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INTERNAL CONSISTENCY OF ECLIPSES AND PLANETARY POSITIONS IN *MAHĀBHĀRATA*

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The ancient intellectual tradition of India holds that the epic *Mahābhārata* reports part of its national history. However historicity of key personalities like Kṛṣṇa has depended more on an unbroken tradition, rather than on archaeological evidences. The single most important physical source available for present-day study is the text of *Mahābhārata* itself. It is unlikely that later reciters and copyists of the epic would have tampered with descriptions of natural phenomena like eclipses, even though transcription and transmission errors cannot be ruled out. Hence, such celestial observations would become the most important physical evidences if they can be scientifically investigated and dated. Planetarium softwares are powerful tools for computer-based searching of thousands of possibilities and for sifting through obscure texts on celestial events. Such an exercise in archaeo-astronomy leads us to the conclusion that the eclipses and planetary observations of *Mahābhārata* should belong to the period 1493 BC-1443 BC of Indian history.

Key words : Eclipses, *Mahābhārata, Māsa, Nakṣatra,* Planetary Positions, Planetary softwares, Sky chart.

INTRODUCTION

The great epic *Mahābhārata* is believed to be historical by a vast majority of people in India. Tradition attributes the authorship of the epic with a hundred thousand verses to Kṛṣṇa-Dvaipāyana, popularly known as Veda-Vyāsa. However, there are sufficient reasons to believe that the epic grew to its present form from a smaller epic called *Bhārata*, which, in turn, developed out of the poem Jaya with only 8800 verses. It is not clear when,

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for the first time, the text of the epic was written down in script form. However it is known that the acclaimed poet, Bhāsa (*circa* 2nd cent. BC) wrote six dramas[1] inspired by *Mahābhārata (MB)*. Thus, the nucleus of *MB* should belong to an ancient period of Indian history carried up to a point in time through oral traditions. Such traditions had regional differences leading to further local variations. Superposed on such oral versions arose, at later times, inconsistencies and errors in writing and copying. Not surprisingly at present, when one reads the *MB* text in printed versions, the material at some places appears inconsistent or incomplete or repetitive with contradictions. On the other hand, taken as a whole all versions tell essentially the same story that has the stamp of belonging to an ancient period. Even a cursory reading of the text indicates, that it refers to a time when week days were not in vogue, royal messengers carried oral messages instead of letters, but people lived in cities and the high watermark of Indian philosophy had been reached in *Bhagavadgītā*, which is a part of *MB*.

Obscurities, exaggerations and contradictions pertaining to religious, cultural and sociological themes could have crept into the text due to vested interests. On the other hand, it is expected that descriptions of natural phenomenon such as an evening sky or a flood or an earthquake would not have been distorted intentionally. Similar would be the case, after due allowances are made for a poetic language, with planetary positions and observations of eclipses. *MB* contains descriptions of several celestial phenomena as the story unfolds. It would be interesting to verify whether these descriptions are internally consistent or not. A fair degree of consistency, among the various statements available in the text, is a prerequisite for them to be treated as real observations, worthy of being taken as historical facts. As far as celestial observations are concerned, the test for consistency would mean arriving at one or more possible past dates, for the events, by back calculations. Since this would be a scientific and hence a less controversial approach to date MB, several persons have searched for astronomical references in the text. An excellent discussion on the historicity of *MB* including differing views based on astronomical calculations is available in a book edited by Gupta and Ramachandran

(1976). This book is available in full at the web site *(http://abob.libs.uga.edu/bobk/maha/)*. The major limitation of past studies has been that they do not show how to reconcile inconsistencies such as *Śani* (Saturn) being said to be with star *Rohiṇī* (Aldebaran) as well as being near star *Viśākhe* (α-Librae) in the *Bhīṣma parvan* of the epic. Also in the absence of computers, for back calculations, results found with one or two constraints are not reliable. The only rigorous study to investigate the planetary configurations and eclipses using modern astronomical almanacs and computers has been by Sharma (1986). He proposes that some of the inconsistencies encountered in the epic could be accounted for, if the conversation between Vyāsa and Dhṛtarāṣṭra in *Bhīṣma parvan* is assumed to have taken place on different dates within the same year. His analysis leads to 1493 BC and 2109 BC as two possible years for the MB war. His study does not account for all the eclipses and planetary positions in the text. The present paper considers the whole issue afresh. The work is motivated by a desire to see whether astronomical informations provided in the different parts (*parvans*) of the epic are compatible among themselves or not. The study is based on interpreting the original Sanskrit text and extensive application of modern planetarium softwares. For this purpose, five different versions of the original epic have been consulted. The first is the edition of Bhandarkar oriental Research Institute, Pune that is available on the web site (http://home.dongguk.edu/user/india/text/e-mbh.htm)[2]. The second is the edition brought out by Pt. Hayagrīva Śāstri in Telugu script[3] in 1850-60. The edition brought out by Gita Press of Gorakhpur, with the 17th century commentary of Nīlakaṇṭha also has been referred for planetary positions of *Bhīṣma parvan*. The 19th century line by line English translation of Kisari Mohan Ganguly[4] and *Bhārata Darśana*, a Kannada version of the epic, by a team of scholars[5] have also been consulted.

Approach of Study

The procedure adopted for the present investigation may be described in five steps.

(i) Almanac-related informations available in the text are briefly reviewed. The effort has been to highlight what is relevant in marking relative and hopefully absolute time frame of some important events. All the original Sanskrit text used is reproduced along with its brief meaning, which is not a literal translation, but which provides the implications clearly. Chapter and verse numbers refer to the second version of the text cited above. Differences between the various versions are discussed wherever necessary.

(ii) The long period of 3000 BC—501 BC is searched with the help of modern planetarium and eclipse softwares to prepare a candidate list of possible years for the war as per the most reliable part of the text in *Bhīṣma parvan.*

(iii) Dates compatible with the occurrence of an eclipse at Dwaraka in the 36th year reckoned from the Great War are identified, as per the text in *Mausala parvan.*

(iv) All possible solar eclipses 13-15 years prior to the one in the war year are found as per the text in *Sabhā parvan.*

(v) All the above triplets of years are further matched with the most reliable planetary positions as per the text in *Udyoga parvan* for further discussion and conclusions.

Background Information

Before one can look for internal evidences for dating the text, it is important to have an overall view of the concepts that might have existed in that ancient period about time and how the calendar was handled. The intention here is not to get into a critical discussion on the ancient calendar systems. We go through the text somewhat selectively to find what textual evidences are available to help our discussion on the internal consistency of the planetary configurations. Anecdotes and events not contemporaneous with the period of MB, as per the text itself, are ignored.

At the very beginning in the second chapter of the First Book, verse thirteen reads :

antare caiva samprāpte kali-dvāparayor abhūt
samanta-pañcake yuddham kuru-pāṇḍava-senayoḥ (Ādi.p. 2.13)

The war between the armies of Kurus and Pāṇḍavas took place at samanta-pañcaka during the transition between Kali yuga and Dvāpara yuga.

In the absence of other independent statements within the text regarding the beginning of *Kaliyuga*, the above verse is not of much help in fixing a date for the war.

Tithi, Nakṣatra, Māsa and Varṣa

There are several references to *tithi* (moon's phase) and *nakṣatra* (star), which can fix a day or night within a given year. The language at times can be obscure leading to different interpretations. For example, Yudhiṣṭhira's birth date is described as

aindre candra-samāyukte muhurte abhijite aṣṭame
divā madhyagate sūrye thithau purṇe atipūjite (Ādi.p. 123.6)

Under star Jyeṣṭhā, during the eighth time-interval called Abhijit, with sun at the mid-day position, in the much-revered Pūrṇa tithi (Yudhiṣṭhira was born).

The star mentioned here is clearly *Jyeṣṭhā*, but there is no mention of the month and *tithi*. Nevertheless, the great commentator Nīlakaṇṭha of 17th century infers that the verse indicates the month of *Āśvina* and the *tithi* of *śukla pañcamī*. There are many instances where the meaning of the stars and *tithis* are very clear. For example, when the young Pāṇḍavas were coaxed to go to Vāraṇāvata

aṣṭame ahani rohiṇyām prayātā phālguṇasya te (Ādi. p. 145.34)
They travelled on the eighth day of Phālguṇa month, under star Rohiṇī.

The *nakṣatras* were decided based on the position of moon which is explicitly stated as in (*Ādi. p. 123.6*) quoted above and again when Vyāsa advises Yudhiṣṭhira regarding his marriage :

adya pauṣyam yogam upaiti candramāḥ (Ādi.p. 198.5*)*

Today moon will attain the yoga of star puṣya.

Again in *Bhīṣma parvan* Sanjaya tells :

Maghā-viṣayagaḥ somaḥ taddinam pratyapadyata (*Bhī.p.*17.2)

On that day moon was with star maghā.

Very specific details are given sometimes, like when Bhīma fights Jarā sandha. It is said that the fight started on the first day of the *Kārttika* month and ended on the fourteenth day (*Sab.p.* 24.28-30). The months should have been lunar, ending with full moon. This is clear from the nomenclatures, *ardhamāsa* and *pūrṇamāsi.* Bhīṣma advises Yudhiṣṭhira:

māsārdhe kṛṣṇa-pakṣasya kuryāt nirvapaṇāni ca (Anu.p. 92*)*

At the middle of the month in the dark fortnight rites to the dead should be done.

This is clearly *amāvāsya* (new moon) being called *māsārdha* or middle-of the-month. The name for full moon is *pūrṇamāsi,* literally meaning full-month. The month of *Kārttika* finds mentioned more often than other months. With which month the new-year started is not clear. Based on the statement of Kṛṣṇa in Bhagavadgītā, (*māsānām mārgaśirṣoham*) it is surmised that the new-year started on the first day of the *Mārgaśira* month. This may explain the importance given in the text to *Kārttika* full moon which would be the new year eve. About stars, a list of twenty-nine stars starting with *Kṛttikā* (Pleiades) is provided in *Anuśāsana parvan* (see Table 7). It has to be noted that later Indian astronomers retained only twenty-seven stars to specify planetary positions. Month names appear in several places, but year names are conspicuously absent like week names. Different words are used to indicate year. When Arjuna leaves Indraprastha to keep up a vow, we read :

vane dvādaśa varṣāṇi vāsāya anujagāmaha (Ādi.p. 213.35*)*

He set out for living in the forest for twelve years.

It is not mentioned how the years were counted; except for a hint in *Sabhā parvan* (ch. 75 v. 11-12) where *vatsara*, and *parivatsara* are used to mean year. Hence, in all probability, the five-year cycle of *Vedāṅga-jyotiṣa* was in vogue and the *Vaidika-sāvana* year with 360 days was used for the civil calendar. This has been asserted to be so by the commentator Nīlakaṇṭha, while accounting for the thirteen-year exile of Pāṇḍavas, when Arjuna reveals himself on the *aṣṭamī tithi* of a month surmised to be *āṣāḍha* (*Vir.p.* ch. 52) in the summer season. The seasons are mentioned indirectly, as in

tānyanīkānyadṛśyanta kurūṇām ugradhanvinām
saṃsarpante yadā meghāḥ gharmānte mandamārutaiḥ (Vir. p. 56.1)

The armies of the Kurus were seen between the end of summer and the beginning of the rainy season.

kaumude māsi revatyām śaradante himāgame (Udy.p. 82.7)

(Kṛṣṇa set out on his mediation effort) at the end of autumn with dew starting, in the month of Kārttika under star Revatī.

