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A Profile of Indian Astronomy before the Siddhāntic Period

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Introduction

S.B.Dikshit[1], the first person to write a definitive history of Indian astronomy, traces the subject in two distinct periods called pre-siddhāntic and siddhāntic. The word *siddhānta* in this context may be roughly translated as mathematical or computational astronomy. The content, outreach and limitations of the siddhāntic astronomy are better known, with large number of texts starting from the Common Era. A typical feature of these texts is their postulation of a long period of time called *Kalpa* in which planets execute integral number of revolutions. These texts also divide the ecliptic into twelve equal parts (Rāśi) sequentially named Meṣa, Vṛṣabha etc. Another distinguishing feature of texts belonging to the siddhāntic period is their silence about comets, except for the Bṛhat-samhitā (*abbr. BS*)[2,3] and the Nārada-samhitā[4]. Varāha-mihira the famous author of *BS* frankly declares that he is only presenting what ancient astronomers Parāśara, Garga, Asita and Devala have said about comets. Thus clearly there is nothing original in the *Ketucāra* of *BS (Chapter XI)*, but is notable for the bulk of information provided, which in parts appears realistic, even though there are inconsistencies. Even a casual reading of *BS* makes one wonder why Parāśara and others living several centuries before Varāha should have named, classified and left observational records about comets. For the pre-siddhāntic period we have only a single published text namely, Lagadhā's Vedānga Jyotiṣa[5]. This text is solely devoted to the calendar and is silent about planets, eclipses and comets. However, several scholars have pointed out that a class of texts called *samhitā*, containing astronomical information, authored by Parāśara, Garga and others should have existed in the pre-siddhāntic period[1,6]. Since Pāṇini, the famous grammarian, cites Parāśara and Garga, it is generally surmised that these astronomers should have lived before 700 B.C.[7,8] The texts of these authors are perhaps not any more available in their original form. Nevertheless there are two sources from which we can know the basic features of the ancient *samhita*s. These are the commentary of Utpala (10th cent A.D.) on *BS*[2] and more importantly the Adbhuta-sāgara of Ballāla-sena[9] (11-12th Cent A.D.), wherein the original texts, at least in part, are reproduced as lengthy quotations. Parāśara's text, denoted here as Parāśara-samhitā *(abbr. PS)* is in prose, a literary form rare in Sanskrit. Many of the sentences in *PS* end with the word *iti* typical of Vedic Brāhmaṇa texts. As per Roy[10], William Jones in 18th century had access to a copy of Utpala's commentary, which had quoted Parāśara with accents common to Vedic texts. In the available published version Utpala refers to *PS* as *Parāśara-tantra*, a technical name

for the same prose composition[2]. Varāha-mihira himself cites this *tantra* by name in *BS* (Ch. VIII 8-13) on Mercury's transit. He presents the same visibility information given in *PS* as quoted by Utpala.

Adbhuta-sāgara *(abbr. AS)* is a book belonging to the genre of compilations focusing on anomalous phenomena. The compiler of this book was Ballāla-sena about whom considerable historical information is available[11,12]. Ballāḷa-sena was a king ruling at Mithilā, but his origins were in Karnāṭaka. He collected information on anomalous happenings from available sources and named his book aptly Adbhuta-sāgara (Ocean of Wonders). His intention was perhaps to bring in one place scientific information, myths and religious beliefs prevalent during his time about natural phenomena. *AS* repeats the statements of Varāha-mihira, Garga, Asita, Devala, Atharva-muni, Parāśara, Vṛ.Garga and a few others. *AS* has three sections, called celestial *(divya*), atmospheric *(antarikṣa)* and terrestrial *(bhauma)* anomalies *(utpāta)*. It is the first part, with fourteen chapters, that is important for our study. Among the above authors Parāśara writing conspicuously in prose attracts our attention. A comparison of *AS* with Utapala's commentary clearly brings out that the unique prose text of *PS* was widely known in India till at least 12th Cent A.D. *PS* preserves a tradition of *nakṣatra* (stars along the ecliptic) as the background for observing the sky. *PS* indicates the seasons also in terms of *nakṣatra* divisions and is unaware of the twelve zodiacal signs or *Rāśi* of siddhāntic astronomers. This tradition appears to have been continued by Vṛ. Garga with significant additions. As is typical of ancient Indian authors, the identity of the above persons is not known. Moreover, Parāśara and Garga being family names there are several claimants for the authorship of the *samhitā* connected with these authors. Pingree's Census[13] lists more than twenty-five individual titles attributed to Garga and Parāśara with several hundred manuscripts spread over libraries in India and abroad. With this constraint in the background, here the material preserved in *AS* and corroborated by Utpala is considered further. Fortunately *PS* distinguishes itself from others by being in prose. To be on the safe side we omit verses attributed to Parāśara and also limit our attention among the various Gargas, to the statements of only Vṛddha Garga, that is, Garga the senior. Interestingly, the preserved texts of these two pre-siddhāntic astronomers provide a consistent list of comets through which a dim historical basis can be established for the first Flood that finds mention in Vedic, *Itihāsa* and *Purāṇa* literature. In this paper a brief account of *PS* is presented to illustrate the nature of astronomy in India before the *Siddhāntic* era. However, this does not exhaust all questions related to the origins and evolution of Indian astronomy.

