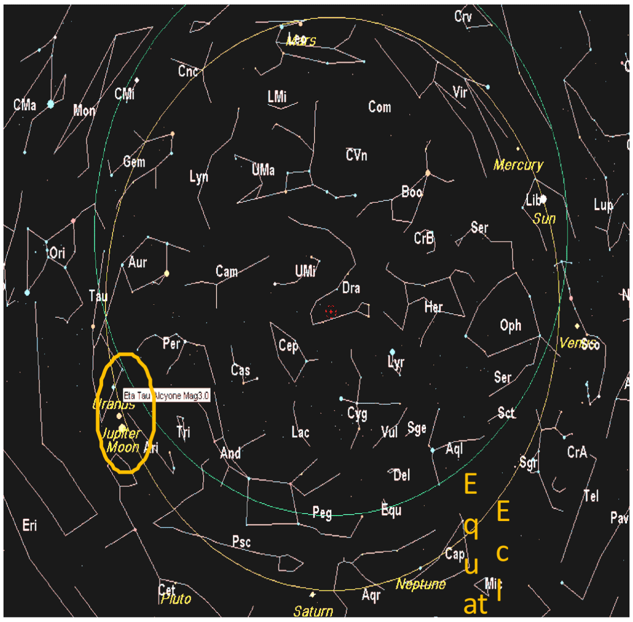


Fig. 1. In 3102 BCE, Kārtika *Pūrṇimā* occurred on 31 August in the rainy season around Delhi. The Moon (RA 22h40.3m Dec -10° 35′) is seen in Kṛttikā (η Tau). Moon passed Revatī *Nakṣatra* (ζ Psc) 2 days before that, on 29 August. The Sun (RA 10h40.4m Dec+8°24′) would reach Autumn equinox 21 days later on 21 September. (Full ecliptic view at 07:46 Hrs)

August, which fall in the rainy season over Delhi-Hastinapur region. In the year 3138 BCE, Revatī *Nakṣatra* occurred on 5 September **(Fig. 2)**, when the Sun was nearly 16º behind autumnal equinox (AE), whereas it should be in AE or beyond it as per the description of the prevailing season. Therefore, we find a clear 'disconnect' between the *Bhārata* war and the years 3102 and 3138 BCE, which relate to *Kali* Era. Similarly, many other astronomical events described in the text do not match with the MB description for 3102 BCE, as discussed further under Section 5.

3.3. Autumn-Kārtika link as indicator of Equinox position

We analyze here in detail the Kārtika-Autumn relation described in **MB** 5.81/7 and 3.179/11, 16 above. We know that on Kārtika *Pūrṇimā*, the Moon is located in Kṛttikā *Nakṣatra* (*η* Tauri) and the Sun should be found exactly

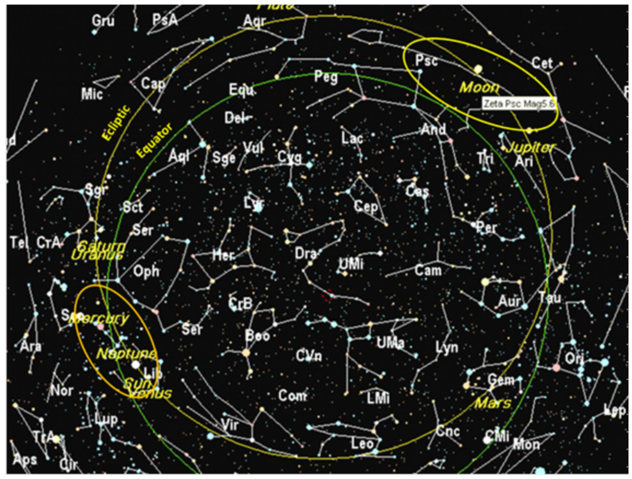


Fig. 2. In 3138 BCE, Moon (RA 20h32.5m Dec -20° 17) passed Revātī *Nakṣatra* (ζ Psc) in Kārtika month on 5 September, before the Autumn season. The Sun (RA 10h57.6m Dec +6° 39') was 16 degrees away from the Autumnal Equinox (Full ecliptic view at 02-30 Hrs)

opposite, i.e., between Anurādhā (δ Scorpii) and Visākhā (η Librae) *Nakṣatras*. The autumn season implies that the Sun was located in or close to autumnal equinox (AE). This fixes the position of the AE between Visākhā and Anurādhā*,* which occurred on 22 September 1768 BCE (**Fig. 3**). AE

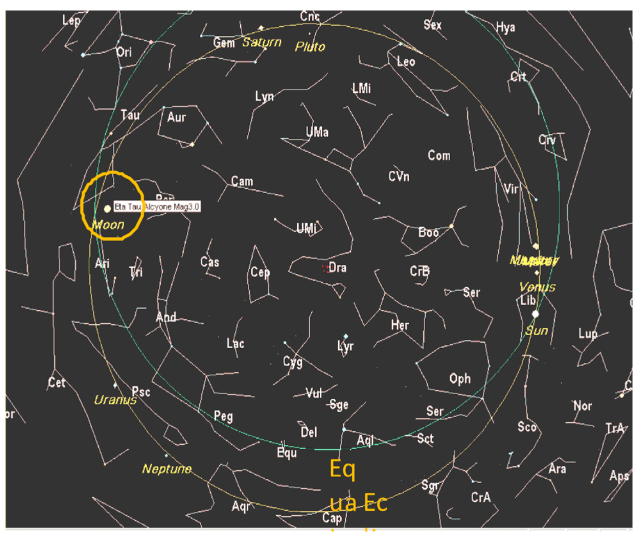


Fig. 3. Kārtika *Purṇima* (Kṛttikā *Nakṣatra*-ηTau) occurred on Autumnal equinox day on 22 September 1768 BCE. (Sun's RA 12h, Moon's RA 00h). (Full ecliptic view at 10:50 Hrs)

would remain in one *Nakṣatra* for about 960 years. This limits the period of our search roughly from the year -2250 to -1280. Beyond these limits, Kārtika month of sidereal luni-solar Indian calendar begins to lose its connection with autumn season and the corresponding tropical calendar dates.

3.4. Winter Solstice location and Precession of Maghā (α Leonis)

The following verse from both, the Critical Edition as well as the Calcutta Edition (Sanskrit online) shows directly the relation between Winter Solstice and the Śraviṣṭhā (Dhaniṣṭhā) *Nakṣatra*. It also clearly states that the months begin with the bright half meaning that they are *Amanta*.

ahaḥ pūrvaṃ tato rātrir māsāḥ śuklādayaḥ smṛtāḥ|
śraviṣṭhādīni ṛkṣāṇi ṛtavaḥ śiśirādayaḥ |2|

MB 14. 44.2

It has been said that the day was first, then arose night. The months are said to have the lighted fortnights first. The constellations have Śraviṣṭha for their first; The seasons have that of dews, viz., winter for their first.

Our simulations show that winter solstice occurred in Śraviṣṭhā (Dhaniṣṭhā) *Nakṣatra* during the period 2250 to 1280 BCE, its principal star identified as β Delphini being at the beginning of the *Nakṣatra* division. *Vedāṅga Jyotiṣa* mentions the same location of the winter solstice (WS). This location is quite consistent with the location of Autumnal equinox arrived earlier.

We find the next important set of verses (**MB** 13.152/10, 13.153/5, 6, 26, 27, 28 and 12.47/3) that link the winter solstice (WS) with the luni-solar calendar in the following descriptions about demise of Bhishma Pitamaha:

āgantavyaṃ ca bhavatā samaye mama pārthiva|
vinivṛtte dinakare pravṛtte cottarāyaṇe||10||

MB 13.152/10

'When the hour comes for my departure from this world, do thou come here, O king. The time when I shall take leave of my body is that period when the sun, stopping in his south-ward course, will begin to return northwards!' …

uṣitvā śarvarīḥ śrīmān pañcāśannagarottame|
samayaṃ kauravāgryasya sasmāra puruṣarṣabhaḥ||5||

saniryayau gajapurādyājakaiḥ parivāritaḥ|
dṛṣṭvā nivṛttamādityaṃ pravṛttaṃ cottarāyaṇam||6||

MB 13.153/5,6

'The blessed monarch (Yudhishthira) having passed fifty nights in the capital recollected the time indicated by his grandsire as the hour of his departure from this world. Accompanied by a number of priests he then set out of the city named after the elephant, having seen that the sun ceasing to go southwards had begun to proceed in his northward course.'

diṣṭyā prāpto'sikaunteya sahāmātyo yudhiṣṭhira|
parivṛtto hi bhagavānsahasrāṃśur-divākaraḥ||26||

mā̄gho'yaṃ samanuprāpto māsaḥ saumyo yudhiṣṭhira|

tribhāgaśeṣaḥ pakṣo'yaṃ śuklo bhavitumarhati||28||

MB 13.153/26,28

'That thorough master of words (Bhishma) said, 'By good luck, O son of Kunti, thou hast come here with all thy counsellors, O Yudhiṣṭhira! The thousand-rayed maker of day, the holy Surya has begun his northward course.'

'O Yudhiṣṭhira, the lunar month of Māgha has come. This is, again, the lighted fortnight and a fourth part of it ought by this (according to my calculations) be over.'

nivṛttamātre tvayana uttarevaidivākare|
samāveśayadātmānamātmanyeva samāhitaḥ||3||

MB 12.47/3

…the high-souled Bhiṣma cast off his body. 'As soon as the Sun, passing the solstitial point, entered in his northerly course, Bhiṣma, with concentrated attention, caused his soul to enter its independent and absolute state'.

This statement of Bhishma that 3/4th part of Māgha month was still remaining and that it was the bright half of the month (*Śukla Pakṣa)* explicitly shows that the lunar months were New-Moon-ending (*Amanta*) in **MB** time. The months began with the *Śukla Pakṣa* is also stated directly in MB 14.44/2 given under this Section above. There is another verse in the context of *Śrādha* that is interpreted by many as *Amāvasyā* falling in the middle of the month.

māsārdhe kṛṣṇapakṣasya kuryān nivapanāni vai |

MB 13.92.19

Since it is inconsistent with the other more direct statements, we have not considered it.