Kṛṣṇa describes the onset of the cool season to Karṇa as :

saumyoyam vartate māsaḥ suprāpaḥ yavasendhanaḥ
pakvoṣadhivanasphītaḥ phalavān alpamakṣikaḥ
niṣpaṅko rasavattoyo nātyuṣṇa-śiśiraḥ sukhaḥ
saptamāccāpi divasāt amāvāsyā bhaviṣyati
*saṅgrāmam yojayet tatra tāmāhuḥ śakradevatam (Udy.p.*140.16-18)

This month is mild, with easily procured cereals and fuel. Forests are with ripe fruits and medicinal plants and with not too many flies. Water is tasty without dirt. This season is not too hot but pleasant. Seventh day from today is the new moon, important for god Indra. Let the battle be planned for that day.

In chapter 163 of *Araṇya parvan*, Dhaumya, the family priest of Pāṇḍavas, explains in detail a theory of rotation of Sun and Moon around the pole star. Excerpts from the 19th century translation of the original by K.M. Ganguli reads "....Sun who dispelleth darkness, goeth round this (mountain) obscuring other luminaries....And in this way, the divine Moon also together with the stars goeth round this mountain, dividing the month

unto several sections, by his arrival at the Parvas....Sun...when, desirous of causing dew, he repaireth to the south, then there ensueth winter to all creatures. Then the Sun, turning back from the south, ...that divine effulgent one causeth shower....the Sun unerringly turneth on the wheel of Time, influencing created things....dividing time into day and night, and Kala, and Kaṣṭhā, that lord, the Sun, dealeth life and motion to all created things."

Eclipses

The *Mahābhārata* proposes a rudimentary theory of eclipses. In *Bhīṣma parvan,* before the start of the war, Sanjaya states the following reason for eclipses :

parimaṇḍalo mahāraja svarbhānuḥ śrūyate grahaḥ
yojanānām sahasrāṇi viṣkambho dvādaśasya vai
parimāṇena saṭtriṃśat vipulatvenacānagha
ṣaṣṭhimāhuḥ śatānyasya budhāḥ paurāṇikāstathā
candramāstu sahasrāṇi rājan ekādaśaḥ smṛtaḥ
viṣkambhena kuruśreṣṭha trayastriṃśattu maṇḍalam
ekonaṣaṣṭhivaipulyāt śītaraśmeḥ mahātmanaḥ
sūryasya tu aṣṭau sahasrāṇi dve cānye kurunandana
viṣkambhena tato rājan maṇḍalam triṃśatam samam
aṣṭapañcāśatau rājan vipulatvena cānagha
śruyate paramodāraḥ patngosau vibhāvasuḥ
etat pramāṇam arkasya nirdiṣṭam iha bhārata
sarāhuḥ chādayatyetau yathā kālam mahatyaya
candrādityau mahāraja saṃkṣepoyam udāhṛtaḥ (Bhī.p. 12.40-12.47*)*

Briefly, this means, the diameter of Rāhu is 12,000 yojanas, where as the diameters of Moon and Sun are 11,000 and 10,000 yojanas, respectively. The circumference of Rāhu, Moon and Sun works out to be 36000, 33000 and 30000 yojanas, respectively. Hence, being bigger, Rāhu at appropriate times covers (*chādayati*) Moon and Sun. Indirectly the value of the irrational number Pi (π = 3.1415926536...) has been taken as 3 in the text. It is also given that the *vipulatva* (?) of Rāhu, Moon and Sun are 6000, 5900 and 5800,

respectively. Gangūly, in his translation adds the *vipulatva* figures to the circumferences, which cannot be justified. The Kannada language *Bhārata Darśana* takes this to mean the thickness of the planets, which meaning is also doubtful in the context. Nevertheless, the statements are interesting in that a physical reason is given for eclipses instead of the usual mythological stories. This also provides the reason for referring Rāhu as *mahābraha*, the big planet.

There are eight places in the text where solar eclipses (SE) are mentioned, but not all of them are credible as actual observations. The first is in *Sabhā parvan* after Pāṇḍavas are banished to the forest. In answer to a question on how Pāṇḍavas started their journey, Vidura gives a graphic description of the various events and incidentally mentions

anabhre vidyutaścāsan bhūmiśca samakampatā
rāhuragrasadādityam aparvaṇi viśāmpate (Sab. p. 79.29*)*

In the cloudless sky there were lightnings; the earth shook and Rāhu caught the sun, but, not on the fifteenth day.

Several portents are described in the text starting with the Rājasuya sacrifice and ending with the gambling episode. Hence the above eclipse might not have occurred exactly at the time of Pāṇḍavas leaving Hastināpura. Dhṛtarāṣṭra confirms this eclipse much later as he broods over the sad happenings, in the last chapter of *Sabhā Parvan.*

divā ulkāḥ patanyaśca rāhuśćārkam upāgrasat
aparvaṇi mahāghoram prajānām sañjanayan bhayam (Sab.p. 80.23*)*

Meteorites are falling in daytime, and Rāhu covered Sun on an odd day causing great fear among people.

The place of observation of this eclipse was Hastināpura, not far away from Kurukṣetra. The second mention of a SE is in *Udyoga parvan* when Karṇa tells Kṛṣṇa :

somasya lakṣma vyāvṛttam arkam rāhuḥ upaiṣyati (Udy.p. 142.11*)*

Brightness of Moon is covered up and Rāhu is approaching Sun.

This is not an observation of an eclipse but only an expectation. The alternate reading of this verse is similar, the last word being replaced by *upaiti cha*. The text is very clear that the conversation between Kṛṣṇa and Karṇa (quoted previously, *Udy.p.* 140.16-18) took place a week before a new moon. Hence the above cannot be a direct observation. Since prediction of eclipses is not mentioned anywhere in the text, even as a possibility, the above can at best be an observation before the month of *Kārttika* in the same year.

The third mention is again in *Udyoga parvan*, chapter 182 describing an old battle between Bhīṣma and his teacher Paraśu Rāma. Bhīṣma himself says that on the 4th day of their 23-day battle at Kurukṣetra

arkam ca sahasādīptam svarbhānuḥ abhisaṃvṛṇot (Udy.p. 183.22*).*

Svarbhānu (Rāhu) suddenly approached the brightened Sun.

The language of the text is realistic in that the eclipse was unexpected. This should have been some 50 or 60 years before the MB war, when Bhīṣma was in his youth.

The fourth solar eclipse is in *Bhīṣma parvan* chapter 3 when Vyāsa tells Dhṛtarāṣṭra :

abhīkṣṇam kampate bhūmiḥ arkam rāhuḥ tathāgrasat (Bhī.p. 3.11*)*

The earth shakes often, similarly Rāhu caught up Sun (often ?).

This statement is in past tense. The alternate reading of the above verse is :

abhīkṣṇam vartate bhūmiḥ arkam rāhuḥ upaiti ca (Bhī.p. 3.11*)*

The meaning is essentially the same, except the eclipse occurrence is in present tense. After three sentences, all versions have another reference to *mahāgraha*, which is Rāhu.

senayoḥ aśivam ghoram kariṣyati mahāgrahaḥ (Bhī.p. 3.13*)*

Rāhu does bad to both the armies.

Thus some time before the war all versions indicate occurrence of a solar eclipse. But a difficulty arises due to the mention of another eclipse a

few verses later in the same chapter. This fifth mention of a solar eclipse in the MB text is :

candra-sūryāvubhau grastau ekamāse trayodśīm (Bhī.p. 3.29)

Moon and Sun were eclipsed in the same month at thirteen days (interval).

This eclipse will be discussed in detail later in this study. The sixth mention of an eclipse appears in *Śalya parvan,* on the last day of the war, before the duel between Bhīma and Duryodhana. Among the several bad omens an eclipse finds mention as:

rāhuśca agrasadādityam aparvaṇi viśāmpate
cakampe ca mahākampam pṛthivī savanadrumā (Śal.p. 56.10)

Rāhu caught up Sun at an odd time. The earth shook along with trees and forests.

All the editions carry this verse. However this event is not credible as an eclipse. This follows from the previous statements in *Bhīṣma parvan* that the eighteen-day war started the day next to a *Kārttika* full moon. The seventh solar eclipse, which is again not reliable, is in *Āśvamedhika parvan,* during a fight between Arjuna and the Saindhavas:

rāhur agrasat ādityam yugapat somam eva ca
tataḥ khāt tu vinirbhidya maṇḍalam śaśino-patat (Āsh.p. 77.15, 77.18)

This means Rāhu caught both sun and moon together. The imagery would look quite interesting in that sun and moon are together anyway on a new moon day. But in the next verse it is said that a part from moon fell out breaking the sky, which would mean, moon was visible. Thus this event is not reliable. The eighth and final solar eclipse is in *Mausala parvan,* in the thirty-sixth year after the war :

caturdaśī pañcadaśī kṛteyam rāhuṇā punaḥ
mene prāptam sa-ṣat-triṃśaṃ varṣam vai keśisūdanaḥ (Mau.p. 2.19, 2.20)

The fourteenth day has been made into the fifteenth day again by Rāhu. Kṛṣṇa understood that the 36th year (as said by Gāndharī at the end of the MB war) had arrived.

This eclipse is mentioned in all the editions of the text. Also this event finds prominent mention in the Prabhāsa Khāṇḍa of Skanda Purāṇa, while describing the last days of Kṛṣṇa. In contrast with solar eclipses, mention of lunar eclipses is almost absent. In *Udyoga parvan*, Karṇa during his conversation with Kṛṣṇa mentions *somasya lakṣma vyāvṛttam*, (*Udy.p.* 141.10) meaning light of the moon is circumscribed. In *Bhīṣma parvan* during his discourse Vyāsa says :

alakṣyaḥ prabhayā hīnaha paurṇamāsīnca kārttikīm
candro abhūdagnivarṇah padma-varṇe nabhasthale (Bhī.p. 2.23*)*

This is a poetic reference to the *Kārttika* full moon becoming invisible and devoid of light, but turning fiery in the lotus coloured sky. This may indicate an eclipse, or just describe an optical anomaly. The only clear lunar eclipse is the one associated with a solar eclipse in the same month, already mentioned above.