Besides Vedānga Jyotiṣa, the Vedic Samhitā texts and the most ancient parts of the Purāṇa legends contain astronomical information. Dikshit[1] and later a few others have attempted to unearth some astronomical hymns from the core Vedic texts. In the present study, after discussing the text of Parāśara, the possibility of the Ṛgveda containing astronomical information, wrongly interpreted over time, is highlighted. The special number 3339 arising for the first time in the Ṛgveda is demonstrated to be related to the eighteen year eclipse period. This indicates that further work is necessary to decipher ancient symbolisms to bring out a cogent picture of sky observations alluded to in the Vedic literature.

Date of Parāśara's Tradition

In the second chapter of *AS* titled, *Sūrya-adbhuta-āvarta* or sun's wonder, the position of solstices as stated by Varāha-mihira is given. This corresponds to summer solstice being at the third quarter of star *Punarvasū* (β-geminorum). This is followed by the position during Ballāla-sena's time, when summer solstice was observed to be at the beginning of *Punarvasū*. This amounts to a precession of 7^0- 8^0 indicating a time difference of 500-600 years (72 years per degree) between Varāha-mihira and Ballāla-sena. Allowing for errors of naked eye astronomy, the above observation appears quite realistic, since we know that Varāha-mihira lived in the 6th century whereas *AS* was composed in the 12th century. Next the relation between seasons and sun's position among stars as per Parāśara is quoted:

[तथा च स्वकालिकम् ऋतुक्रमम् आह पराशरः ।]

तस्य श्रविष्टाद्यात् पौष्णान्तम् चरतः शिशिरः । वसन्तः पौष्णार्धात् रोहिण्यान्तम्। सौम्यात् सर्पार्धम् ग्रीष्मः । प्रावृट् सर्पार्धात् हस्तान्तम् । चित्राद्यात् ऐन्द्रार्धं शरत् । हेमन्तो ज्येष्टार्धात् वैष्णवान्तमिति॥

[Parāśara said (the following) order of the seasons during his time]
Śiśira(cold season) is when he (Sun) transits from beginning of Dhaniṣṭhā till middle of Revatī. Vasanta (spring) is from middle of Revatī till end of Rohiṇī. Grīṣma (summer) is from beginning of Mṛgaśirā till middle of Āśleṣā. Varṣā (rainy season) is from middle of Āśleṣā to end of Hastā. Śarat season is from Citrā to middle of Jyeṣṭhā. Hemanta (dewy season) is from middle of Jyeṣṭhā to end of Śravana.