From the above references, it can be observed that Bhiṣma Pitāmaha left this world on or immediately after the winter solstice (WS) day. It can also be inferred that since the Moon was in its first-quarter phase in *Amānta* Māgha*,* the *Nakṣatra* was Rohinī (α Tauri) and the *tithī* (lunar date) was Māgha *Śukla Aṣṭamī,* (with an uncertainty of one *tithī*). Now, we know that the Sun's longitude at WS is 270º. Therefore, longitude of the Moon on *Śukla Aṣṭamī* day should be 354 º to 366º (6º), ie, around vernal equinox. At the epoch 1950.0, the longitudes of the stars α Tauri (Rohinī) and α Leonis (Maghā) were 69º.1 and 149º.13 respectively. They are about 80º apart in longitude. Again, it being the month of Māgha*,* the full moon would occur in Maghā *Nakṣatra* (α Leonis), seven days after *Aṣṭamī* when the longitude of the Sun would be about 277 º and that of the full moon and α Leonis 97º. Since the difference of about 80º between the longitudes of the two stars remains more or less constant, the longitude of α Tauri works out to about 17 º at the time of Bhisma's demise. Thus, vernal equinox would be between Bharanī (41 Ari) and Kṛttikā (η Tauri), 17 º behind α Tauri. Further, the change in the longitude of α Leonis, from 97º in **MB** time to 149º in 1950.0, arises due to precession. Occurring at the rate of 50″.3 per year, this change of about 52º takes 3722 years. Thus, we arrive approximately at the year 1773 BCE. We looked around this year for other evidence.

3.5. Eclipses

The next important clues come from description of eclipses in the following:

caturdaśīṃ pañcadaśīṃ bhūtapūrvāṃ ca ṣoḍaśīm|
imāṃ tu nābhijānāmi amāvāsyāṃ trayodaśīm||28||

candrasūryāv ubhau grastāv ekamāse trayodaśīm |
aparvaṇi grahāv etau prajāḥ saṃkṣapayiṣyataḥ||29||

MB 6.3/28,29

'A lunar fortnight had hitherto consisted of fourteen days, or fifteen days (as usual), or sixteen days. This, however, I never knew that the day of new-moon would be on the thirteenth day from the first lunation, or the day of full-moon on the thirteenth day from the same. And yet in course of the same month both the Moon and the Sun have undergone eclipses on the thirteenth days from the day of the first lunation.'

The above verse mentions occurrence of a pair of solar and lunar eclipses in the same month at an interval of 13 days. The eclipse canons published by NASA [Espenak and Meus (2009)], provide circumstances and maps of all eclipses of the Sun and the Moon from -1999 to +3000. Our period of interest is -2250 to -1280, as determined above. We searched the tables from the beginning (-1999) going up to -740 to cover wider period.

These canons base the predictions on the latest ephemerides of the Sun and the Moon and are an improvement over the previous eclipse canons. Their accuracies on eclipses are superior to those of sky simulation software discussed above. These publications provide full details about the basic data used for computing the eclipses and the uncertainties in the predictions due to various factors such as the variations in the rotation of the Earth (leading to uncertainties in the values of ΔT) and the Moon's distance due to its secular acceleration. Due to inherent uncertainties in the predictions, the observed times, magnitude and area of visibility of the **MB** eclipses may differ slightly from the predicted ones within the specified limits. For this reason, it is not possible to verify the statement about the 13-day interval between eclipses described in **MB.** Such occurrence is possible because of large perturbations of the Moon's orbit by the Sun resulting in variation in the length of the lunation. Moreover, the interval is in terms of civil days only ignoring the fractions. A recent example is the pair of solar and lunar eclipses that occurred[6],[7] on Apr 30, 1957 and May 13, 1957 respectively. In our search, we found 75 suitable pairs of eclipses over the period out of which, we were to select the one that matched the description in **MB** and was not far from the year -1773 determined above using precession. The major criteria for selection were that the winter solstice in the year should fall on Māgha *Śukla Aṣṭamī* (±1) and the eclipses should have occurred well before the WS to allow time for the war to take place and for Bhishma's departure after the Sun turns north on the WS day. Out of the above, the events[8,9] that meet the criteria fully are the **Solar Eclipse** of **Apr 19, -1792** {Julian May 4, -1792} and **Lunar Eclipse** of **Apr 05 -1792** {Julian Apr 20, -1792}, visible over Kurukshetra/ Hastinapur region, (**Fig. 4**). Further, Vyāsa observes in the following verse that the Kārttika full moon was lusterless.

alakṣyaḥ prabhayāhīnaḥ paurṇamāsīṃ cakārttikīm |
candro 'bhūdagnivarṇaśca samavarṇe nabhastale ||23||

MB 6.2/23

'On even the fifteenth night of the lighted-fortnight in (the month of) Karttika, the Moon, divested of splendour, became invisible, or of the hue of fire, the firmament being of the hue of the lotus'.

The above is clearly a description of a lunar eclipse. The canons of eclipses[8,9] list a partial lunar eclipse in the same year on **Sep 28, -1792** {Julian October 13, -1792}. It happens to be the day of Kārttika full moon. Planetarium Gold also shows this to occur on Kārttika *Pūrṇimā* in **(Figs. 5 & 6)**. A solar eclipse (not visible in India) follows[8,9] it on 14 Oct -1792{Julian 29 October, -1792}. These evidences fix the year of our search as -1792 (1793 BCE).

The year 1793 BCE happens to be the only year among the 75 shortlisted (based on the eclipse pairs) that satisfies the observation of winter solstice of 20 December (**Figs. 7, 8**) occurring on Māgha *Śukla Aṣṭamī* on Rohinī *Nakṣatra* day, as depicted in the verse on Bhishma's demise (**MB** 13.153/28).

Iyengar (2003) in a detailed analysis of the **MB** eclipses points to two important events from *Sabhā Parva* and *Mausala Parva*, when Pandavas proceed to exile and the eclipse in the 36th year after the war respectively. The *Sabhā parva* references could be traced in the Ganguli's translation (1883-1896, 2/79, p. 154, 2/80, p.157). The critical edition gives a different *śloka*, but

[6] Espenak and Meeus (2009), 5 M Catalog of Solar Eclipses, cat. no. 9414, p. A 159.
[7] Espenak and Meeus (2009), 5 M Catalog of Lunar Eclipses, cat. no. 9551, p. A 160
[8] Espenak and Meeus (2009), Solar Eclipse Canon, Maps 0, Plate 026; Cat. No. 512, p. A 11; Cat. No. 513, p. A 11.
[9] Espenak and Meeus (2009), Lunar Eclipse Canon, Maps 0, p. A 26; Cat no. 516, p. A 9; Cat No. 517, p. A9.

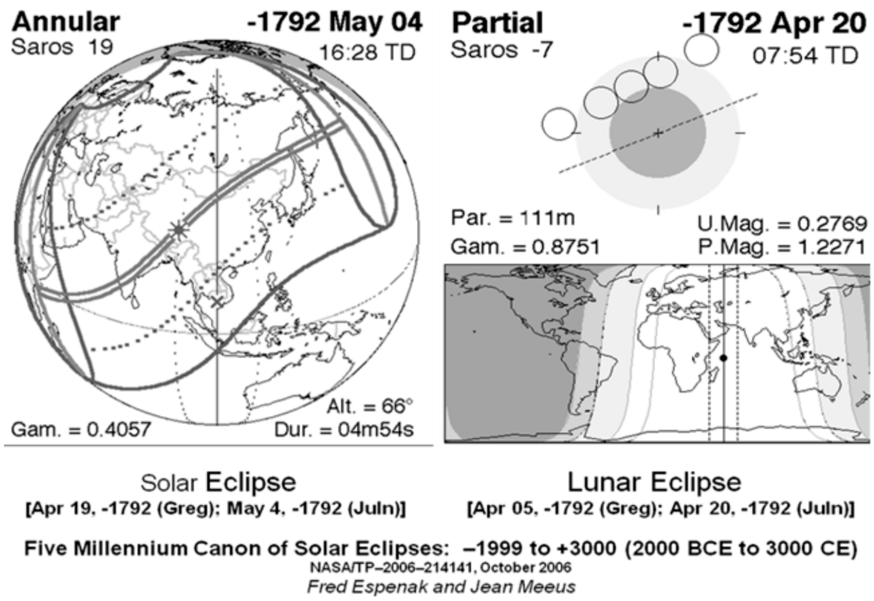


Fig. 4. The above Solar Eclipse of Apr 19, 1793 BCE and the Lunar Eclipse of Apr 05, 1793 BCE visible over Kurukshetra/ Hastinapur are the only events among 75 pairs shortlisted that satisfy other astronomical phenomena in that year described in MB

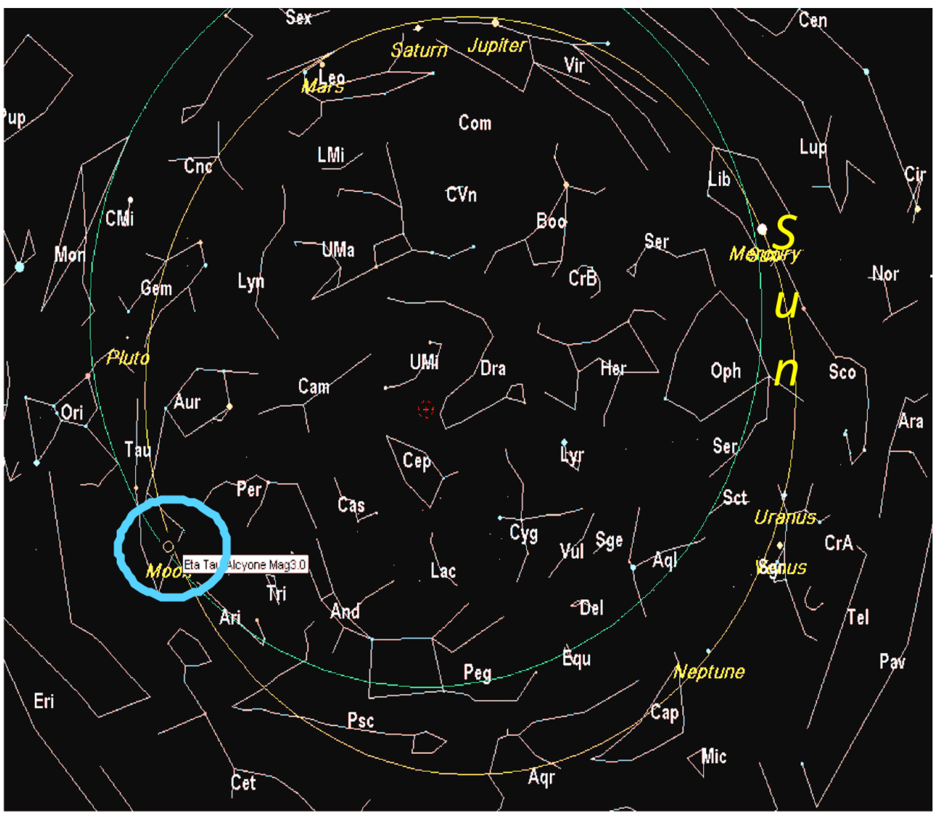


Fig. 5. Lunar eclipse on Sep 28, 1793 BCE on Karttika full moon. The Moon is located in Kṛttika *Nakṣatra* (η Tauri) and the Sun exactly opposite between Anurādhā (δ Scorpii) and Viśākhā *Nakṣatras* (α Librae) (Full ecliptic view at 22-39 Hrs)