Planetary Positions

Positions of planets are described in the text with reference to their nearness to fixed stars. Since these statements are needed for our later discussion here the text and a simple working translation, with a number, are provided. The first statement about planetary positions occurs in *Udyoga parvan*, when Karṇa and Kṛṣṇa are conversing :

prājāpatyam hi nakṣatram grahastīkṣṇo mahādyutiḥ
śanaiścaraḥ pīḍayati pīḍayan prāṇinodhikam
kṛtvā ca aṅgārako vakram jyeṣṭhāyām madhusūdana
anūrādhām prārthayate maitram samśamayanniva
nūnam mahādbhayam kṛṣṇa kurūṇām samupastitham
viśeṣeṇāhi vārṣṇeya citrām pīḍayate grahaḥ (Udy.p. 142.8-142.10*)*

Saturn is near star Rohiṇī. Mars (in retrograde ?) is approaching Anūrādhā from Jyeṣṭhā. There is a planet near Citrā. *(p.p.*1*)*

In *Bhīṣma parvan* a series of planetary positions are given, some of which are apparently incompatible. In chapter 2, Vyāsa in conversation with Dhṛtarāṣṭra mentions :

rohiṇīm pīḍayanneṣa sthito rājā śanaiścaraḥ *(Bhī.p.2.32)*
Saturn is staying near Rohiṇi *(p.p.2)*

In the next chapter, again it is said :

śveto grahaḥ tathā citrām samatikramya tiṣṭhati *(Bhī.p.3.11)*
A white planet resides, having crossed Citrā. *(p.p.3)*

These two are in conformity with the earlier text (p.p.1) in *Udyoga parvan.* However, after three lines, not connected with planetary positions, Vyāsa is supposed to say again :

maghāsvaṅgārako vakrah śravaṇe ca bṛhaspatiḥ
bhagam nakṣatram ākramya sūryaputreṇa pīḍyate
śukraḥ proṣṭhapade pūrve samāruhya viśāmpate
uttare tu parikramya sahitaḥ pratyudīkṣate
śyāmo grahaḥ prajvalitaḥ sadhūmaḥ saha pāvakaḥ
aindram tejasvī nakṣatram jyeṣṭhām ākramya tiṣṭhati
dhruvaḥ prajvalito ghoram apasavyam pravartate
citrā svāti antare caiva dhiṣthitaḥ paruso grahaḥ
vakrānuvakram kṛtvā ca sravane pāvakaprabhaḥ
brahma-rāśim samāvṛtya lohitāṅgo vyavasthitaḥ *(Bhī.p.3.14-3.19)*

Mars (in retrograde) is in Maghā and Jupiter is in Śravaṇa. Saturn is afflicting Pūrva-Phalgunī. Śukra (literally one who is white, Venus) previously getting up in star Pūrvabhādra and having circled in North (or star Uttarābhādra or star Uttarā) is looking up, with a company. The dark planet blazing with smoke and fire is with Jyeṣṭhā. Brightened Dhruva (pole star) is positioning itself anti-clockwise. A rough planet is seen between Citrā and Svātī. The fire coloured planet has gone retrograde in Śravaṇa. The red-bodied planet is in Brahma-rāśī. (p.p.4)

In the above itself it is seen that the previous position of Saturn remains contradicted. About Mars, also it is ambiguous. The position of Venus is given as being near Pūrvābhādra. However, its described motion can be interpreted in three different ways. The last two lines of the text are not clear as to what planets were meant by the poet. Traditionally this verse is taken to indicate the position of Mars. The word *lohitāṅga* (red-bodied) may indicate Mars. However, the word *pāvakaprabha* (fire-coloured) may not

necessarily refer again to Mars, since the location of *Śravaṇa*, was assigned previously to Jupiter. An extra observation *rohiṇīm pidayatyevam ubhauca śaśi-bhāskarau* is also available in some versions. Some editions read *bhagam* in the second line above as *bhāgyam*. Similarly, in the fifth line, *śyāmo grahaḥ* is read as *śveto grahaḥ*. In all editions, after another six verses a few more positions are stated :

grahau tāmrāruṇa-śikhau prajvalntāviva sthitau
saptarṣīṇām udārāṇām samavacchādya vai probhām
saṃvatsara-sthāyinauca grahau prajvalitāvubhau
viśākhayoḥ samīpasthau bṛhaspati-śanaiścarau
kṛttikāsu grahastīvraḥ nakṣatre prathame jvalan
vapūmṣi apaharan bhāsā dhūmaketuriva sthitaḥ
triṣu pūrveṣu sarveṣu nakṣatreṣu viśāmpate
budhaḥ sampatate abhīkṣṇam janayan sumahadbhayam
caturdaśīm pañcadaśīm bhūtapūrvāñca ṣoḍaśim
imāmtu nābhijānāmi amāvāsyām trayodaśīm
candra-sūryāvubhau grastau eka-māse trayodaśīm
aparvaṇi grahāvetau prajāḥ saṃkṣapayiṣyataḥ (*Bhī.p.* 3.23-3.29)

Two blazing planets have reduced the brightness of Saptarṣis (Ursa Major). Jupiter and Saturn, being stationary for a year are near (the double stars) Viśākha. There is a sharp planet with the first star of Kṛttikās, like a comet. In the three stars preceding this, Mercury is seen often. I know instances of amāvāsyā falling on the fourteenth, fifteenth and sixteenth day of the fortnight, but not on the thirteenth day like now. Moon and Sun both got eclipsed in the same month, oddly at thirteen days (interval). (*p.p.*5)

In this position also, there are variant readings. The Gita Press edition gives an extra eclipse statement after the fourth line :

candrādityau ubhau grastau ekāhna hi trayodaśīm
aparvaṇi graham yātau prajā-saṃkṣayam icchataḥ

Nīlakaṇṭha explains this as a solar eclipse on the thirteenth day, highlighting the occurrence of a fortnight short by two days, which is unusual. Another glaring difference in this version is the substitution of

budhaḥ (Mercury) by gṛdhraḥ (eagle) in the eighth line.

A few other passing references to planets are:

hastesma karṇo sarito na sravanti jagāma cāsto kaluṣo divākaraḥ
grahaśca tiryak jvalitārka-varṇo yamasya putro abhyudiyāya rājan
(Kar.p. 68.47)

bṛhaspati-Rohiṇīm samprapīdya babhūva candrārkasamānavarṇa ha
(Kar.p. 68.47)

When Karṇa got killed, rivers stopped flowing; Sun set with pollution, the bright sun-coloured planet, son of Yama (Death) appeared across the sky. Jupiter, afflicting Rohiṇī, became like Moon and Sun. *(p.p.* 6)

The difficulty in relying on this statement will be clear when we compare this with other versions of the text where the event appears in the 95th Chapter as :

hate karṇe sarito na prasasruḥ jagāma cāstam savitāḥdivākaraḥ
grahaśca tiryak jvalanārka varṇaḥ somasyaputro abhyudiyāya tiryak
(Kar.p. 95.49)

bṛhaspatiḥ samparivārya rohiṇīm babhūva candrārkasamo viśāmpate
(Kar.p. 95.51)

Both the versions graphically describe the evening sky on the seventeenth day of the war. The meaning of the first line quoted above, of both the versions is almost same. Further, the second version asserts Mercury could be seen, where as the first version refers to the risen planet as Yama's offspring (?), which is not Mercury. Similarly, the second version strongly implies an occultation of star *Rohiṇī* by Jupiter, whereas the first version indicates only nearness of Jupiter to *Rohiṇī*. Hence, one can at best conclude that some bright planet was seen in the sky after sun set and Jupiter was not far away from star *Rohiṇī*. Again in *Śalya parvan* in the context of the next day daylight battle itself we read:

bhṛgusūnu-dharāputrau śaśijena samanvitau
caramam pāṇḍuputrāṇām purastāt sarva-bhūbhujām (Sal.p. 11.17)

Venus and Mars along with Mercury appeared behind the Pāṇḍavas. (*p.p.*7)

This verse is not available in all the editions of MB. In particular, the Pune edition does not have this statement. In the beginning of *Bhīṣma parvan* itself the camping positions have been described, to understand the phrase 'behind the Pāṇḍavas'

prāṅgmukhāh paścime bhāge nyaviśanta sasainikāḥ (Bhī.p. 1.5)

Pāṇḍavas camped on the western side (of Kurukṣetra), facing east.

Hence, the plnetary positions of p.p.7, if taken as reliable, would be broadly applicable to the western part of the evening sky.

Admittedly, the variant readings of the text bring in an element of uncertainty about the correctness of the stated planetary positions. The traditional rendering of *śvetograha* to mean *Ketu*, by Nīlakaṇṭha in his commentary adds to the confusion. He goes to the extent of interpreting the text at p.p.3 above and the eclipse mention a line before that to mean:

kārttikyāh param hi saṅgrāmārambhaḥ, tatra tulāstham arkam rāhurupatiti; tadeva śveto grahaḥ ketuḥ citrām atikrāmati svātyādau vartate, nityam sama-saptakasthau rāhu-ketū idānīm eka-rāśi-gatau mahā-aniṣṭasūcakau iti bhāvaḥ.
(Bhi.p. 3.11-12)

After Kārttika (month) is the start of the war. There Rahu approaches Sun in Tulā (Libra). That white planet Ketu crosses Citrā and resides in the beginning of Svātī. Rāhu and Ketu, who always stay diametrically opposite at the seventh places, being now in the same sign, are indicative of great calamity; is the meaning.

Ganguly in his translation also adopts the same interpretation. This would mean that the ascending and descending nodes of Moon were together during the MB war, which statement cannot be taken seriously. The white planet referred in the text should have been a visible planet not requiring any convoluted interpretations. Notwithstanding some such difficulties, there are no reasons to ignore the above citations of eclipses and planetary positions as being fictitious. They could be approximate and even erroneous due to recording errors, but from the context and style of the text on the whole, they have to be accepted as genuine observations. The reigning star or *nakṣatra* citations have been explicitly associated with

the position of the moon, as already noted. It follows for the planetary positions also the same observational approach should have been used with the help of the night sky. Notwithstanding the rich imagery employed by the poet, the planetary observations are not occultations, but only approximate locations with respect to a nearby bright star, on either side of the ecliptic, which had already been named by previous astronomers. Even though the textual planetary positions *p.p.*4; *p.p.*5; *p.p.*6 and *p.p.*7 cannot be taken on their face value, the other positions *p.p.*1, *p.p.*2, *p.p.*3 should be reliable since all editions agree on these. Also all editions agree on the occurrence of a solar eclipse in the year of the war, even though the relative timing of this event with respect to the war is not clear. About eclipses at other places there is concordance amonjg all editions of the epic. Hence it is worthwhile to study the internal consistency of eclipses and planetary positions, which automatically means finding one or more dates compatible with all or at least a majority of the textual statements. Specifically, three solar eclipses, one each from *Sabhā parvan* (SE1), *Bhīṣma parvan* (SE2) and *Mausala parvan* (SE3), have to be found satisfying a time sequence. The first or the second or both could have succeeded or preceded a lunar eclipse in the same month (denoted further as Double Eclipse). While the first two should have been observable at Kurukṣetra, the third one should have been observed at Dvārakā, in the 36th year reckoned from the MB war. The interval between the first and the second is not stated in the text. But from other considerations it is known that fourteen years should have elapsed between the gambling episode of *Sabhā parvan* and the war commencement in *Bhīṣma parvan*. The text is not clear on how long Pāṇḍavas stayed at Upaplavya town, before the start of the war. But it can be inferred that they did not fight in the same year, within a few months, after their thirteen year exile was completed. This we see, in all editions, in the statement of Kṛṣṇa during his speech in the conclave of kings at Upaplavya;

katham goharaṇe hyuktam naitat śarma tathā hitam
yāsyamānopi bhīṣmeṇa samvatsara-gate adhvani (Udy.p. 88.19-20)

How, during the journey about a year ago after the cattle stealing episode, even when Bhīṣma pleaded for peace.....