There is a scribal mistake in the first sentence, which should read *pauṣṇārdham*, as seen from the next statement, which is correct. Utpala's *PS* text reads exactly as above with the correct phrase *pauṣṇārdham* in place of *pauṣṇāntam*. This is the *nakṣatra* system of astronomy, using stars along the ecliptic as background for sky observations. Since the winter season started at the first point of star *Dhaniṣṭhā* (β-delphini) this would be same as the year beginning of *Vedāṅga-jyotiṣa*, which is a well discussed topic[1,5]. Varāha-mihira whose time may be taken as 530 AD provides sun's position at winter solstice as the first quarter of star *Uttarāṣāḍha* (σ-sagittari). He also says that before his time once it was observed to be at the beginning of star *Dhaniṣṭhā*. Utpala, attributes this ancient observation to Parāśara quoted above. This movement amounts to a precession of 23^0 20'. From this information the era of *PS* has to be assigned to 1150-1370 B.C., same as that of *Vedāṅga-jyotiṣa*. It is noteworthy that *PS* does not indicate the seasons in terms of the twelve zodiacal signs or *Rāśi*, as done by Varāha-mihira and Brahma-gupta. However, it is possible Parāśara himself or his family members might have observed variations to the above positions and remarked them as anomalous. This is inferred from a statement about the position of the solstices.

यद्यप्राप्तो वैष्णवमुदग्मार्गं प्रपद्यते। दक्षिणमाश्लेषां वा महाभयाय इति ॥

If (sun) goes north without reaching [the last point of] star Śravaṇa and goes south without reaching [the midpoint of] star Āśleṣā, it causes great fear.

Such drift in the solstices could have been observed after one or two generations due to precession. Hence *PS* might have been edited over time. However, the initial point of the tradition should be assigned to *circa* 1400 B.C.

Planets as per Parāśara

The archaic astronomy of *PS* is quite unlike that of later *siddhāntas* that give the number of revolutions of different planets in a long period of years called *kalpa*[14]. *PS* on the other hand knows all the planets but is too primitive in describing their motion. Thus, this seems to belong to the early stages of Hindu astronomy, when the subject was still rooted in empirical observations without appeal to computations. *PS* treats many configurations as anomalous and hence portentous. To conclude an observation to be anomalous one has to have an idea of what is normal. This average behaviour could have only come out of long observations. About Sun, besides the seasons in terms of four-and-half *nakṣatras* stated above, colours in the various seasons and sunspots are described. Position of Sun at solstices is mentioned. Moon is described in terms of its colour, shape and position with the stars. Association of moon with other planets and possibility of occultation of Mars, Venus, Jupiter and Saturn by Moon is mentioned. Next, Rāhu the imaginary dark planet responsible for causing solar and lunar eclipses is discussed. Concept of Rāhu as the node or point of intersection of the lunar orbit with the ecliptic is not present. *PS* mentions about prognosis of eclipses based on precursors related with the shape, colour and such other observable anomalies of Sun and Moon. Obviously the real causes for either solar or lunar eclipses were not known. Varāha-mihira in *BS* strongly criticizes the precursors of Parāśara as invalid. Nevertheless *PS* contains statements, which presuppose systematic observations as can be inferred from the following.

षण्मास्या चन्द्रमसस्ततो अर्धषष्टे चादित्यस्याभिपूजितमाहुः आचार्याः।
सप्तदशत्रयोदशपंचत्रिंशत् मासिकानि चेन्दोस्त्रीणि विसन्धि ग्रहणानि।

Our teachers said: moon gets eclipsed at six months and sun at three months interval. Seventeen, thirteen and thirty-five monthlies are the three Visandhi eclipses of moon.

The above statement implies that there were several lunar eclipses observed at six full moons apart. Perhaps once a new eclipse in such a series started the subsequent ones were predictable. The exceptions mentioned, as *Visandhi* should have been the observed intervals of eclipses that were not at six months. *PS* also introduces a three-and-half year cycle of *Parvan* (syzygy) at six months interval, which has been borrowed by *BS* and other later writers. *PS* classifies eclipses based on colour, the way the shadow spreads and moves out of the solar and lunar orbs. Even though both solar and lunar eclipses are covered under one heading called *Rāhu-adbhuta* in *AS* and *Rāhu-cāra* in *BS*, it is the lunar that has received more attention. All the five planets are described at length, starting with Mars. Tracking Mars should have been difficult, since unlike other planets no visibility or movement number is given. But considerable effort has been made to

verbally describe the retrograde motion of Mars. The movement of Mercury is traced in seven lanes depending on its station with the stars along the ecliptic.