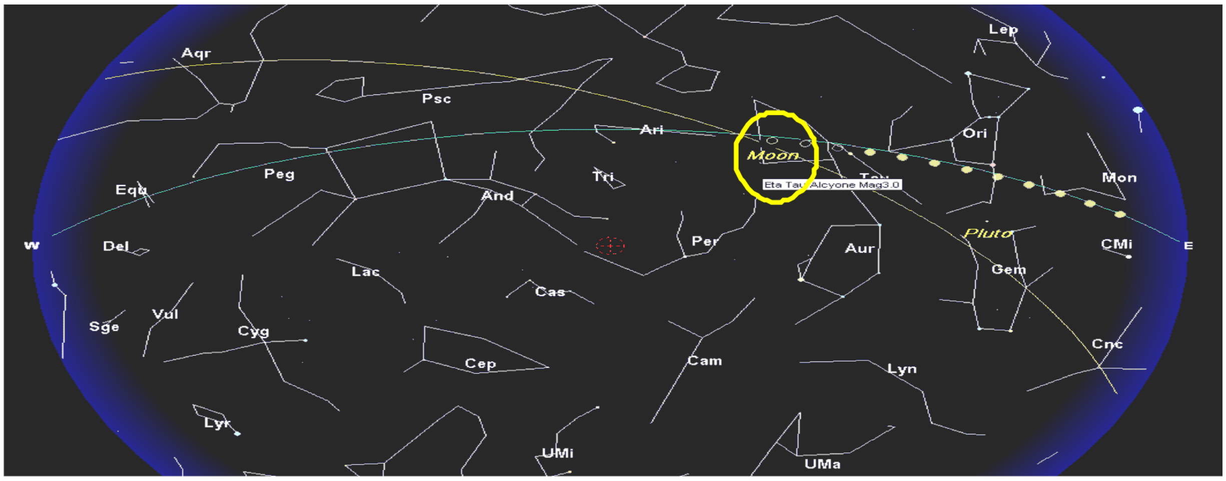


Fig. 6. Moon's trail shows Lunar eclipse on Sep 28, 1793 BCE on Kārtika full moon night in Kṛttikā *Nakṣatra* (η Tauri). (Horizon view 22-39 Hrs)

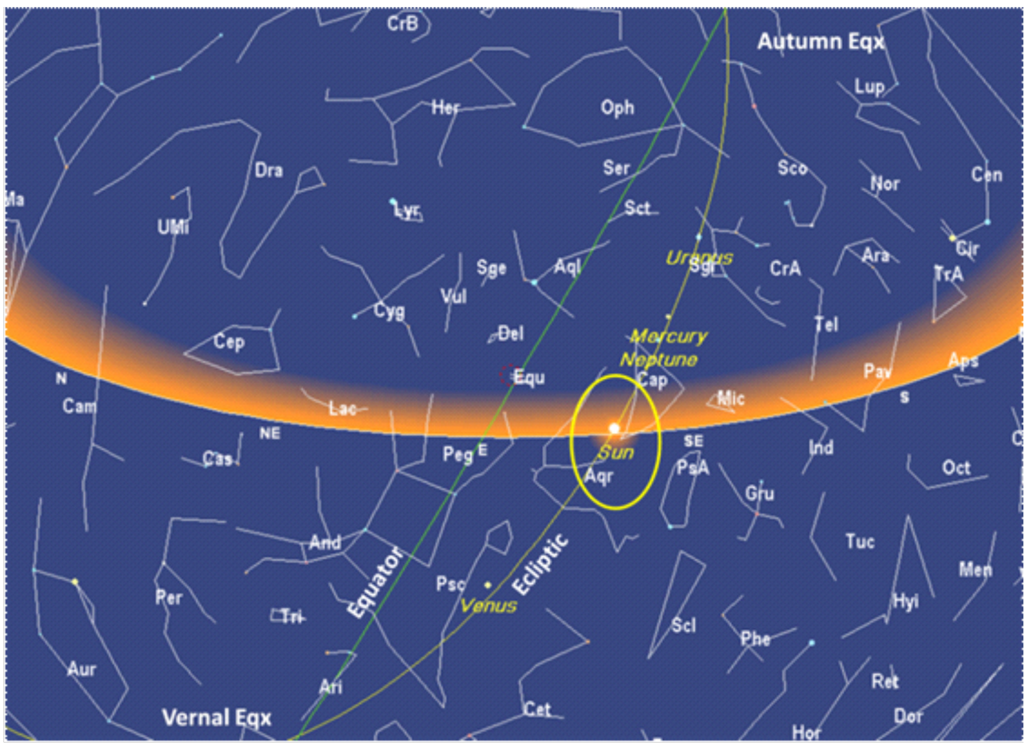


Fig. 7. Sky at sunrise time on Winter Solstice Day, 20 December 1793 BCE (Horizon view at Kurukshetra, 07:30 Hrs)

means more or less the same that an untimely eclipse occurred.

rāhur agrasad ādityam aparvaṇi viśāṃ pate
ulkā cāpyapasavyaṃ tu puraṃ kṛtvā vyaśīryata

MB 2.71/26

caturdaśī pañcadaśī kṛteyaṃ rāhuṇā punaḥ
tadā ca bharate yuddhe prāptā cādya kṣayāya naḥ

MB 16.3/17

The fourteenth lunation has been made the fifteenth by Rahu once more. Such a

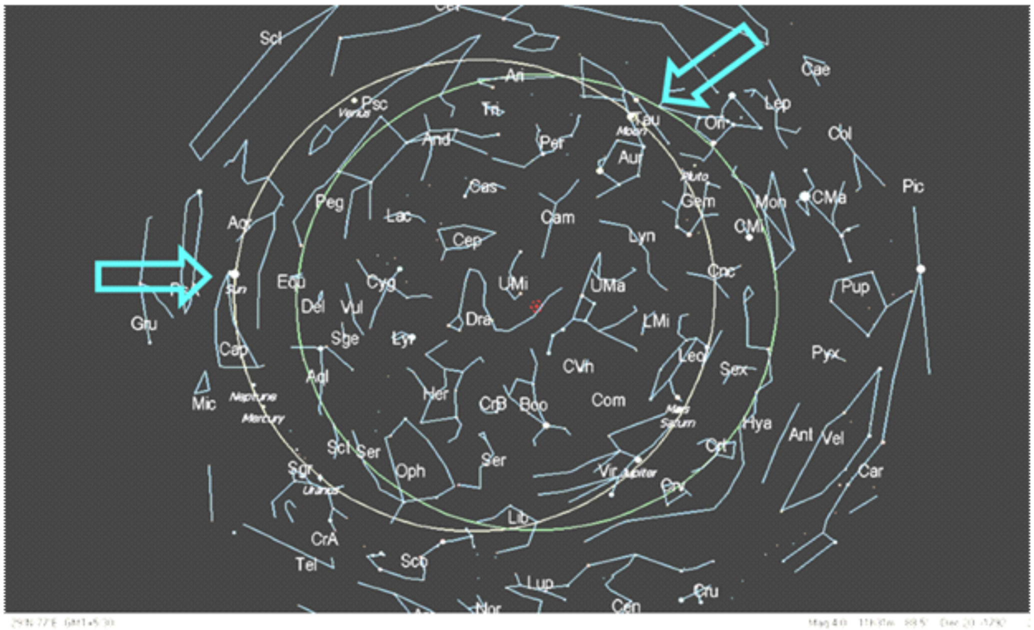


Fig. 8. Winter Solstice day on 20 December 1793 BCE (Sun's RA is 18h 00m). Moon's phase is First Quarter as depicted in the verse on Bhishma's demise (MB 13.153/28). The *tithi* Māgha *Śukla Aṣṭamī* is completed. Moon is in Rohinī *Nakṣatra* (α Tau). (Full ecliptic view at 21:05 Hrs).

> day had happened at the time of the great battle of the Bhāratas.

While *Sabha Parva* references indicate occurrence of an eclipse at the time of Pandavas going in exile, the event of *Mausala Parva* only mentions some variation in the count of days in the lunation. We have shown in Section 3.10 below (**MB** 5.88/46) that the war took place during the 15th year after Pandavas went in exile. The Eclipse Canons referred earlier show 13 solar eclipses that occurred during 11 to 17 years before the exile began. Out of these, the only eclipse visible over Delhi-Hastinapur is an annular eclipse of the Sun that occurred on 16 August 1808 BCE (Julian), i.e., 15 years 2 months before the war. Now coming to the eclipse during the 36th year after the war, the above Canons show 11 solar eclipses between 34th to 38th years after the war. Out of this, one total solar eclipse of 11 December 1759 BCE (Julian) is visible during the 35th year from western-Central India. Interestingly, there is another annular solar eclipse during the 36th year after war, belonging to the same *Saros* cycle 19 as the eclipse seen during the war-year. Eclipses of the same *saros* cycle have common characteristics. However, this eclipse was not visible from India. Since the MB reference only attributes the variation in the duration of the lunation to *Rāhu* without mentioning the eclipse, we cannot be sure whether this was the event. If it was, then what observable was it that was common between the two events separated by some 35 years remains to be seen. Let us now examine other astronomical events in **MB**.