In *Sabhā parvan*, (chapter 75), before going to the forest both Bhīma and Arjuna, say that they will come back and fight in the fourteenth year that is, after their exile of thirteen years. But the above statement of Kṛṣṇa should be taken to indicate that they waited for a year more. Still, this does not resolve when SE1 occurred. Hence we are forced to take a sliding window of 13-15 years as the possible interval between SE1 and SE2. Interestingly, the planetary position mentioned in *p.p.*1 and *p.p.*2 come in handy in fixing SE2. These are unambiguous about Saturn being near star *Rohiṇī* in the war year. The Sanskrit name for Saturn is appropriately *Śanaiścara*, meaning one-who-moves-slowly. Thus, the position of Saturn would be the most reliable among the planets. However, two conflicting statements appear later. First, *sūryaputra* (son of Sun) which in later times meant Saturn, is associated with star *Bhaga*, that is same as *Pūrva-phalgunī* (*Purva*, δ-leonis) in *p.p.*4. Next, Saturn unambiguously referred as *Śanaiścara* is once again located with *Viśākhā* in *p.p.*5. Now this situation hints at the possibility of these two positions having occurred at some other time and/or errors having crept into the text. Verses corresponding to *p.p.*5 and *p.p.*4 might have come into their present positions due to some recording errors. When Yudhiṣṭira, after the Rājasūya sacrifice asks for clarification from Vyāsa regarding the three types of portents previously mentioned to him by Nārada, the text indeed sounds incomplete. What were the celestial and terrestrial anomalies ? Could the double eclipse be one of them ? There is a conversation between Vyāsa and Dhṛtarāṣtra in *Sabhā parvan*, which is too short by the standards of the epic. Is it possible some of the verses of *Bhīṣma parvan* really belong to *Sabhā parvan* ? Alternatively, is it possible what Vidura mentions and later Dhṛtarāṣtra muses, as an eclipse (SE1) at an odd time at the end of *Sabhā parvan* could be the one, with Saturn near *Viśākha* ? Before this can be discussed further, it is worthwhile to have a list of double eclipes with Saturn near *Rohiṇī*. For this purpose, modern planetarium softwares come handy.

PVIS, EZC-Planetarium Software

Among several planetarium softwares available, it is found that the planet visibility software PVIS is user friendly for eclipse search (Fig. 1).

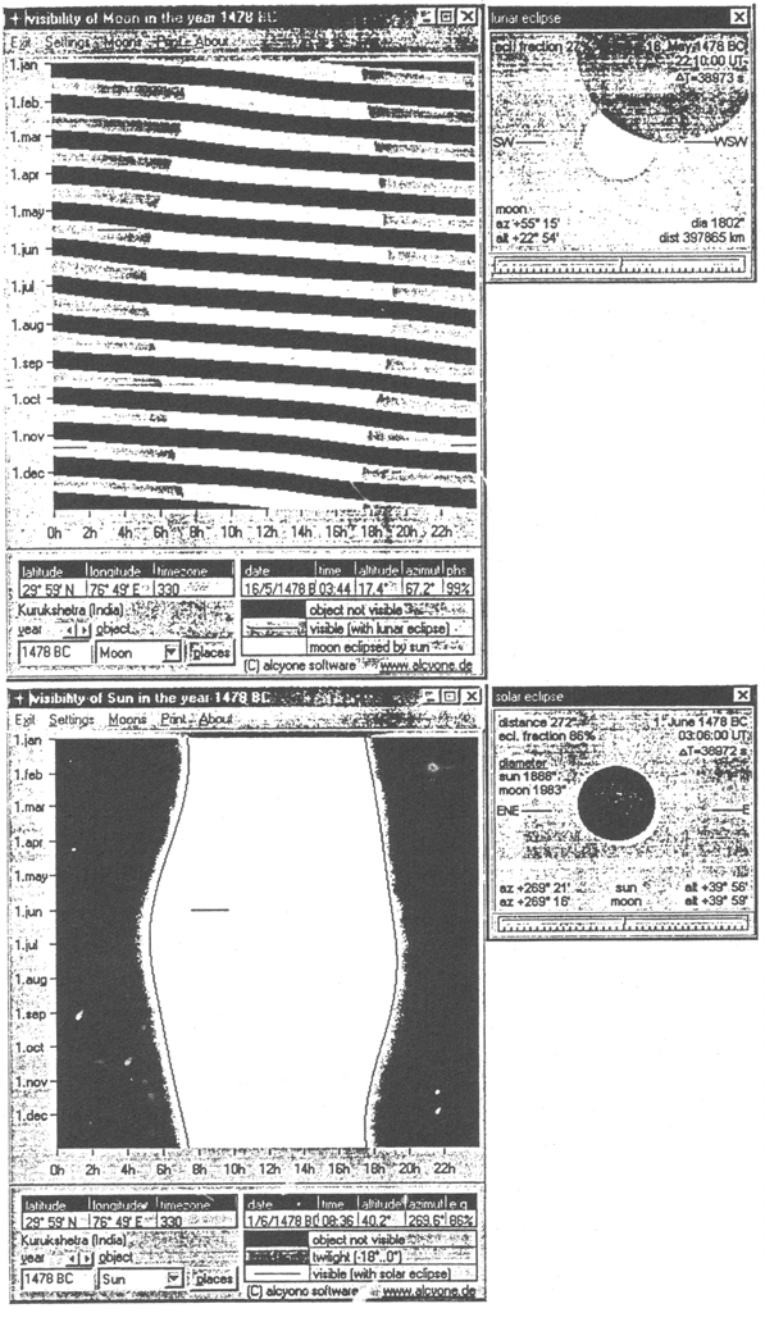

Fig. 1. Double Eclipse in 1478 BC.

For finding planetary positions, softwares such as EZC, Hplanet, Skyglobe, can be easily handled. Here the period of search has been restricted to the interval 501 BC-3000 BC. In the discussions available in the book by Gupta and Ramachandran (1976), it is found that all scholars agree that MB should have been before 900 BC. However, since Kṛṣṇa is accepted in all traditions to be earlier than the historical personality of Gotama Buddha (563-483 BC), here 501 BC is selected as the lower limit. The upper limit is based on the limitation of the PVIS software. The location for the eclipse search has been taken as Kuruks.etra at 76°49'E and 20°59'N. Initially each year in the above time interval is searched for occurrence of solar eclipses. This is followed by a search for lunar eclipses only in years with solar eclipses. It is found that during 501-1000BC, 177 solar eclipses were possible at Kuruksetra. The numbers for 1001-2000 BC and 2001-3000 BC were 369 and 345 respectively. These are further scanned for preparing a list of double eclipses, that is, a solar eclipse succeeding or preceding a lunar eclipse at a fortnight's interval. It is found that in the period under consideration 247 such double eclipses were possible. It is noted here that different softwares may lead to slightly different answers for eclipse occurrence. Without going into the issue of accuracy of these softwares it is mentioned here that PVIS has been checked and found correct with respect to the eclipses listed at the NASA website (http://sunearth.gsfc.nasa.gov/eclipse/SEcat/SEcatalog.html). Among the 247 double eclipses, our interest is initially restricted to those during which Saturn was near *Rohiṇī*. These results are presented in Table 1. Since Saturn has a long period of nearly 30 years to complete a cycle, it may be safely concluded that in the war year during the eclipse, Saturn should have been near *Rohiṇī*. The planetary positions are as seen from the sky chart of EZC software. The nearness to the star is liberally interpreted to mean a wide interval of two stars on either side of *Rohiṇī*. This way, solutions even if they are remotely possible, are not left out at the first level of sorting. No effort is made to resolve the positions of the planets more accurately since the textual statements, which were naked eye observations, have to be taken as true but approximate.

SEARCH FOR SE3 AND SE1

All solar eclipses preceded or succeeded by a lunar eclipse in the same month and with Saturn near *Rohiṇi* are listed in Table 1. Since all these years are possible candidates for the war year, any compatible SE3 should have occurred 35 years later reckoned from the *Kāratikā* month of these years. In Table 1, solar eclipses visible at Dvārakā (22° N, 69° E) 34-36 years after SE2 are also listed. It is observed that among the 31 solutions for SE2 only 13 are compatible with SE3. Thus, further search for SE1 would naturally get limited to these 13 pairs of (SE2, SE3) only. For each of these SE2 years, all possible antecedent solar eclipses at intervals of 13, 14 and 15 years are found. The results of such a search are presented in Table 2. For sake of completeness, lunar eclipses if any in the resulting years are also listed. The positions of Saturn and Jupiter on the night of SE1 date are listed for later discussions. It is seen that out of the thirteen possibilities of (SE2, SE3) only eight cases have had a solar eclipse SE1 occurring at the required interval. Thus, a detailed search and analysis of 2500 years of data produces eight possible sequences of three eclipses, as being compatible with the statements appearing in the text of MB. These triplets (SE1, SE2, SE3) in chronological order are (520,505,469/70); (724,711,676); (811,798,763); (843,830,795/96); (1493/91,1478,1443/44); (2638,2624,2588/89); (2758/57/56,2743,2708); (2759/58/57,2744,2709). It is recalled that all these sequences are compatible with the position of Saturn being near star *Rohiṇī* during the war. The only other reliable text available for further analysis is that before the war, on a *kārttika-kṛṣṇa-aṣṭamī* night, Mars was between *Jyeṣṭha* and *Anūrādhā* (*p.p.*1). With this in view for all the eight SE2 years, the planetary positions on the corresponding *kārttika-kṛṣṇa-aṣṭamī* night, as per EZC software are listed in Table 3. For finding the Julian date corresponding to the Indian date, the *pañcāṅga* software of Yano (http://kyoto-u.ac.jp/pub/doc/sanskrit/pancanga/) has been used. Now, it is observed from this table that there is only one SE2 year, namely 1478 BC, satisfying the stated position of Mars. The sky chart for 20.9.1478 BC is shown in Fig. 2a and Fig. 2b for two different times. Mars, on this date was not in retrograde motion; but Saturn was. To this extent, the observation of Mars may be

Table 1. Double eclipses observable a Kurukṣetra during 501-3000 BC Rohinī Series