अथास्य गतयःसप्त प्राकृता विमिश्रा संक्षिप्ता तीक्ष्णा घोरा पापा योगान्तिका च । तत्र प्राकृता याम्याग्नेयरोहिणीवायव्यानि । मिश्रा सौम्यार्द्रा मघाश्लेषा च । संक्षिप्ता पुष्यार्यम्णभाग्यादित्यानि । तीक्ष्णा अजापदतस्चत्वारि ज्येष्ठा च । घोरा त्रीणि श्रवणादीनि त्वाष्टं च । पापा सावित्रेन्द्राग्निमैत्राणि । योगान्तिका मूलमाषाढे ॥ अथ चत्वारिंशत्त्रिंशद् द्वाविंशत्यष्टादशपञ्चदश एकादशनवरात्राणि गतिक्रमादुदितो अभिदृश्यते तान्येवास्तमितो भवति ।

Mercury's paths are seven: prākṛtā, vimiśrā, samkṣiptā, tīkṣṇā, ghorā, pāpā and yogāntikā. Prākṛtā is with stars Bharaṇī, Krttikā, Rohiṇī, Svātī. Miśrā is followed with stars Mṛgaśirā, Ārdrā, Maghā and Āśleṣā. Samksiptā is with stars Punarvasū, Pusya, Pūrva- and Uttara-phalgunī. Tīkṣṇā includes the four stars from Pūrvābhādra and Jyeṣṭhā. Ghorā is along Śravaṇa, Dhaniṣṭhā, Śatabhiṣak and Citrā. Pāpā is along Hastā, Viśākhā and Anūrādhā. Yogāntikā is along Mūla and the two Āṣāḍha. Along these seven paths it (Mercury) is visible for 40, 30, 22, 18, 15, 11 and 9 days respectively. It sets in the same way for the same duration.

The above text is not available in *AS*, but is given by Utpala while commenting on *BS* (VII.8-13). He remarks that even though the above figures are not correct as per calculations, Varāha has reported them as Parāśarā's opinion. The months when Mercury can be seen are also mentioned. But in the available text no specific cycle is stated. The sidereal motion of Jupiter is clearly enunciated as

सपादमृक्षद्वयमब्देन प्रविचरन् सस्यसम्पत् करोति ।

Jupiter, traveling two-and-quarter nakshatras in a year leads to good crops.

This motion amounts to the well-known twelve year sidereal cycle. *PS* lists portents related to Jupiter's rise in conjunction with different stars, starting from Kṛttikā, but makes no mention of Jovian years or of the associated sixty year cycle. The motion of Venus as per Parāśara is not stated by either Varāha-mihira or Utpala, but is detailed in *AS.*

प्राक्प्रतीच्योः उदयास्तमयात् उदङ्मध्यदारुणाः (दक्षिणाः?) त्रयो मार्गाः तेषां दक्षिणोत्तरमध्यमोत्तरमध्यममध्यमदक्षिणा गत्यन्तरालदेशं पञ्चधाविभज्य पञ्चमार्गाः कल्पनीयाः । प्रागस्तमित उत्तरोत्तरमध्यममध्यमानुत्तरदक्षिणेषु मार्गेषु पञ्चपञ्चाशत् षष्टिपञ्चसप्तत्येकाशीतिनवतिभिर्दिवसैः पश्चाद्दर्शनमुपैति । प्रतीच्यां अस्तमितः षडष्टद्वादशपञ्चदशचतुर्विंशतिभिरहोभिः प्रागुदयते ॥ प्रागुदितो नवभिर्मासैः एकविंशति नक्षत्राणि चरति । प्रतीच्यां अष्टाभिरेकोनविंशति नक्षत्राण्याप्तः शुभाशुभफलः ॥

(For Venus), in east and west three routes called north, central and south are prescribed for rise and setting. Further, dividing the intermediate space five fold as, south, north, central, north-central and south-central, five routes have to be devised. Setting in east, (Venus) rises in the west along north, north-central, central, south-central and south routes after fifty-five, sixty, seventy-five, eighty-one and ninety days respectively. Setting in west it rises in east after six, eight, twelve, fifteen and twenty-four days (along the above routes respectively). Rising in east it travels twenty-one stars in nine months. Rising in west it travels nineteen stars in eight months.