3.6. Bhishma falls in the battle

The following lines show that Bhishma fell in the battle on the 10th day.

> *ahāni yuyudhe bhīṣmo daśaiva paramāstravit|*
> *ahāni pañca droṇastu rarakṣakuruvāhinīm||*
>
> **MB** 1.2/26

> 'Bhiṣma acquainted with choice of weapons, fought for ten days. Droṇa protected the Kaurava Vāhinis for five days'.

In the following verse Bhishma tells Yudhishthira about the number of days that he had been lying in the battle field.

aṣṭapañcāśataṃ rātryaḥ śayānasyādya me gatāḥ |
śareṣu niśitāgreṣu yathā varṣaśataṃ tathā||27||

MB 13.153/27

'I have been lying on my bed here for eight and fifty nights. Stretched on these sharp-pointed arrows I have felt this period to be as long as if it was a century.'

Bhiṣma, after falling in the battle on the 10th day spent the next 58 days there. Thus, he breathed his last on the 68th day since the battle began. Therefore, going back 68 days from 20 December -1792, we arrive at 14 October -1792 as the date when **MB** war actually began according to this count.

Let us now see how this date fits into other astronomical events of **MB**.

3.7. Kṛṣṇa's peace mission

Autumn equinox occurred on 23 September, 1793 BCE (**Fig. 9**). Kṛṣṇa started for his peace mission for Hastinapur in the month of *Kaumuda (*Kārtika*),* under the Revatī *Nakṣatra*, when the season was in transition from *Śarad* to *Hemanta* (**MB** 5.81/7 above). The scenario is reproduced on 26 Sep 1793 BCE in **Fig.10**. This date is well after 15 September, the normal date of withdrawal of monsoon from Delhi-Haryana region (IMD, 2017), when the autumn season sets in.

Kṛṣṇa stopped overnight at Vrikasthala on the way to Hastinapur.

sumṛṣṭaṃ bhojayitvā ca brāhmaṇāṃ statrakeśavaḥ |
bhuktvā ca saha taiḥ sarvairavasattāṃ kṣapāṃ sukham ||29||

MB 5.82/29

… and wending with them to their house, he returned in their company to his own (tent). 'And feeding all the Brahmanas with sweet-meats and himself taking his meals with them, Kesava passed the night happily there.'

Kṛṣṇa arrived at Hastinapur the next day, ie, 27 Sep -1792 (in Bharaṇī *Nakṣatra*).

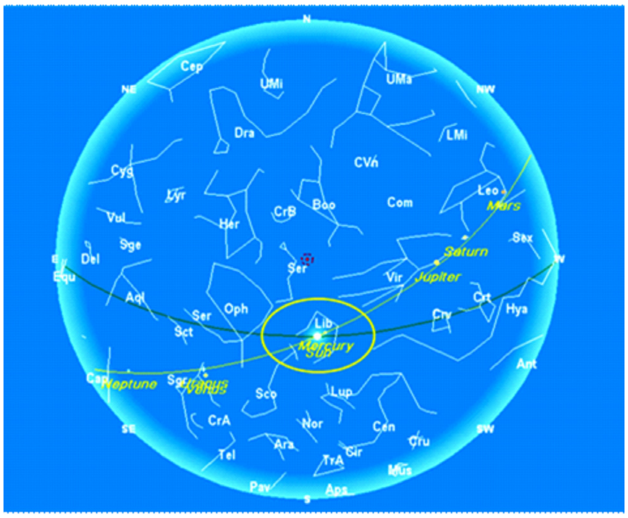


Fig. 9. Autumn equinox (Sun's RA 12h 00m) occurred in Viśakha *Nakṣatra* (α Lib) on 23 Sep, 1793 BCE, well after 15 Sep, the normal date of withdrawal of monsoon from Delhi-Hastinapur region (Horizon view at 12-30 Hrs)

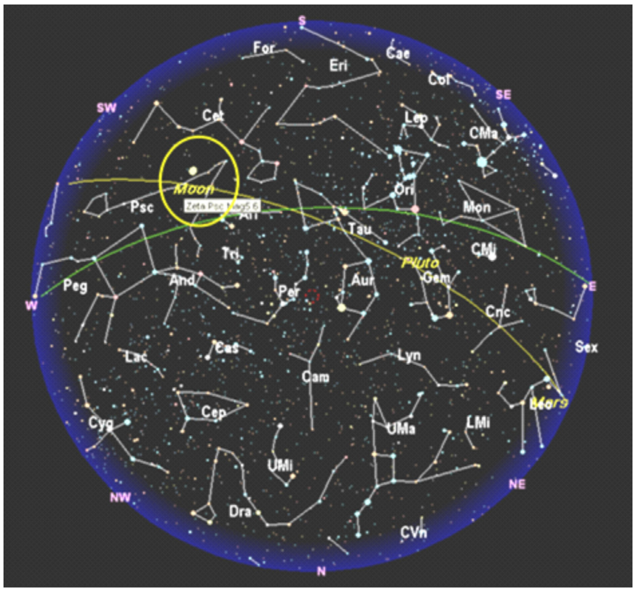


Fig. 10. Kṛṣṇa starts for peace mission; Kārtika month, Revatī *Nakṣatra* (ζ Psc), autumn season (**MB** 5.81/7). Scenario is reproduced on 26 Sep 1793 BCE above, 2 days before *Purṇimā* (Horizon view 00-30 Hrs). Kārtika

3.8. Reference to beginning the War on ensuing *Amāvasyā*

After the peace talks at Hastinapur had failed, the following dialogue took place between Kṛṣṇa and Karṇa:

pakvauṣadhivanasphītaḥ phala-vānalpamakṣikaḥ|
niṣpaṅko rasavattoyo nātyuṣṇa śiśiraḥsukhaḥ||17||

saptamāccāpi divasādamāvāsyā bhaviṣyati |
saṃgrāmaṃ yojayettatra tāṃ hyāhuḥ śakradevatām||18||

MB 5.140/17,18

…The weather is neither very hot nor very cold and is, therefore, highly pleasant'.

'Seven days after, will be the day of the new moon. Let the battle commence then, for that day, it hath been said, is presided over by Indra'.

In this conversation, Kṛṣṇa tells Karṇa that the battle would commence on *Amāvasyā* 7 days later. In the Indian system, *Indra* is the presiding deity for the Jyeṣṭhā *Nakṣatra*. The simulations show that Kārttika *Amāvasyā* did indeed occur in

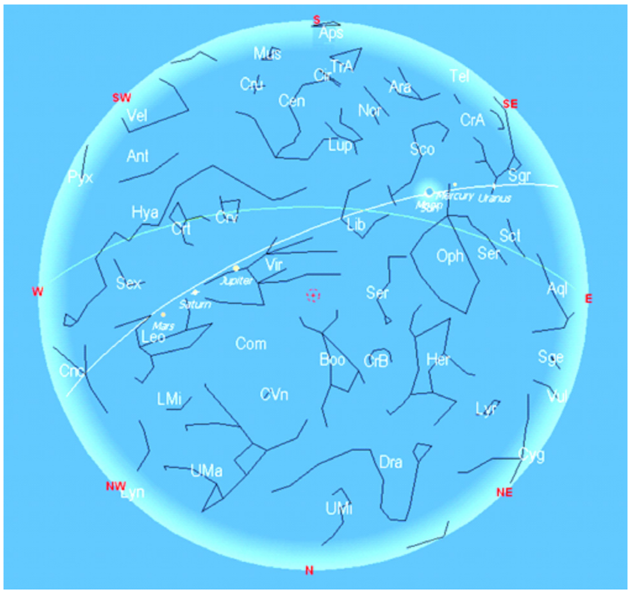


Fig. 11. *Kārttika Amāvasyā* occurs in Jyeṣṭha *Nakṣatra* on 14 Oct 1793 BCE, the day the war starts as declared by Kṛṣṇa (MB 5.140/18) (Full Horizon view at 09-35 Hrs)

Jyeṣṭhā *Nakṣatra* on 14 October 1793 BCE as shown in Fig. 11. Therefore, as declared by Kṛṣṇa, the war started on *Amāvasyā* on 14 October-1792 (1793 BCE) (MB 5.140/18). This matches perfectly with the date of Bhishma's demise 68 days later on 20 December as calculated above.

After Bhishma had fallen on the 10th day and Dronacharya on the 15th day (**MB** 1.2/26), the following verses give time of Karṇa's fall as 17th day and the final duel between Bhima and Duryodhana on the 18th day of the war.

ahanī yuyudhe dve tu karṇaḥ parabalārdanaḥ|
śalyo 'rdhadivasaṃ tv āsīd gadāyuddham ataḥ param||27||

tasyaiva tu dinasyānte hārdikya drauṇigautamāḥ|
prasuptaṃ niśi viśvastaṃ jaghnur yaudhiṣṭhiraṃ balam|| 28||

MB 1.2/27, 28

Karṇa the desolator of hostile armies fought for two days; and Salya for half a day. After that lasted for half a day the encounter with clubs between Duryodhana and Bhīma. At the close of that day, Aswatthaman and Kripa destroyed the army of Yudhiṣṭhira in the night while sleeping without suspicion of danger.

The total duration of the war was 18 days. Thus, the whole sequence of events, namely, occurrence of eclipse pair, Kṛṣṇa's peace mission to Hastinapur, lunar eclipse on Kārttika *Purnimā,* commencing the war on Kārttika *Amāvasyā* and Bhishma's demise on WS on Māgha *Śukla Aṣṭamī* in Rohinī *Nakṣatra,* is accurately reproduced. From here, one can work out dates of other events mentioned in **MB** before and after the war.