No.	Year BC	Lunar eclipse	Solar eclipse	Saturn	S.E at Dvārakā after 35 years
1.	505	31 Jan.	16 Feb.	Bharaṇi	1.9.469; 20.3.470
2.	624	23 Jun	8 July	Bharaṇi	N.P
3.	679	1 June	17 June	Mṛgaśira	N.P
4.	711	27 Feb.	14 March	Bha-Kṛttikā	15.4.676
5.	768	21 Sept.	7 Sept.	Rohi-Mṛga	N.P
6.	798	23 Nov.	7 Nov.	Rohiṇi	15.6.763
7.	830	14 Jan. 829	30 Dec.	Aśvini	6.9.795; 24.3.796
8.	974	19 Oct.	4 Oct.	Rohiṇi	N.P
9.	1122	5 Oct.	21 Sept.	Rohiṇi	N.P
10.	1154	3 July	18 June	Aśvini	N.P
11.	1181	1 June	16 June	Rohiṇi	N.P
12.	1183	27 Jan.	12 Jan.	Aśvini	N.P
13.	1328	1 Nov.	17 Oct.	Rohi-Mṛga	N.P
14.	1478	16 May	1 June	Bha-Kṛttikā	7.1.1443, 18.1.1444
15.	1710	26 Oct.	10 Nov.	Ardrā	N.P
16.	1711	11 June	27 May	Rohiṇi	N.P
17.	1713	8 Jan.	22 Jan.	Aśvini	8.8.1677; 23.2.1678
18.	1832	29 May	13 June	Aśvi-Bhar	N.P
19.	1861	24 Dec' 62	9 Jan.	Rev-Aśvi	10.2.1826
20.	1917	7 July	23 June	Mṛgaśira	N.P
21.	2213	5 Nov.	20 Nov.	Kṛttikā	N.P
22.	2215	6 Jan.	22 Jan.	Rev-Aśvi	23.2.2180
23.	2567	19 Nov.	4 Dec.	Kṛttikā	N.P
24.	2594	18 Nov.	3 Nov.	Mṛgaśira	N.P
25.	2682	8 Feb.	24 Feb.	Mṛgaśira	28.3.2647
26.	2624	30 dec.	13 Jan.	Kṛttikā	4.2.2588; 11.8.2589
27.	2743	15 Nov.	31 Oct.	Kṛttikā	8.7.2708
28.	2744	1 June	16 June	Kṛttikā	24.1.2709
29.	2774	1 August	18 July	Bhar-Kṛtt	N.P
30.	2889	10 Sept.	26 Sept.	Mṛga-Ardrā	N.P
31.	2950	28 June	13 July	Kṛttikā	19.2.2915; 15.8.2915; 4.8.2914.

Table 2. Compatible eclipse years, from Table 1 (N.P = Not Possible)

No.	Year	Lunar eclipse	Solar eclipse	Saturn	Jupiter
1.	505	31.1	16.2	Bharaṇi	Pūrvābhādrā
	518	—	N.P	—	—
	519	—	N.P	—	—
	520	8.11	23.11	Anūrādhā	Uttarāṣāḍha
2.	711	27.2	14.3	Bhar-Kṛttika	Anūrādhā
	724	N.P	6.5	Mūla	Svāti
	725	—	N.P	—	—
	726	—	N.P	—	—
3.	798	23.11	7.11	Rohiṇi	Maghā
	811	N.P	30.12	Pūrvāṣāḍha	Punarvasū
	812	—	N.P	—	—
	813	—	N.P	—	—
4.	830	14.1.829	30.12	Aśvinī	Jyeṣṭhā
	843	N.P	2.5, 26.9	Anūrādhā	Citrā
	844	—	N.P	—	—
	845	—	N.P	—	—
5.	1478	16.5; 10.11	1.6	Rohiṇī	Revatī
	1491	11.2	23.7	Anū-Viśākhā	Dhaniṣṭha
	1492	—	N.P	—	—
	1493	4.3	19.3	Viśākhā	Mūlā
6.	1713	8.1	22.1	Rohiṇī	Kṛttikā
	1726	—	N.P	—	—
	1727	—	N.P	—	—
	1728	—	N.P	—	—
7.	1861	24.12.' 62	9.1	Revati-Aśvinī	Jyeṣṭhā
	1874	—	N.P	—	—
	1875	—	N.P	—	—
	1876	—	N.P	—	—
8.	2215	6.1	22.1	Aśvinī	Śravana
	2228	—	N.P	—	—
	2229	—	N.P	—	—
	2230	—	N.P	—	—
9.	2624	3013.'25	13.1	Kṛttikā	Puṣya
	2637	—	N.P	—	—
	2638	N.P	19.3	Mūlā	Rohi-Mṛga
	2639	—	N.P	—	—

Table 2 Continued

No.	Year	Lunar eclipse	Solar eclipse	Saturn	Jupiter
10.	2682	8.2	24.2	Rohiṇī	Citrā
	2695	—	N.P	—	—
	2696	—	N.P	—	—
	2697	—	N.P	—	—
11.	2743	15.11	31.10	Rohiṇī	Maghā
	2756	N.P	28.7	Jyeṣṭhā	Punarvasū
	2757	22.8	8.8	Jyeṣṭhā	Ardrā
	2758	10.3	25.3	Anūrādhā	Aśvinī
12.	2744	1.6	16.6	Rohiṇī	Puṣya
	2757	22.8	8.8	Jyeṣṭhā	Ardrā
	2758	10.3	25.3	Anūrādhā	Aśvinī
	2759	—	5.4	Viśākhā	U.hādra
13.	2950	28.6	13.7	Rohiṇi	Dhaniṣṭha
	2963	—	N.P.	—	—
	2964	—	N.P.	—	—
	2965	—	N.P	—	—

Table 3. Planetary positions as per EZC on kārttika kṛṣṇa-aṣṭamī of possible SE2 years

Date-BC	Saturn	Jupiter	Venus	Mars
1.10.505	Kṛttika	Revatī	Svāti	Bharanī
29.9.711	Kṛttika	Anūrādhā	Viśākhā	Citrā
1.10.798	Rohiṇī	Maghā	Hasta	Maghā
26.9.830	Kṛttika	Anūrādhā	Uttarā	Maghā
20.9.1478	Bhar-Kṛtt	Pūrvābhādra	Jyeṣṭha	Jyeṣṭha-Anūrādhā
31.8.2624	Mṛgaśitra	Pūrva	Jyeṣṭha	Uttarā
27.8.2743	Kṛttika	Maghā	Citrā-Svāti	Ardrā
6.9.2744	Kṛttika	Puṣya	Jyeṣṭha	Citrā-Svāti
28.9.1183	Bhar-Kṛttika	Śrav-Dhani	Svāti	Citrā
20.9.1185	Revatī	Jyeṣṭha	Uttarā	Hasta
30.9.1479	Aśvini	Dhaniṣṭha	Citrā-Svāti	Puṣya
6.9.1919	Bhar-Kṛttika	Śravaṇa	Mūla	Punarvasu-Puṣya

Table 4. Planetary Positions for sequence 1493-1478 B.C.

Date-BC	Saturn	Jupiter	Venus	Mars	Remarks
19.3.1493	Viśākhā	Mūla	P.bhādra	Maghā	Solar Eclipse
23.7.1491	Anū-Viś	Dhaniṣṭa	Uttarā	Viśākhā	Solar Eclipse
11.6.1479	Aśvini	Śhatabhiṣhak	Punarvasu	Kṛttika-Rohiṇī	Solar Eclipse
1.6.1478	Bharaṇi-Kṛttika	Revatī	Punarvasu	U.phalguni	Solar Eclipse
20.9.1478	Bhar-Kṛtt	P.bhādra	Jyeṣṭha	Jyeṣṭha-Anūrādhā	Kārtika Kṛṣṇaṣṭamī
12.10.1478	Bhar-Kṛtt	U.bhādra	P.āṣāḍha	Jyeṣṭha-Mulā	Kārtika Pūrṇimā

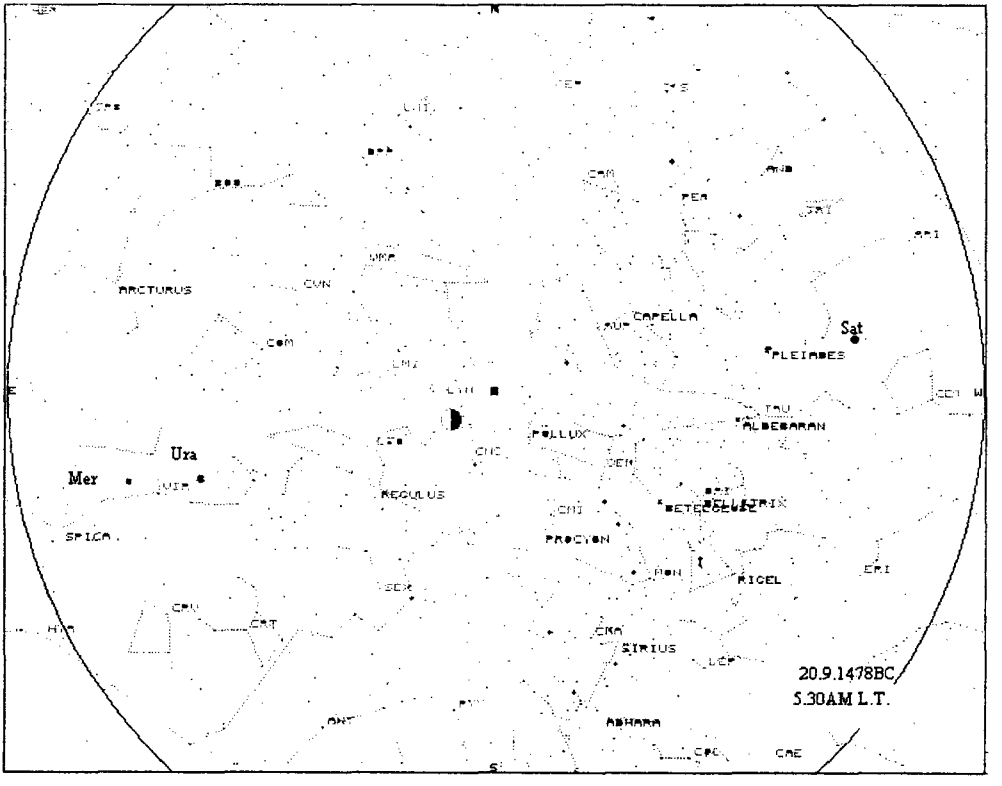

Fig. 2a. Sky Chart for 20.9.1478 BC 5.30 AM (LT)

inaccurate or taking Mars to be *vakra* could be a poetic fancy. It is clear from the figures that the un-named planet said to be afflicting star *Citrā* in *p.p.*1