As per *PS,* the visibility in east is for 270 days followed by an average invisibility of 68 days. Similarly in the west visibility is for 240 days followed by 13 days of invisibility on average. Thus, the Venus cycle according to Parāśara is of 591 days. As per modern astronomy, it is known that Venus as morning star is seen for some 263 days and afterwards it remains invisible for nearly 50 days. Then it rises in the west to be seen for another 263 days and to be invisible for about 8 days before rising in the east. The average synodic period of Venus is 584 days. The visibility of the planet depends sensitively on several parameters and hence the figures stated by Parāśara have to be taken as remarkably accurate. The last planet is Saturn described in terms of its sidereal motion.

तस्य अष्टाविंशतिवार्षिकः सप्तविंशतिनक्षत्रचारः । त्रिमार्गस्तत्र । प्रवासक्रमात् सप्तविंशति त्रिंशतधिकोना चाह्नामन्यथा त्वहितः ॥

His (Saturn's) travel through twenty-seven stars is for twenty-eight years. There are three paths. The setting period (in the three paths?) will be 27, 30 and a day more or less. Otherwise it is a bad omen.

It is noted that *PS* could only be describing an observational tradition. Sun's association with seasons and the corresponding position of sun with the stars along the ecliptic was known. Reasons for eclipses were perhaps not known, but observations were done to note that lunar eclipses were to be expected at six months interval, with some exceptions. The naming and counting of seven *parvans* in a sequence, at six-month interval is an interesting exercise the reasons for which are lost. The total number of lunations in such a series adds to forty-two. Among the eight celestial objects considered above, *Rāhu* and thus the eclipse phenomenon gets more textual space. But Parāśara conspicuously devotes more attention to *Ketu* than to *Rāhu.*

Comets of Parāśara

Ketu-adbhuta (Comet-wonder) is the 8th chapter in *AS*. Parāśara classifies comets into eleven groups making a total of 101 comets.

शतमेकोत्तरं केतूनां भवति तेषां षोडशमृत्युनिःश्वासजाः। द्वादशादित्यसम्भवाः। (एका–) दशदक्षयज्ञविलयने रुद्रक्रोधजाः। षट् पैतामहाः। पञ्चदशक्रुद्धोद्दालकसुताः। पञ्चप्रजापतेर्हासजाः। सप्तदशमारीचिकश्यपललाटजाः। त्रयो विभावसुजाः। चतुर्दश

मथ्यमाने समुद्रे सोमेन सह संभूताः। धूमोद्भव एकः। एकस्तु ब्रह्मकोपजः इति॥ एभ्यः षड्विंशतिरुदयैः फलमावेदयन्ति। तन्नामतोरूपतः फलतस्तत्कालतो अभिधास्यामः।

There are 101 comets. Among them 16 are born out of mṛtyu (Death), 12 are from āditya (Sun), 10 (11?) are due to anger of Rudra, 6 are out of Pitāmaha (Brahma or Creator), 15 are children of angry Uddālaka, 5 are from the laughter of Prajāpati, 17 are from the forehead of Mārīci and Kaśyapa (stars of U. Major), 3 are from Vibhāvasu, 14 are coeval with Moon when the ocean was churned. One is born of Dhūma (smoke or dust) and one is from the anger of Brahma. From the rising of twenty-six of these effects are expressed. We shall describe them by name, form, effect and their time.

तत्र मार्त्यवाः त्रय उदयन्ति। एकैकशो वसाकेतुरस्थिकेतुः शस्त्रकेतुर्वा॥ तत्र वसाकेतुः स्निग्धो महान् उदगायतशिखः त्रिंशत् वर्षशतम् प्रोष्य संप्लवेषु पश्चिमेनोदितः सद्यो मरकफलः सौभिक्षकरः। रूक्षो अस्थिकेतुः असौभिक्षकरः तुल्यप्रवासकालफलः। पूर्वेण स्निग्ध एव शस्त्रकेतुः शस्त्रवृत्तराजविरोधमरकफलः समो रूक्षः इति ॥

Therein arise three related to Death namely, Vasāketu, Asthiketu and Śastraketu one after another. Elapsing 130 years in the Floods, Vasāketu, big and sharp, with its crown bent towards north having risen in the west, causes immediate destruction. Harsh Asthiketu appears in the same period causing famine. Śastraketu rising sharply in the east results in destruction of weapon handling kings.