3.9. Pandavas' Departure for Varnavata

The following verse from *Ādi Parva* gives the astronomical details of the day when young Pāṇḍavas left for Varnavata at the command of Dhritarāṣṭra.

aṣṭame 'hani rohiṇyāṃ prayātāḥ phalgunasyate|
vāraṇāvatamāsādya dadṛśurnāgaraṃ janam||30||

MB 1.133/30

'The Pāṇḍavas set out on the eighth day of the month of Phalguna when the star Rohinī was in the ascendant, and arriving at Varnavata they beheld the town and the people.'

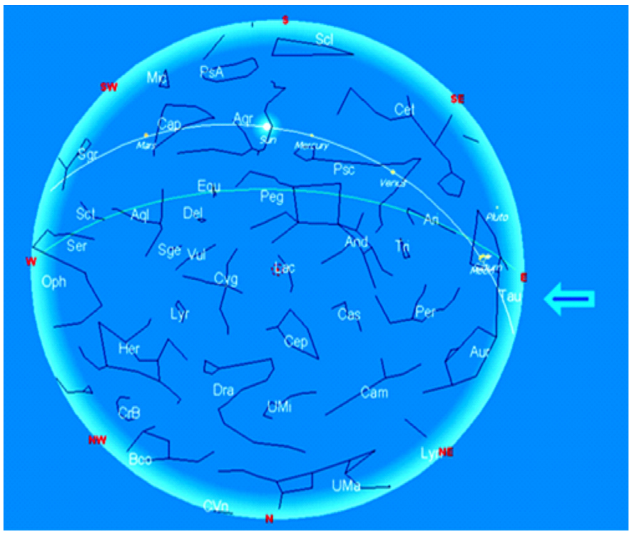


Fig. 12. Departure of young Pāṇḍavas to Varanavata. Sky on 5 Jan, 1829 BCE at 12:55 Hrs shows First Quarter of Moon (Phālguna *Śukla Aṣṭami*) and Rohinī *Nakṣtra* Ascendant (MB 1.133/30) (Horizon view)

This configuration is accurately reproduced (**Fig. 12**) on 5 January 1829 BCE, i.e., nearly 36 years before Bhiṣma passed away on 20 December 1793 BCE. The intervening period also contains the years when Pāṇḍavas succeeded in surviving the *'Lākṣyā Griha'* episode and spent a year or two in secrecy. During this period, they married Draupadī and finally returned to Indraprastha. A couple of years later, Arjuna went into self-exile for 12 years during this period:

so'bhyanujñāpya rājānaṃ brahma-caryāya dīkṣitaḥ|
vane dvādaśavarṣāṇivāsāyopajagāma ha||

MB 1.205/30

'Obtaining then the king's permission, Arjuna prepared himself for a forest-life; and he went to the forest to live there for twelve years.'

3.10. Pandavas' Exile of 13 years - the intercalary month

Following is a reference to the completion of 13-year exile of Pāṇḍavas and to the method of adding intercalary months.

teṣāṃ kālātirekeṇa jyotiṣāṃ ca vyatikramāt|
pañcame pañcame varṣe dvau māsāḥ upajāyataḥ||3||

teṣām abhyadhikā māsāḥ pañca dvādaśa ca kṣapāḥ|
trayodaśānāṃ varṣāṇām iti me vartate matiḥ||4||

MB 4.47/3, 4

...Bhiṣma said, 'In consequence of their fractional excesses and the deviations also of the heavenly bodies, there is an increase of two months in every five years. It seems to me that calculating this wise, there would be an excess of five months and twelve nights in thirteen years'.

We also find a reference to the time of Kṛṣṇa meeting Kunti during his peace mission to Hastinapur, shortly before the war began.

caturdaśam imaṃ varṣaṃ yan nāpaśyam ariṃdama|

putrādhibhiḥ paridyūnāṃ draupadīṃ satyavādinīm||46||

MB 5.88/46

'Full fourteen years have passed since the day when Duryodhana first exited my sons'.

This shows that the war preparations took six months to one year after Pāṇḍavas' return from exile. Kṛṣṇa's peace mission was the last attempt to avert the imminent war amidst the final stages of war preparations. The above reference to excess months clearly points to the method of intercalation. Two lunar months should be added at the end of five lunar years, for the period to fall in step with five solar years. Calculating in this way, we get 1860 *tithis* equated with 1830 civil days over a five-year period. This calendar system is identical to the one found in the *Vedāṅga Jyotiṣa* with a five-year *Yuga*. The time of *Vedāṅga Jyotiṣa* is known as 14th century BCE based on a reference (Saha and Lahiri, *Vedāṅga Jyotiṣa*, 1955, p. 224) in it that the WS was in Dhaniṣṭhā *Nakṣatra* (β Delphini). Abhyankar (Abhyankar 1991 pp. 1-13) has re-identified the principal stars of some of the Indian *Nakṣatras* based on detailed astronomical analysis. He identifies Dhaniṣṭhā with β Aquarii. Based on the new identification, we obtain the time of *Vedāṅga Jyotiṣa* around 1800 BCE, which matches perfectly with the time of **MB** determined in this paper.

4. Resolving Ambiguities

4.1. Balaram's pilgrimage reference

Balaram returned on the 18th and the last day of the war to witness the duel between his two disciples, Bhīma and Duryodhana, as per the following lines.

> *catvāriṃśad ahānyadya dve ca me niḥsṛtasya vai |*
>
> *puṣyeṇa saṃprayāto 'smi śravaṇe punarāgataḥ |*
>
> *śiṣyayorvai gadāyuddhaṃ draṣṭukāmo 'smi mādhava ||*
>
> **MB** 9.33/5
>
> 'Two and forty days have passed since I left home. I had set out under the constellation Puṣyā and have come back under Śṛāvaṇa. I am desirous, O Mādhava, of beholding this encounter with the mace between these two disciples of mine'!

There is an inherent contradiction in the above statement, which cannot be reconciled astronomically unless we presume a complete reversal of the *Nakṣatra* naming system in the above verse. Let us see it in the following way. Balarama arrives at the scene after 42 days on the 18th and last day of the battle. Yudhishthira spends 50 days in Hastinapur after the battle ends and then arrives to pay his last respects before Bhishma's demise on Winter solstice day (MB 13.153/5,6). It totals up to 92 days from the time Balarama left for pilgrimage upto the time of Bhiṣma's demise. We know that the average duration from AE to WS is close to 90 days. This means that Balarama left for Pilgrimage 2 days before the AE day. Thus we have two solar events independent of the lunar months to provide landmarks for checking moon's *Nakṣatras*. Simulations show that a given *Nakṣatra*, say Puṣyā on AE day occurs frequently at intervals varying from 8 to 19 years. The Moon with its mean sidereal period of 27.3 days moves through very nearly 1 *Nakṣatra* (27/27.3) per day. So, if Balarama leaves in Puṣyā *Nakṣatra* 2 days before AE day, the *Nakṣatra* on WS day after 92 days should be 91st from Puṣyā, i.e. Anurādhā/Jyeṣṭhā and not Rohinī as determined under Section 3.4 above.

The following verse provides a different count of days to WS.

> *pañcāśatam ṣaṭ ca kurupravīra śeṣam dinānām tava jīvitasya|*
>
> **MB** 12.51.14
>
> Six and fifty days, O foremost one of Kuru's race, still remain for thee to live! Casting off thy body, thou shalt then, O Bhiṣma, obtain the blessed reward of thy acts.

According to above, if we count 56 days instead of 50 after the war ends, we get 98 days from the time Balarama left in Puṣyā upto the day of WS. After 98 days, it is Dhaniṣṭhā *Nakṣatra* and not Rohinī. Going back 56 days from Dhaniṣṭhā, the *Nakṣatra* is Śrāvaṇā. Now, we have seen earlier that the WS itself is in Dhaniṣṭhā. So Dhaniṣṭhā *Nakṣatra* on WS day would imply

Moon also in Dhaniṣṭhā and *Amāvasyā tithī*. This would demolish the widely accepted scenario of Māgha *S 8* and Rohinī *Nakṣatra* on the day of Bhiṣma's demise. In fact the two scenarios happening together any time are not possible astronomically, although many researchers in the past have tried to fit it by considering the possibility of war beginning on Kārttika *Pūrṇimā* without direct evidence of it in the text. Hence this verse (**MB** 12.51.14) is not considered fit for inclusion in our calculations.

We can further establish this impossibility with the help of other facts mentioned earlier. **MB** 5.81/7 explicitly mentions that Kṛṣṇa left for the peace mission in Revatī *Nakṣatra*. The parleys failed 7 days before Kārttika *Amāvasyā* (**MB** 5.140/18). The war began on the Kārttika *Amāvasyā* and the final battle between Bhima and Duryodhana took place on the last day, i.e., on the 18th day of the war. We have seen that on Kārttika *Amāvasyā,* the first day of the war, the Sun and the Moon were in Jyeṣṭhā *Nakṣatra*. **MB** 5.140/18 above mentions that the day is presided over by *Indra* (presiding deity of Jyeṣṭhā). Our simulations correctly reproduced *Amāvasyā* in Jyeṣṭhā. Therefore, the *Nakṣatra* cannot be Śrāvaṇa on the 18th day of the war, as it is only the 4th *Nakṣatra* from Jyeṣṭhā. Similarly, the *Nakṣatra* on the day of Bhiṣma's demise (on *Magha S 8)* was deduced as Rohinī *(*MB/13/167/28*)*. He passed away 68 days after the war began. Going back 50 days from there, we see that the *Nakṣatra* on the 18th day of the war cannot be Śrāvaṇa. Counting from Jyeṣṭhā on the first day of the war, and from Rohinī backwards, the *Nakṣatra* turns out to be *Puṣyā* on the 18th day. We find from the simulation that the *Nakṣatra* on the 18th day of the battle, i.e., 31 October,1793 BCE was indeed Puṣyā (**Fig. 15**). We also find that it was Śrāvaṇa 42 days earlier, i.e on 20 September 1793 BCE (**Fig. 16**). The position stated in the verse (**MB** 9.33/5) is perfectly resolved if the *Nakṣatras* are taken in reverse order as mentioned here.