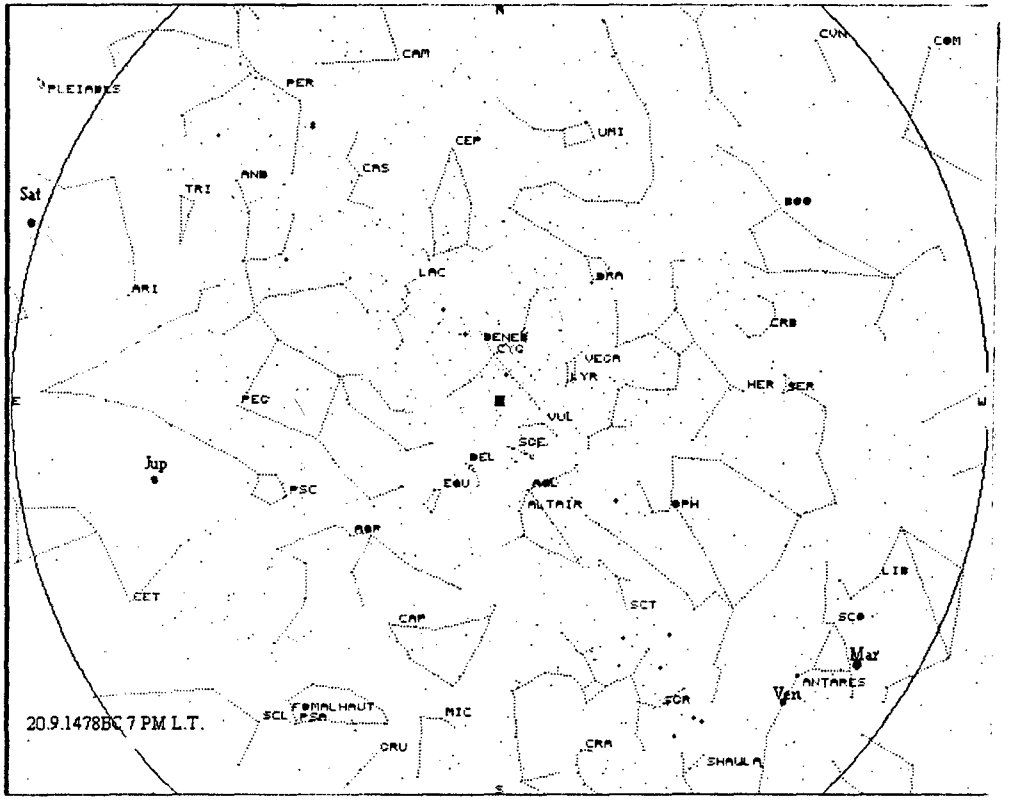

Fig. 2b. Sky Chart for 20.9.1478 BC 19 hrs. (LT)

should have been Mercury. This also matches with the further reliable statement of Vyāsa (*p.p.*3) on the following *kārttika pūrṇimā* night (12.10.1478 BC) that a white planet planet had crossed star *Citrā*. These positions can be seen in the early morning and evening sky charts for this date shown in Fig. 3a and Fig. 3b.

Hypothesis

The above results point out that the text is internally consistent with respect to eclipses and the first planetary position of Saturn and Mars.

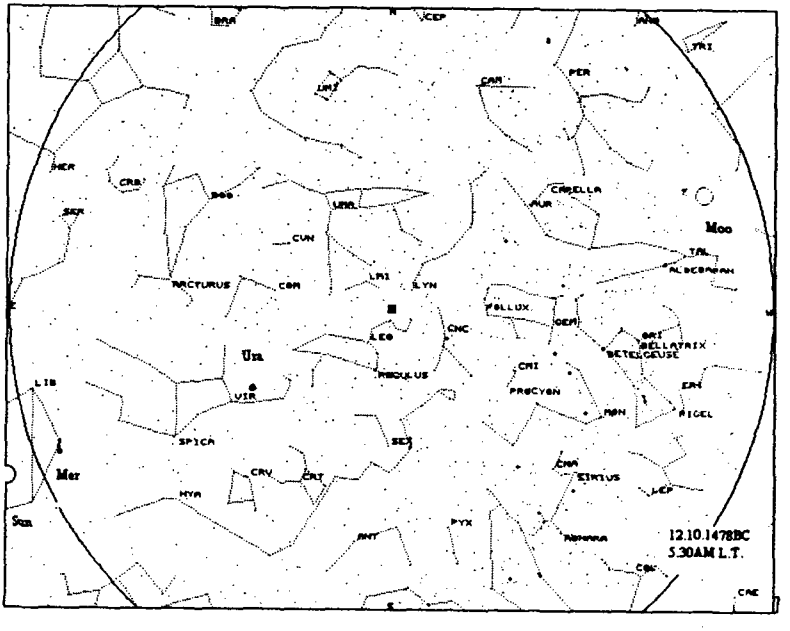

Fig. 3a. Sky Chart for 12.10.1478 BC 5.39 AM (LT)

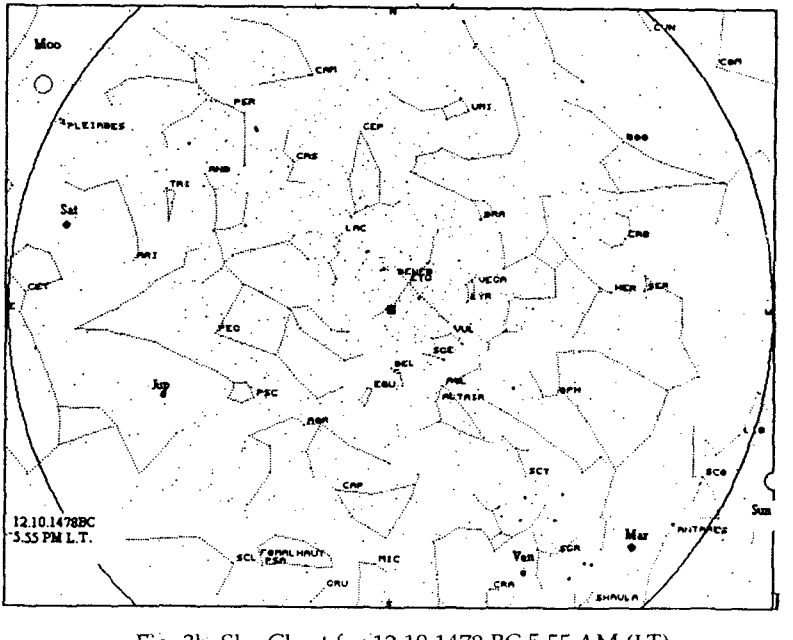

Fig. 3b. Sky Chart for 12.10.1478 BC 5.55 AM (LT)

However, the problem of the other statements from *p.p.*4 onwards remains to be sorted out. For this purpose, we proceed as follows. In Table 2, for the solar eclipse date in 1493 BC, the position of Saturn is seen to be near *Viśākhā*. It is only natural that if in the year of the war Saturn was near *Rohiṇī*, some fifteen years earlier Saturn should have been near *Viśākhā*. This agrees with the text at *p.p.*5, except that its relative position in the epic is wrong. Thus, it is hypothesized that whereas the text stating the planetary positions *p.p.*1; *p.p.*2 and *p.p.*3, refer to the war year, the later textual statements should belong to *Sabhā parvan* or refer to events therein. This hypothesis stands largely verified since the period 1493-1478 BC is compatible with the planetary positions mentioned in *p.p.*4 and *p.p.*5 as seen from Table 4, where the planetary positions are listed for some years arising as possible solutions during this period.

Analysis

The results of Table 3 and Table 4 are self-explanatory. Eight sequences of triplets have been identified as being compatible with the eclipses of the MB text. The least controversial *p.p.*1, mentions Mars as being between *Jyeṣṭhā* and *Anūrādhā*. This observation fits in with only one of the eight solutions namely, 20.9.1478 BC. The sky chart for this date is also shown in Fig. 2a, and Fig. 2b. This clearly confirms that the eclipse observations of MB could have been possible only in the period 1493 BC-1443 BC. It may be emphasized here that the two lengthy, but ambiguous, positions p.p.4 and *p.p.*5 have not been used to identify the above epoch as the historic period of the observations. In the identified year 1478 BC of the war not only a compatible double eclipse (SE2) was possible (Fig. 1) but also the planetary positions *p.p.*1 (Fig. 2a, 2b) and *p.p*2; *p.p.*3 were satisfied (Fig. 3a, 3b). The controversial positions *p.p.*4 and *p.p.*5 also get reasonably well confirmed, if they are taken to belong to another year. Table 4 again indicates 19.3.1493 BC (SE1) as the most likely date of observation for *p.p.*5. Both Saturn and Jupiter were near *Viśākhā* as mentioned (Fig. 4b). There was no planet in the *Kṛttikā* cluster. This may be in order, since the text only mentions a comet like planet in *Kṛttikā*. From the same figure, it is seen that

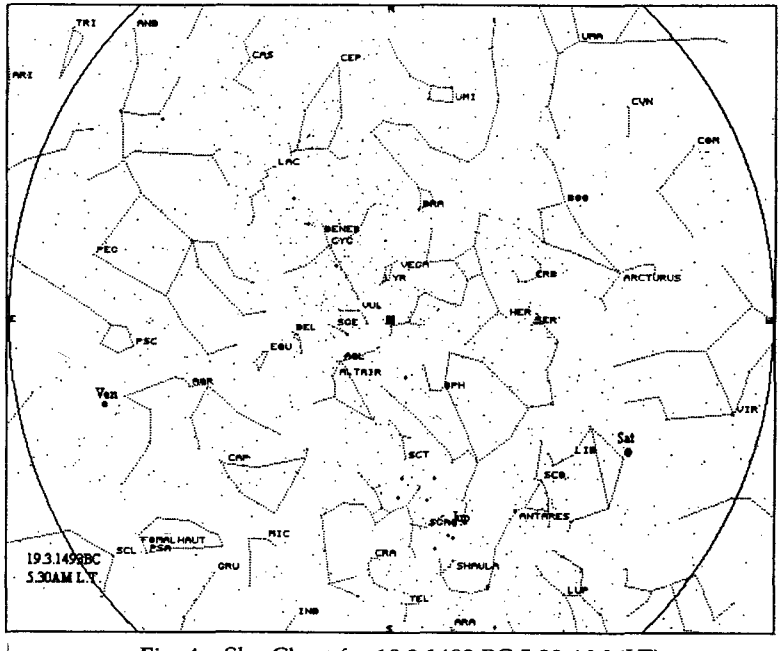

Fig. 4a. Sky Chart for 19.3.1493 BC 5.30 AM (LT)

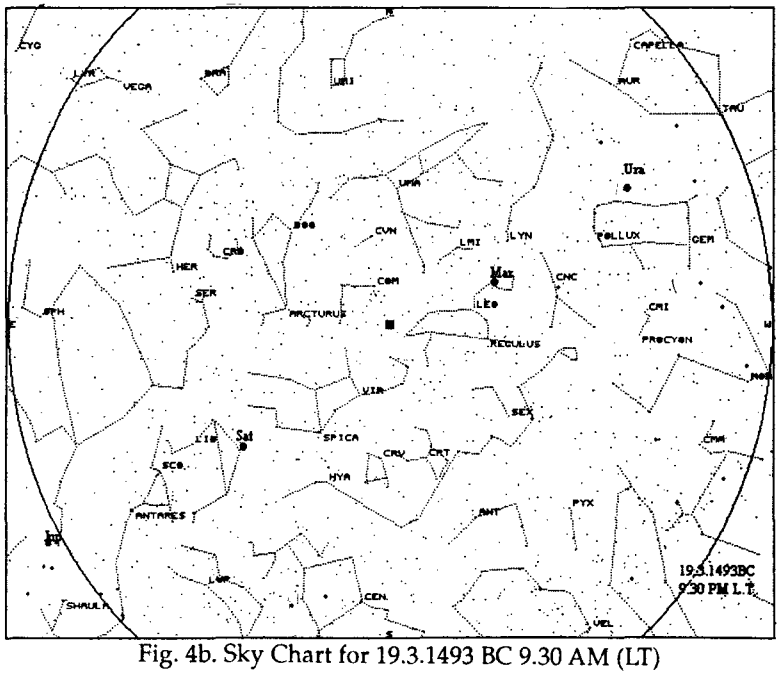

Fig. 4b. Sky Chart for 19.3.1493 BC 9.30 AM (LT)

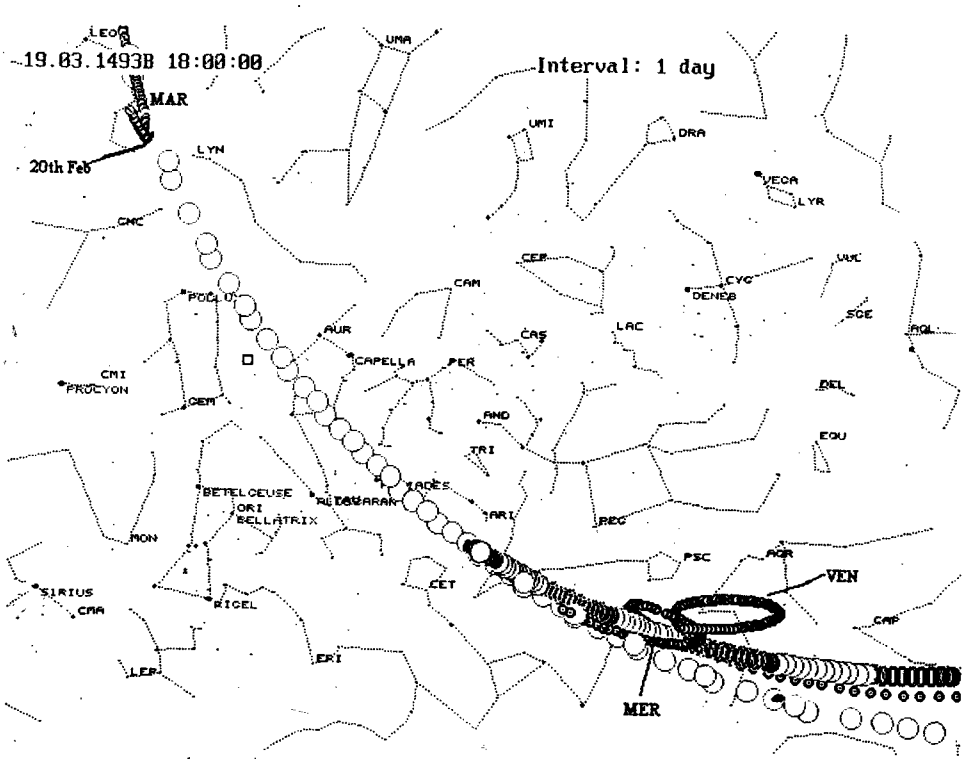

Fig. 4c. Retrograde motion of Venus and Mars during 19.12.1494 BC-19.3.1493 BC.

Mars was near star *Maghā* as mentioned in *p.p.*4. Mars was not exactly in retrograde (east to west) motion on the date, but it can be verified that Mars had turned back from such motion a month earlier and the loop had not yet been completed (Fig. 4c). The sky chart for the same date at 5.30 hours just before sunrise is shown in Fig 4a, where the positions of Venus and Jupiter can be clearly seen. Now, it is easy to conjecture that the positions of Jupiter given in *p.p.*4 and *p.p.*5 are in fact same. In the former, it is mentioned as being near *Śravaṇa*, while in the latter it is said to be near *Viśākhā*. The position of Venus in *Pūrvābhādra or Pūrva-Proṣṭhapadā* was also valid for this date as given in *p.p.*4. Further, it can be seen from Fig 4c that the movement of Venus mentioned, as having risen previously in *Proṣṭhapada* and after circling northwards to be seen with another planet is true. This figure shows the motion of Venus for a period of three months

prior to 19.3.1493 BC. The anonymous planet with which Venus was seen should have been Mercury before sunrise. If the star that was traversed by Venus is taken as *Uttarā*, then also the text fits in with the actual positions since, Table 4 supports this for the next solar eclipse date. The sky chart for the night of 12.10.1478 BC at 17.55 hours local time is shown in Fig. 3b. Venus was seen for some time in the western sky with Mars, after sunset. This chart indicates that the fiery dark planet (*śyāmo grahaḥ*) in *Jyeṣṭhā* was perhaps Mars on the eve of the war. From Fig. 3a, it is seen that the rough planet between *Citrā* and *Svātī* could have been Uranus. Thus, *p.p.*4 may contain some statements corresponding to the war year and some corresponding to a previous episode. Back calculation of eclipses and planetary positions uphold the hypothesis that some of the verses in *Bhīṣma parvan* of the text should belong, in all likely hood, to the conversation between Vyāsa and Dhṛtarāṣṭra towards the end of *Sabhā parvan* or beginning of *Araṇya parvan*. The remaining planetary positions for the 13th and the 18th day of the war are not reliable as indicated by wide differences in the text editions. However, if the nomenclature *yamasya putraḥ* in *p.p.*6, is taken to mean Saturn, the retrograde motion during the war, as indicated in the text is correct. Similarly, Jupiter was also retrograde, near star *Revatī*, but not near Rohini. The two planets appearing bright in the evening sky separated by some distance might have lead to the simile that they were like Sun and Moon.

Discussion

There are many clues in the text of MB for fixing dates within a year. For example, one can easily guess that the war should have started immediately after a *kārttika pūrṇimā*. Similarly we find that Bhīṣma died on or very near the day of winter solstice. But such informations are not sufficient to fix the epoch or macro-date of the epic. The longest historic time interval the epic mentions is the thirty-six year time period between the war and the end of the clan of Vṛṣṇis including Kṛṣṇa. Internal evidence in the text indicates the war was used as an origin to mention another time period namely the length of stay of Dhṛtarāṣṭra with Pāṇḍavas as fifteen

years. Thus to estimate the year of the war with reference to a longer or present day time frame, one needs reliable observations of dateable events. Fortunately, the epic contains several observations of eclipses and planet positions. Some of these may be approximate and even difficult to interpret today. The present effort has been to interpret the celestial observations of the text with the help of modern computer softwares. The primary question asked is whether or not the various statements of the epic are internally compatible. From the extensive search of solar and lunar eclipses and planetary positions carried out, it is found that the textual statements are consistent among themselves provided, they were observed during the period 1493-1443 BC. Infact one can quite accurately estimte that the war should have taken place in the year 1478 BC. This result may have an error

Table 5. Double eclipses observable at Kuruksetra during 501-3000 BC Viśākha Series

No.	Year BC	Lunar eclipse	Solar eclipse	Saturn	Jupiter
1.	664	13 Aug.	28 Aug.	Mūla	Viśākha
2.	758	1 Sept.	17 Sept.	Svāti	Jyeṣṭha
3.	782	30 June	15 June	Mūla	Anūrādhā
4.	876	18 July	4 July	Citrā	Mūla
5.	1198	4 Nov.	21 Oct.	Anūrādhā	Anūrādhā
6.	1375	18 May	3 May	Viśākha	Anūrādhā
7.	1436	28 August	13 August	Citrā-Svāti	Citrā-Svāti
8.	1493	4 March	19 March	Viśākha	Mūlā
9.	1849	1 Nov.	17 Nov.	Svā-Viś	Jye-Mulā
10.	1932	26 April	11 April	Jyeṣṭha	Jyeṣṭha
11.	2051	16 Sept.	2 Sept.	Anūrādhā	Jyeṣṭha
12.	2053	13 April	29 April	Viśākha	Hasta-Citrā
13.	2171	28 Feb.	14 Feb.	Viśākha	Svā-Viś
14.	2289	5 Dec.	20 Dec.	Viśākha	Jyeṣṭha
15.	2406	11 Oct.	26 Sept.	Viśākha	Mūlā
16.	2407	27 April	13 May	Svāti	Anūrādhā
17.	2433	9 Sept.	24 Sept.	Jyeṣṭha	Citrā-Svāti
18.	2492	5 June	22 May	Jyeṣṭha	Hasta
19.	2527	29 Sept.	14 Oct.	Svāti	Viśākha
20.	2703	24 Sept.	10 Sept.	Citrā-Svāti	Jyeṣṭha
21.	2704	11 April	26 April	Hasta	Viśākha
22.	2762	22 May	6 June	Svāti	Mūla

band of one year, since the intervals between the three constraining eclipses are uncertain to the extent of one year. Also, while we have followed the solar year for our calculations, it is not known which system has been followed by the text. It is important to discuss one important aspect of the present approach. The work reported and the results obtained are based on the premise that the double eclipse mentioned in the text occurred in the war year. A close look at the text in *p.p.*5 of *Bhīṣma parvan* (3.29) gives a feeling that this could as well be associated with the position of Saturn and Jupiter being near *Viśākhā*, which has been identified previously with an earlier eclipse (SE1). This raises the question whether other results are possible if one starts with SE1 as a double eclipse with Saturn and Jupiter being near *Viśākhā* in that year. The reverse search to identify SE2 and SE3 starting from all possible SE1 years has also been carried out. In Table 5, all possible double eclipses observable at Kuruksetra in the search period, when Saturn and Jupiter were near *Viśākhā* are listed. From this table another list of possible solar eclipses 13-15 years later with Saturn being near *Rohiṇī* are prepared and shown in Table 6. In this table, the possibilities of an eclipse (SE3) after 35 years from SE2 are also indicated. It is seen that there are three triplets (1198, 1185/83, 1150), (1493, 1479/78, 1444/43), (1932, 1919, 1884) which satisfy the relative time sequence of the eclipses and the important Saturn positions. It is interesting to see that the second among this new sequence is nearly same as the one previously discovered as the MB eclipse triplet. For the four possible SE2 years of this sequence, the position of Mars as per *p.p.*1 on the *kārttika-kṛṣṇa-aṣṭamī* night is presented in the last four rows of Table 3. Even with this alternate interpretation and extensive reverse search, year 1478 BC remains as the unique and most likely year of the war.