4.2. Alternate Scenarios

Let us now consider the following statements again that did not fit into the above analysis, to examine whether they yield different sets of dates independently. Many researchers in the past struggled hard to accommodate some of these references, often at the cost of modifying the other genuine events. For example Sengupta (1947) suggested that sage Vyasa may have mistaken the *Trayodaśi* moon as full moon of Kārttika and described it as full moon divested of splendor (*MB 6.2/23)*. He has also suggested that in MB 13.153/28, somebody later might have changed the time of Bhiṣma's departure from this world to *Śukla Pakṣa* instead of *Kṛṣna Pakṣa* because that can explain some of the contradictions found in the text. The same are discussed below.

Balarama leaves in Puṣyā *Nakṣatra* and returns 42 days later in Śravaṇā *Nakṣatra* (MB 9.34/6) on the 18th day of the war. This very night, Shri Kṛṣṇa and Yudhishthira visit Bhishma Pitamaha lying in the battle field. Kṛṣṇa tells that Bhiṣma will live for 56 days upto the day of WS (MB 12.51/14-16). When they are returning at Sunset to Hastinapur, the Moon is seen rising (MB 12.52/26,33). This combination implies that it was a full moon that occurred in Śrāvaṇa *Nakṣatra*. This means further that the Sun was located opposite in Punarvasu *Nakṣatra*. Fifty six days later, the Sun would be in Uttara Phālguni (β Leo), when it is also supposed to be at the WS at tropical celestial longitude of 270 degrees. The celestial longitude (1950.0) of ā Leo is 171 degrees. Thus, there is a change of 90+171=261 degrees due to precession at the rate of 50".3 per year. This is equivalent to 18679 years. Thus, the WS in Uttara Phālguni (β Leo) occurred around 16700 BCE. This does not appear to be a plausible date for MB.

We have another poetic reference to the bright crescent moon that arose in the wee hours after midnight at the end of the 14th day of the battle (Pandey, 1965,7.84/46-49). From the circumstances described, one can assign *Ekādaśī/ Dvādaśī tithī* of *Kṛṣṇa Pakṣa* to it. Since it is happening 3 to 4 days before Balarama's return in Śrāvaṇa *Nakṣatra*, the crescent Moon should be located 3-4 *Nakṣatras* ahead in Jyeṣṭhā/Mulā *Nakṣatra*. According to the configuration, the Sun should be located 3 *Nakṣatras* away to the east, i.e. in Srāvaṇa *Nakṣatra*. This is 4 days before Sri Krishna meets Bhiṣma Pitāmaha lying in the battlefield. Therefore, WS day will occur after 4+56= 60 days. The Sun, according to this scheme will be in Revatī (ζ Psc) on WS day, which happened around 5850 BCE. This again does not yield a satisfactory date in the absence of supporting evidence. Therefore, the astronomical references leading to above improbable dates are untenable.

4.3. Planets

Most of the references to planets in **MB** are astrological in nature, claiming good or bad omens and constitute the most difficult part of determining the date of the observation. They, however, do show the intricacies such as direct and retrograde motion of planets in the *Nakṣatra* belt. This shows that the observations were recorded systematically, even if they were for astrological purpose. It is noticed that many references do not mention the name of the celestial object in a straightforward manner. This makes the identity of some of them ambiguous. We list below the **MB** references to planets in Table 2 along with the position indicators without reproducing full *śloka*. Often they indicate the same planet associated with two widely different *Nakṣatras* at the same time. In this context, Sengupta (1947) notes

> In our selection of astronomical data in the present chapter no use has been made of those that are found in chapter 143 of the *Udyog parva* and in chapter 3 of the *Bhiṣma Parva*. I have understood them to be mere astrological effusions of bad omens; they are also inconsistent among themselves, and as such they cannot have any bearing on the date of the *Bhārata* battle.'

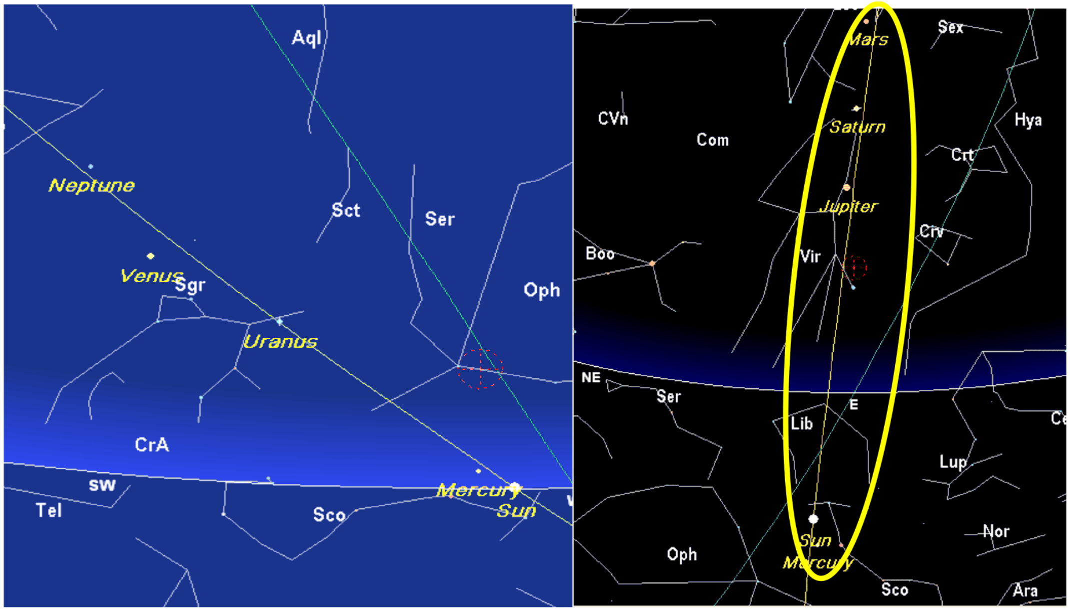
Iyengar (2003) handled the task by using modern simulation tools and could reproduce the complex motions, but not all for the same date.

The planetary references being astrological in nature do not leave much scope for any corroboration with actual happenings, especially in the absence of any knowledge about the kind of astrology that was practiced then. Looking at the references in the same chapters to other bizarre happenings on Earth, it appears that many of these statements about planets also may have been added later depending on one's idea of a worst omen. We have, nevertheless attempted to simulate the sky during and around the *amānta* lunar month of Kārttika of 1793 BCE. The time is the eve of the war. We have simulated the planetary positions from 20 September 1793 BCE, when the war appeared imminent, up to 14 October 1793 BCE, when the war actually began. Table 2 gives the computed locations on 5th and 14th October 1793 BCE. We find that the Moon was approaching Maghā and the five planets were visible in the night sky of 5 – 6 October 1793 BCE (**Fig. 13 A & B**) after sunset until next sunrise as narrated in **MB** 6/17/2 below.

> *maghāviṣayagaḥ somas tad dinaṃ pratyapadyata* |
> *dīpyamānāśca saṃpeturdivi saptamahāgrahāḥ* ||2||
>
> **MB** 6.17/2

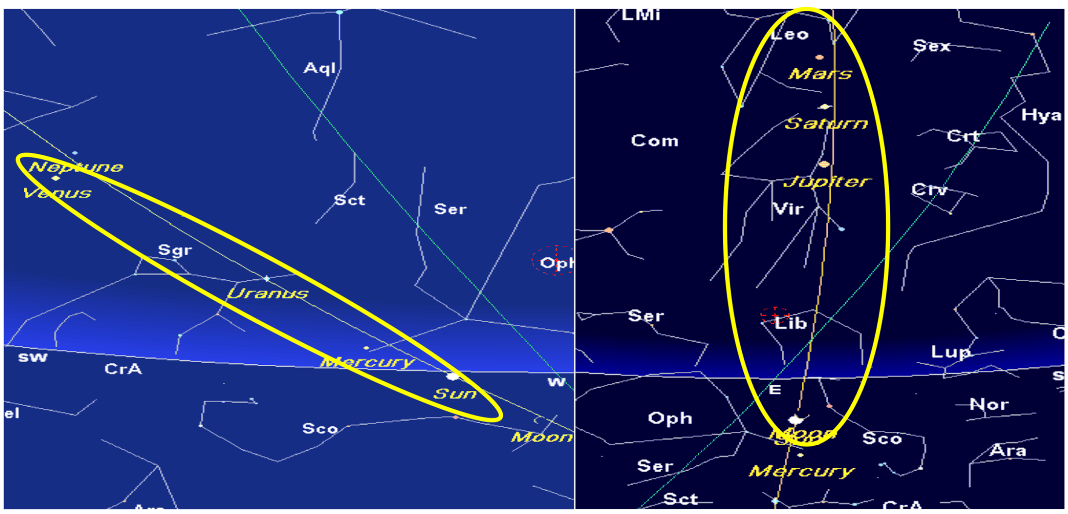
> 'On that day on which the battle commenced Soma approached the region of Pitris (Maghā). The seven large planets (*Grahās*), as they appeared in the firmament, all looked blazing like fire'.

Here, Moon approaches Māgha. It will be in Jyeṣṭhā on the Kārttika *Amāvasyā* when the battle begins (MB/5/140/18). The difference



(A) 5 Oct 1793 BCE; Evening Sky;18:01 Hrs (B) 6 Oct 1793 BCE; Morning Sky;6:24 Hrs

Fig. 13. Five planets were visible in the night sky, (A) Mercury and Venus after Sunset and (B) Jupiter, Saturn and Mars until next sunrise and the Moon and Mars were close to Maghā (α Leo) as narrated in MB 6/17/2 (Horizon view).



(A) 13 Oct 1793 BCE; Evening Sky (17:52 Hrs) (B)14 Oct 1793 BCE; Morning Sky (05:00 Hrs)

Fig. 14. On the eve of the war, five bright planets continue to be visible in the night sky, (A) Mercury and Venus after Sunset and (B) Jupiter, Saturn and Mars up to next sunrise. The Sun and the Moon are together in *Amāvasyā* in Jyeṣṭha (α Sco) on 14 October -1792 (MB 5.140/18) (Horizon view).

corresponds to 7 to 8 days (Fig. 13). The Sun and the Moon can be seen together in *Amāvasyā* in Jyeṣṭhā on 14 October 1793 BCE (**Fig. 14**).