It has not been possible to interpret one of the positions of Saturn said to be near *Pūrva-phalgunī*. This may not be a serious limitation because reference to Saturn as *Śanaiścara* is more reliable than the mythological name *Sūryaputra*. The last verse of (*p.p.*4) referring to Mars (?) also has not been fully interpreted here. In the present analysis, the positioning of the planets with the stars has been done by inspection of the star chart as shown by the

Table 6. Compatible eclipse years from Table 5. (N.P = Not Possible)

No.	Year BC	Lunar eclipse	Solar eclipse	Saturn	Jupiter	S.E3 at Dwaraka 35 years after war
1.	664	13.8	28.8	Mūla	Viśākha	—
	651		7.6	Rohiṇī	Jyeṣṭha	N.P
	650	—	N.P	—	—	—
	649	—	N.P	—	—	—
2.	782	30.6	15.6	Mūla	Anūrādhā	—
	769	—	N.P	—	—	—
	768	21.9	7.9	Rohi-Mṛga	U'āṣāḍha	N.P
	767	—	N.P	—	—	—
3.	1198	4.11	21.10	Anūrādhā	Anūrādhā	—
	1185	18.2	28.8	Revatī	Jyeṣṭha	7.4.1150
	1184	—	N.P	—	—	–
	1183	27.1	12.1	Rohini	Śravaṇa	N.P
4.	1493	4.3	19.3	Viśākha	Mūla	—
	1480	—	N.P	—	—	—
	1479	N.P	11.6	Aśvini	Śravaṇa	18.1.1444
	1478	16.5;10.11	1.6	Krttika	Revati	7.1.1443
5.	1729	31.5	16.5	Svā-Viś	Śravaṇa	—
	1716	—	N.P	—	—	—
	1715	—	N.P	—	—	—
	1714	N.P	29.7	Rohini	Krttikā	N.P
6.	1932	26.4	11.4	Jyeṣṭha	Jyeṣṭha	—
	1919	29.7	18.2	Bharaṇi	Śravaṇa	15.9.1884
	1918	—	N.P	—	—	—
	1917	7.7	23.6	Rohini	Śravana	N.P
7.	2289	5.12	20.12	Viśākha	Jyeṣṭha	—
	2276	—	N.P	—	—	—
	2275	—	N.P	—	—	—
	2274	27.2	15.3	Bharani	Dhaniṣtha	N.P
8.	2433	9.9	24.9	Jyeṣṭha	Cit-Svāti	—
	2420	N.P	4.7	Kṛttika	Cit-Svāti	N.P
	2419	2.12	23.6	Rohiṇi	Anūrādhā	N.P
	2418	—	N.P	—	—	—
9.	2492	5.6	22.5	Jyeṣṭha	Hasta	—
	2479	—	N.P	—	—	—
	2378	4.3	14.8	Rohiṇi	Jyeṣṭha	N.P
	2477	—	N.P	—	—	—

Table 7. Nakṣatras of Mahābhārata and their identifying stars

No.	Naksatras	Identifying Stars	Star Names	Diety Names
1.	Kṛttikā	η Tauri	Alcyone	Agni
2.	Rohiṇī	α–ε Tauri	Aldebaran	Brahma
3.	Mṛgaśirā	λ, ϕ Orionis	Meissa	Candra
4.	Ardrā	α Orionis	Betelgeuse	Rudra
5.	Punarvasū	β, α Geminorum	Pollux	Aditi
6.	Puṣya	θ, δ, γ Cancri	Asellus	Bṛhaspati
7.	Aśleṣā	ε, δ, σ, η, ρ Hydrae	Minhar	Sarpa
8.	Maghā	α–ε Leonis	Regulus	Pitṛ
9.	Pūrva-Phalgunī	δ Leonis	Zozma	Bhaga
10.	Uttara-Phalgunī	θ Leonis	Zozma	Aryamā
11.	Uttarā	β Leonis	Denebola	
12.	Hasta	δ, γ, ε, α, β Corvi	Algorab	Sāvitri
13.	Citrā	α Virginis	Spica	Tvaṣṭr
14.	Svātī	α Bootis	Arcturus	Vāyu
15.	Viśākhā	α Librae	Zubenelgelubi	Indra-agni
16.	Anūrādhā	δ, β, Π Scorpii	Dschubba	Mitra
17.	Jyeṣṭhā	α, σ, τ Scorpii	Antares	Indra
18.	Mūla	λ–ε Scorpii	Shaula	Nirṛti
19.	Pūrvāṣāḍha	δ, ε Sagittarii	Kaus Australis	Āpaha
20.	Uttarāṣāḍha	σ, ζ Sagittarii	Nunki	Viśva
21.	Abhijit	σ, ε, ζ Lyrae	Vega	Dakṣa
22.	Śravaṇa	α, β, γ Aquilae	Altair	Viṣṇu
23.	Dhaniṣṭha	β, α, γ, σ Delphini	Formelhaut	Vasu
24.	Satabhiṣak	λ Aquarii, etc.	Situla	Varuṇa
25.	Pūrva-Bhādrapada	α, β Pegasi	Markab	Ajaikapāt
26.	Uttara-Bhādrapada	γ Pegasi, α Andromedae	Alpheratz	Ahirbudhnya
27.	Revati	ζ Piscium, etc.	Rischa	Pūṣan
28.	Aśvinī	α–γ Arietis	Hamal	Asvinau
29.	Bharaṇī	35-41 Arietis	41 Arietis	Yama

software EZC. Certain level of subjectivity is unavoidable in such an exercise. Fixing the position of planets more accurately is possible, but is not warranted in view of the approximate nature of the textual observations. There are again limitations with any eclipse search exercise. For this we have relied on the software PVIS. If another software is used one may get slightly different results. However, it is felt that any objective exercise will lead to a period not far different from what has been obtained here. The result of Sharma (1986), who obtained 1493 BC as the possible war year, amply demonstrates this point. Conversion of an Indian date to corresponding Julian date has been necessitated in the present investigation in one place. Thus the limitations of the *Pañcāṅga* software, listed by Yano, would be applicable to the month and date of *kārttika pūrṇimā* in 1478 BC. This may introduce an error of the order of a month into the dates within a year. An obvious limitation of the present work is the time period studied. For years prior to 3000 BC, it would be interesting to find whether the three eclipse sequences and other textual statements can still be satisfactorily explained.

Summary and Conclusion

The internal consistency of the eclipses and planetary positions mentioned in *Māhābharata* has been studied in this paper from a novel perspective. After a brief review of interesting astronomical informations given in the text, including a theory of eclipses, the data base available for back calculations of eclipses and planetary positions is listed with variant readings. A simple working translation of the archaic statements, part of which is in conflict with the traditional interpretation, is also provided. There is a clear reference in the text to a double eclipse, that is a lunar and a solar eclipse in either order, with in the period of one month. However, it is not clear from the position of the text whether this was with Saturn near *Rohiṇī* or the Saturn-Jupiter combine near *Viśākhā*. To resolve this issue all solar eclipses and double eclipses during 501 BC-3000 BC have been determined for Kurukṣetra and classified into two groups. The constraint that in the 36th year after the war, a solar eclipse was observed at Dvārakā

is also used. This exercise leads to twelve possibilities namely, BC years 2744,2743,2624,1919,1479,1478,1185,1183,830,798,711,505 for the MB war. At this stage invoking the non-controversial statement in *Udyoga parvan* that Mars was between stars *Jyeṣṭhā* and *Anūrādhā* it is found that 1478 (±1) BC is the unique solution to the year of the war of the epic. It is demonstrated, using only the most reliable verses of the text that, some of the statements appearing in *Bhīṣma parvan* should refer to or belong to *Sabhā parvan* and hence almost all the celestial observations of MB are internally compatible. Wrong sequencing of texts in ancient manuscripts, based on which the present day printed versions are made available, is not unusual. Even smaller compositions such as *Dharma Sūtras* have needed special efforts in arranging them in a sequence. For example Sūryanārāyaṇa arranged the available versions of *Āpastamba Dharma Sūtra* in the traditionally understood order in 1933. Similarly Lagaḍha's *Vedānga Jyotiṣa* text was edited and arranged sequentially, still more recently, by Kuppanna Sastri in 1984. In a text as large as *Mahābhārata* it is no wonder the chronological ordering of the events and observations might have got mixed up due to transmission errors. Still it is remarkable, everything falls into place as in a puzzle and an almost unique epoch emerges for the celestial observations.

There are precise informations available in the MB text to prepare a reasonable calendar of events during the discovered period, which is yet to be done. Similarly, reported observations of comets are to be studied. The statements in *Bhīṣma parvan* about the double stars *Vasiṣṭha* and *Arundhatī* (Mizar and Alcor) and the pole star *Dhruva* have to be critically investigated. Another interesting exercise would be to verify the concordance of the results obtained here with other ancient literature concerning Kṛṣṇa. The most important among these would be *Harivaṁśa*, traditionally considered an appendix to MB. Later *Purāṇa* literature rich in Kṛṣṇa lore also contains references to eclipses, comets and similar phenomena, some of which may be amendable for objective present day investigations. The encyclopedic *Mahābhārata* text itself contains references to natural phenomena such as earthquakes, meteorite impacts, floods and famines prior to its period. Now, that the period of some of the natural

phenomena in the epic has been objectively established to belong to 1493 BC-1443 BC, it would be of historical and scientific interest to verify the veracity of still more ancient natural events, including drying up of river Sarasvati.

Acknowledgements

Thanks are due to Prof. Yano of Kyoto University, Japan for permission to download his *pañcāṅga* software. The financial support of Indian National Academy of Engineering (N. Delhi) under its Indian Engineering Heritage (Civil) group is gratefully acknowledged.

Notes and References

1. Thirteen Sanskrit dramas of Bhāsa were unearthed and published by Pandit Ganapati Sastri of Trivandrum in 1913. Even though the date of Bhāsa is not beyond dispute, based on his style, scholars have placed him around 2nd cent. BC. See *Survey of Sanskrit Literature* by C. Kunhan Raja; Bharatiya Vidya Bhavan, Bombay 1962.
2. The *Mahābhārata* text brought out by Bhandarkar Oriental Research Institute, is considered a well researched critical edition of the epic. The Machine-readable text of this version was produced by Prof. Muneo Tokunaga, of Kyoto University, Japan with help from several of his Japanese colleagues. The initial version was completed on November 14, 1991. The first revised version (VI) appeared on September 16, 1994. Further upgraded version (1_1) has been available since October 1, 1996.
3. Pandit Hayagrīva Śastri brought out not only *Mahābhārata* but also several during the first half of 19th century. The year of publication of the MB text is not known: However for the *Bhāgavata Purāṇa*, the publication year is mentioned as *indu-muni-sindhu-śaśidhara* sālivāhana śaka. This corresponds to 1849 A.D. MB should have been brought out earlier. He mentions in his introduction that the has consulted several manuscripts of the epic, to prepare the print version. He has included at many places the Sanskrit commentary of Nīlkaṇṭha. He has identified several portions of the text as interpolated, since they were not available in all manuscripts collected by him from Vārāṇasī and other places.

4. Kisari Mohan Ganguly, was the real translator of *Mahābhārata* into English. This monumental work has been incorrectly attributed to P.C. Roy, who was only a Publisher, in an earlier Calcutta edition. The edition of the translation brought out by M/s Munshiram Manoharlal Publishers Pvt. Ltd. of new Delhi, in 1993 corrects this mistake.

5. *Bhārata Darśana* in Kannada, as the name itself indicates is not a literal translation, although it preserves the original faithfully. The work brought out in 36 volumes is exhaustive and contains critical discussion on the differences among the available versions of the text. Internal inconsistencies in the text are also pointed out in several places. The work closely follows the Gita Press edition containing the commentary of Nīlakaṇṭha.

6. PVIS software does not show any lunar eclipse at Kurukshetra for the year 1493 BC. Since, V.N. Sharma reports a lunar eclipse on 4.3.1493 BC this has been included in Table 5. However, ignoring this will not affect the results and conclusions in any manner.

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