One finds that there are frequent references to a planet '*afflicting*' or '*aspecting*' (*Pidyat)* a particular constellation while it is stated to be located in another *Nakṣatra* in an accompanying *śloka.* Considering that these have an astrological background, we tried to look for the clues in some of the existing astrological treatises. The idea is

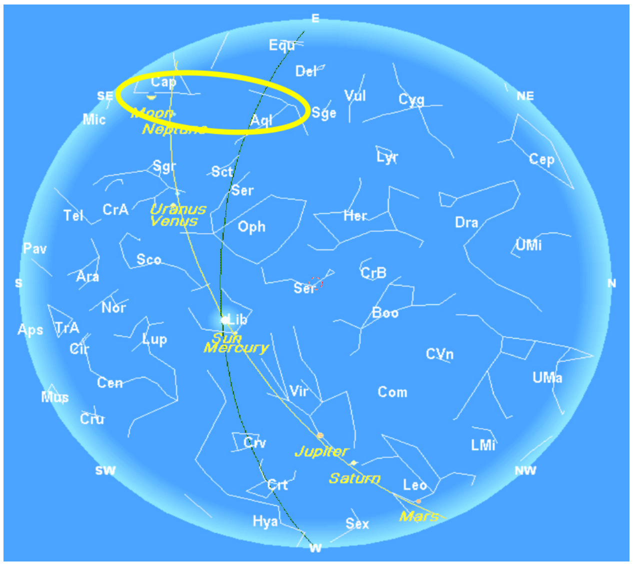


Fig. 15. Sky on 20 Sep 1793 BCE shows *Nakṣatra* as *Śravaṇā* (α Aql). This happened 42 days before Balaram returned from pilgrimage on the 18th day of the war (1 Nov). (Horizon view at 13:05 Hrs)

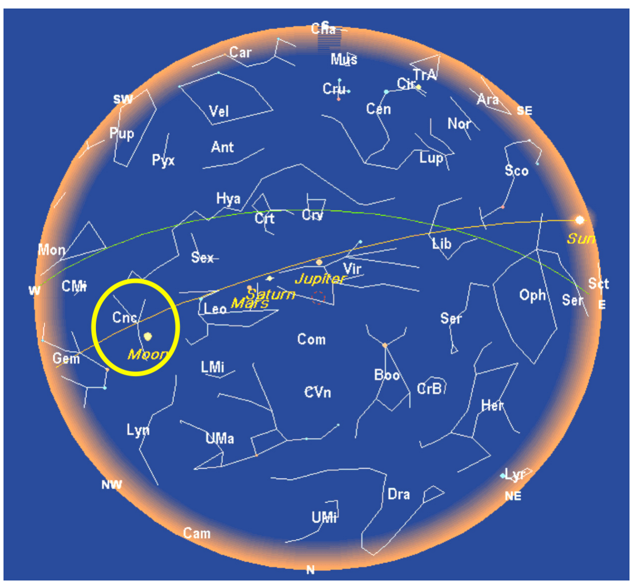


Fig. 16. Sky as seen on in the morning of 1 Nov 1793 BCE on completion of 18 days of war. Moon entered Puṣyā *Nakṣatra* (η Cnc) on the 18th day is seen exiting it the next day. (Horizon view, 07:00 Hrs)

not to establish that astrological omens etc. were right, but only to examine the astronomical content in the **MB** statements.

Varāhamihira (505-587 CE) in *Brihat Jātaka,* Chapter II/13 states that

> "… all the planets aspect the 7th house with a full sight; but Saturn aspects the 3rd and 10th houses with a full sight; Jupiter aspects the 5th and 9th houses with a full sight, and Mars aspects the 4th and 8th houses with a full sight" (Iyer, 1885,p. 18).

This astrological practice appears to be coming down from earlier times and is prevalent at present also. Here, a 'house' indicates the *Rāśi* or the zodiacal sign (sidereal) occupied by a planet.

MB makes predominant use of the *Nakṣatra* system. One cannot say precisely when the 12 zodiacal *Rāśis* came into use in India. Sengupta (1947 p.26 and p. xiv) puts it around 400 CE. However, one can safely presume that the astrological practices based on the earlier *Nakṣatra* system were adapted to the *Rāśi* system at some stage after **MB** time. A planet shown to be afflicting or aspecting a *Nakṣatra* may be actually located in another *Nakṣatra.* We have, therefore, converted the *Nakṣatra* mentioned in the concerned verses to corresponding *Rāśis* to apply the above astrological rule to **MB** planetary positions.

Table 2 below shows the simulated location of planets on 5th and 14th October, 1793 BCE, before the war begins, Houses and *Nakṣatras* afflicted according to *Bṛhat Jātaka*, location indicated in **MB** and corresponding **MB** reference.

One can see in the table that except for Venus, when we add the number indicated by *Bṛhat Jātaka* for a given Planet to its *Rāśi* as in simulated location, we get the location that matches with **MB** reference. In other cases, simulated location itself matches with the **MB** reference. For example, Mars can be seen in Maghā from 5 to14 October 1793 BCE. (**Fig. 13 B and 14 B**) and as per Table 2, it would afflict Jyeṣṭhā as required under MB/6/3/14. Jupiter is found to be in *Hastā* (Virgo) and Saturn in Purva/ Uttara Phālgunī (Leo) (**Fig. 13 B and 14 B**) during

Table 2. Location of Planets indicated in MB; 'Aspecting' other *Nakṣatras*

Object	**Simulated Location on**		**Houses/*Nakṣatras* aspected/afflicted as per *Bṛhat Jātaka***		**Location Indicator in MB**	**MB *Śloka***
	5 Oct. 1793 BCE	**14 Oct 1793 BCE**				
Sun	8Sco/Anurādhā-Jyeṣṭha*[10]*	8 Sco/Jyeṣṭhā	7th	2 Tau/ Rohinī[11]	Jyeṣṭha[10] Rohinī (aflg)[11]	6.3/16 5.140/18
Moon	5Leo/Maghā[10]	8 Sco/Jyeṣṭhā[10]	7th	2 Tau/ Rohinī[11]	Rohinī (afflg)[11] Maghā[10] Jyeṣṭha[10]	6.3/16 6.17/2 5.140/18
Venus	9Sgr/*U.* Aṣādha*[12]*	10 Cap/*Srāvaṇa*	7th	3Gem/Punrvasu 4Cancer/Puṣya	P. Bhādra/ U. Bhādra	 6.3/14
Mars	5Leo/Maghā[10]	5 Leo/Maghā	4th 7th 8th	8 Sco/ Jyeṣṭha[11] 11Aqr/Satabhiṣaja, 12 Psc/Revatī	Jyeṣṭha/Anurādhā[11] Maghā[10] Srāvaṇa (in line with)	5.141/8 6.3/14 6.3/18
Jupiter	6Virgo/Hasta	6 Vir/ Hastā	5th 7th 9th	10Aqr/Srāvaṇa[11] 12 Psc/Revatī, 2Tau/ Rohinī[11]	Srāvaṇa[11] Viśākhā for 1 yr Rohinī (aflg)[11]	6.3/14 6.3/25 8.68/49
Saturn	5Leo/ *P.-U. Phalg.*[10]	5 Leo/ *U. Phalg*	3rd 7th 10th	7Lib/Viśākhā, 11Aqr/Śatabhiṣaja 2 Tau/ Rohinī[11]	Bhaga (Phalg*)*[10] aflg Viśākhā for 1 yr Rohinī (aflg)[11] Rohinī (aflg)[11]	6.3/14 6.3/25 6.2/32 5.141/7

the above period from where they would both afflict Rohinī according to Table 2 and match with **MB** 8.68/49 and **MB** 5/141/8 respectively.

As regards Venus[12], we find that it was in Purvāṣāḍha on 20 September, 1793 BCE (**Fig.16**) and in Uttaraṣāḍha on 14 October 1793 BCE (**Fig.14 A**), whereas the **MB** 6.3/14 interprets it to be in Pūrva Bhādrapada and Uttara Bhādrapada respectively. One can see that astronomically it is not possible for it to be in Pūrva Bhādrapada because Venus cannot go farther than about 46º from the Sun in the sky. We have seen that towards the end of *Amānta* Kārttika month, the Sun was in Jyeṣṭhā (**MB** 5.140/18). Pūrva Bhādrapada is more than 100º away from Jyeṣṭhā.

In this way, the diverse planetary positions indicated in different verses and *Parvas* of **MB** on the eve of the war match either with the simulated position or with one of the derived positions in most cases.

5. Results and Discussion

We present our results on determining the dates of astronomical events mentioned in MB in Table 3 in Chronological Order.

All the dates given above are according to Gregorian calendar without any discontinuity in 1582 CE or earlier. The solstices, equinoxes and therefore the seasons remain nearly fixed with reference to these dates throughout. These dates differ from the Julian calendar dates in the year -1792 (1793 BCE) by about 15 days. Winter solstice on Gregorian 20 December, -1792 thus corresponds to Julian 4 January, -1791.

[10]Simulated location matches with location indicator in MB.
[11]The aspected position matches the location indicator in MB.
[12]See text, explaining the position of Venus.

The dates determined by us do not conform to the date of *Kali Yuga* beginning based on Āryabhaṭa's writings (499 CE), which presumes that all planets were together in conjunction at the beginning of *Kali Yuga*. As mentioned under Section 3.1, such conjunction had never occurred. However, Abhyankar and Ballabh (1996, pp. 23-24) and later Bhatnagar (2012, p. 75-76.) had shown that a spectacular assemblage of the Moon and five bright planets occurred, above the rising Sun on the eastern horizon on 13th January, 3104 BCE, 25 days after the winter solstice and again on 22 January 3102 BCE in the daytime. The authors had suggested that this striking sight came down as 'legendary conjunction' to be associated with the beginning of *Kali Yuga* as mentioned by Āryabhaṭa. However, this scenario did not fit into the location of equinox and solstice based on other astronomical evidences in **MB**. We have examined the point further and found that among the five bright planets, conjunction of the slowest moving objects, Saturn and Jupiter, takes place after every 19.87 years on an average. Within a couple of years of such conjunctions, a close pass of these two planets with other faster moving objects is possible. We verified with the help of Planetarium Gold software that at least 18 such close passes of the seven luminaries coming within 45° of each other have taken place over -3150 to -1750. Some of the recent ones occurred on 4 December 1899 (35°), 5 February 1962 (15°) and 5 May 2000 (25°). In fact, we find one such assemblage around Libra on Oct 31, 1757 BCE in the proverbial 36th year after the war took place in 1793 BCE. In fact, the close pass begins on 8 September 1757 BCE and continues up to 31 October 1757 BCE (**Fig. 17**). Therefore, these frequent close passes cannot serve as the legendary conjunction associated with the *Kali Yuga* and we place greater reliance on other astronomical events to determine the dates of **MB.**

Attempts to reproduce other astronomical phenomena also fail if we link **MB** with the year 3102 (*Kali Yuga* beginning). If we go back 36 years and arrive at nearest WS date of 19 Dec 3139

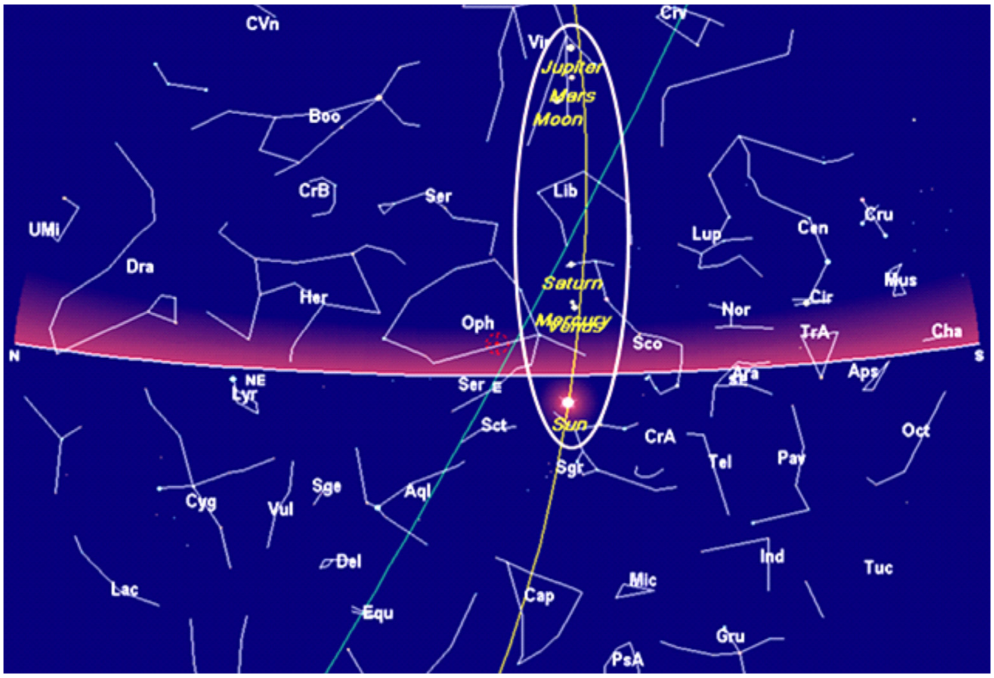


Fig. 17. Close pass of Seven Luminaries in the morning sky on 31 Oct 1757 BCE, in 36th year after the war (Horizon view at 06:00 Hrs)

BCE (36 y 1 m 3 d), we find that the *tithi* on this date is *S* 14 and not Māgha S 8 as per **MB**. However, going back one more year, the WS date of 19 Dec 3140 BCE corresponds to the *tithi* Māgha S 7. It nearly matches the *tithī* of Bhiṣma's demise but for the following discrepancies. The war is to begin on Kārtika *Amāvasyā* in Jyeṣṭhā *Nakṣatra* (á Sco), but we find the *Amavasyā* on 14 Oct 3140 BCE occurring in Purvāṣadha (δ Sgr) and not in Jyeṣṭhā (α Sco). We see further that in 3140 BCE, Kārtika *Pūrṇimā* occurred in autumn on 30 September but there was no evidence of a lunar eclipse as stated in **MB** 6.2/23. In fact, the previous *Pūrṇimā* on 31 August 3140 occurs near Kṛttika *Nakṣatra* and does show a lunar eclipse in Planetarium Gold simulations, but it is not in autumn. The following *Amāvasyā* on 14 September 3140 BCE occurs in Jyeṣṭhā, but if we take this to be the Kārtika *Amāvasyā* to begin the war, the whole sequence of the number of days from the war beginning up to winter solstice (Bhishma's demise) is completely disturbed from 68 days as per **MB**, to 98 days. The date 3140 BCE does not satisfy the astronomical observations and, therefore, is not acceptable.

Table 3. *Mahābhārata* Events in Chronological Order

Event	**Ref. MB Cr Ed**	**Greg Date (Pl. G.)**	**No. of days since the war began**
Pandavas' departure to Varnavat	1.133/30	05 Jan-1828	-36 yrs
Arjun's exile for 12 years	1.205/30	Around-1825	-
Eclipse Pair	6.3/28,29	5 Apr-1792; 19 Apr-1792	-192 days -178
Autumn equinox (reference to autumn)	5.81/7	23 Sep-1792	-21
Kṛṣṇa's Peace Mission (*Revatī*/*Kārtika*)	5.81/7	26 Sep-1792	-18
Lunar Eclipse on Kārttika *Pūrṇimā*	6.2/23	28 Sep -1792	-16
Planets: Moon, and Mars in Maghā	6.17/2; 6.3/14	5 Oct-1792	-9
Venus in *Purva/Uttara* Aṣādha	6.3/14	20 Sep to 5 Oct-1792	-24 to-9
Sun, Moon afflict Rohinī (from Jyeṣṭha)	6.3/16 (17-Cal Edn)	14 Oct-1792	1
Mars afflicts Jyeṣṭha (from Maghā)	5.141/7,8	5-14 Oc -1792	-9 to +1
Jupiter afflicts Rohinī (from Hasta)	8.68/49	5-14 Oct-1792	-9 to +1
Saturn in U Phālguni; afflicts Rohinī	5.141/7,8	5-14 Oct-1792	-9 to +1
War to Begin on Kārttika *Amāvasya*	5.140/17,18	**14 Oct-1792**	1
Bhiṣma falls	1.2/26	23 Oct-1792	10
Drona dies	1.2/26	28 Oct-1792	15
Karṇa killed	1.2/27; 8.68/49	30 Oct-1792	17
Bhima kills Duryodhana in mace duel on the 18th day. War ends	1.2/27	31 Oct -1792	18
Bhiṣma's demise, WS- Maghā *S* 8±1	12.47/3; 13.152/10; 13.153/5,6, 26,27,28.	20 Dec -1792	68
Destruction of Vrishnis and *Mahānirvāṇa* of Kṛṣṇa	16.2/2; 16.3/18; 16.5/21,22	-1756	+36 yrs.

We have the other dates of 3067 BCE determined by Achar (2003) and 1478 BCE by Iyengar (2003). Achar (2003) favours Raghavan's earlier determination of the date of 3067 BCE by testing it for a few events in *Udyoga* and *Bhīṣma Parvas.* His dates (Julian) being closer to the date of *Kali* beginning, suffer from the same shortcomings as discussed above. For example, date for Kṛṣṇa's departure for peace talks does not conform to end of autumn season as clearly described in his benchmark *śloka*, but falls nearly 22 days earlier in the rainy season over Delhi/ Hastinapur. The date fails the fundamental requirement of placing the equinoxes in the right place. The other dates determined by them are in error by 3 to 12 days, e.g., winter solstice occurs on Māgha *Śukla 5* instead of Māgha *Śukla* 8±1 at the time of Bhishma's demise. The time elapsed from the beginning of war up to the time of Bhishma's demise, from their dates, comes out as 56 days instead of 68 days quoted in so many *ślokas* in **MB**. In that respect, the date determined by Iyengar (2003) broadly falls in the correct domain dictated by the equinoxes and solstices as per the prevailing season. It is based on the eclipse pairs identified to have occurred in 1478 BCE in the year when Saturn and Mars met the description in MB. He mentions that the war began immediately after the Kārttika *Pūrṇimā*, which occurred on Julian 12th October 1478 BCE. Winter solstice follows 83 days later on Julian 3rd January 1477 BCE, which does not match the figure of 68 days up to Bhīṣma's demise.

6. Conclusion

In this study, we have simulated and analysed astronomical events recorded in 52 different *ślokas* taken from 10 different *Parvas* of **MB.** Accurate description of the Kārtika *Pūrṇimā* and Revatī *Nakṣatra* in autumn season in **MB** helped us to locate the autumnal equinox between Viśākhā and Anurādhā *Nakṣatras,* limiting the period of **MB** from the year 2250 BCE to 1280 BCE. Beyond these limits, Kārttika month of sidereal luni-solar Indian calendar begins to lose its connection with the short, post-monsoon autumn in northern India around Delhi-Kurukshetra region. Precise details of the winter solstice in the *Amānta Māgha* month, when the Moon was in the first quarter of its phase, further helps us to determine the precession of the Maghā (α Leonis) that brings us closer to the time of **MB**, around the year 1773 BCE. We have used description of occurrence of an eclipse pair in one lunation and then a lunar eclipse on Kārtika *Pūrṇimā* in the same year to finally close in on the year of the war as -1792 (1793 BCE). From there, all other events follow accurately as per daily account given in **MB,** in the same sequence as given in the epic. We determine that the Great War began on 14 October 1793 BCE (Gregorian). We have shown that very few references of astronomical events match for any other dates between 3102 BCE to 3140 BCE based on *Kali* era beginning in 3102 BCE. We also show mismatches of the event dates in earlier determinations.

The accuracy with which such large number of events matches the computed dates cannot be by coincidence. This shows that the events were actually observed and recorded. The calendar used in **MB** establishes that foundations of *Vedāṅga Jyotiṣa* were laid around this time and given a mathematical form soon thereafter.

7. Acknowledgement

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Abbreviations

AE: Autumnal Equinox; RA: Right Ascension; BCE: Before Common Era; Stel: Stellarium 0.10.6.1; CE: Common Era; VE: Vernal Equinox; MB: *Mahābhārata*; WS: Winter Solstice; Pl. G: Planetarium Gold 4.0

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