The alternate reading for *samplaveṣu* is *samplave yuge.* This would mean *in the era of the Floods. Asthiketu* (Bone-comet) and *Vasāketu* (Marrow-comet) are said to have the same transit period. The two may be identical, seen first in the west and later in the east. The text of Utpala is almost similar, with *bhārgavāh* in place of *mārtyavāh*. Varāha-mihira writes about the same comets, perhaps borrowed from the same source, but never refers to the year number and the Floods. The word denoting the year number needs attention in its interpretation. The year number of *Vasāketu* is stated as *trimśat-varṣa-śatam*. In contemporary Sanskrit use, this would be taken to mean 3000. This is how Bhat[3] has translated the above word. However, ancient evidence indicates the meaning to be different. This is seen in the explanation offered for a similar compound word. Garga is quoted by Utpala and Ballala-sena about *Viśvarūpā,* which are celestial objects causing fire. Garga describes them as,

तेऽग्निपुत्रा ग्रहा ज्ञेया लोकेऽग्निभयवेदिनः। विंशत्यग्रहशतम् घोरम् विश्वरूपेति नामतः॥

The count is here given as *vimśat-graha-śatam.* Ballāḷa-sena explains this as: *vimśatyadhikham śatam ityarthaḥ*| Varāha-mihira in *BS (11.23)* and Utpala in his commentary on the same verse give the number of *Viśvarūpā* as 120 without ambiguity. Thus, in ancient India, twenty-above-hundred (not twenty-times-hundred) was the accepted meaning of the above number word. Hence *trimśat-varṣa-śatam* should be taken

to mean 130 years. With this in the background the further comet sequence is given following *AS*.

तत्र कुमुदकेतुः वसादिकेतुचारसमाप्तौ वारुण्यां दर्शनमुपैति। गोक्षीरविमलस्निग्धप्रभां पूर्वेणाभिनतां शिखां कृत्वेकरात्रं चरन् स दृष्ट एव सुभिक्षमुत्पादयति दशवर्षाणि प्रजानामविरोधम्। प्रतीच्यांच मुखरोगावरोधकप्रतिश्यायपाण्डुरोगज्वरैः प्रजां बाधते इति॥ आदित्यजानां कपालकेतुरुदयते। अमावास्यायां पूर्वस्यां दिशि सधूमार्चिःशिखो नभोविषयार्धे चरन् दृश्यते। पञ्चविंशतिवर्षशतं प्रोष्य त्रींश्च पक्षानमृतजस्य कुमुदकेतोश्चारान्ते स दृष्ट एव दुर्भिक्षानावृष्टिव्याधिभयमृत्यूपद्रवान् जनयति। यावतो मासान् दृश्यते तावतो मासान् मासैर्वत्सरान् सप्तपञ्चप्रस्थं च शारदधान्यस्यार्धं कृत्वा प्रजानामर्धमुपयुङ्क्ते॥

There Kumudaketu is seen in the west at the end of the transit of Vasā and other comets. It is seen for one night like a bright spray of cow's milk, with its head bent eastwards. This does good to people for a period of ten years. In the west it causes various diseases to the citizens. Kapālaketu among the offspring of Ādityas, rises in the east. It is seen on a new moon evening with a smoky flaming crown, moving in the center of the sky. Seen 125 years and three fortnights after Kumudaketu, it induces drought and famine upon appearance. For years equal to the months of visibility, it reduces the autumn grain yield by half and also uses away (destroys) half the population.

मणिकेतुरपि कपालकेतोश्चारावसाने प्रतीच्यामुदयन्नुपतापयति। प्रसूक्ष्मो अरुन्धतीतारकमात्रः क्षीरप्रतीकाशया पूर्वाभिनतया स्तब्धया स्निग्धया शिखया शर्वर्यामेकमदृश्यः। स उदयात् प्रभृति अर्धपञ्चमान् मासान् क्षेमसुभिक्षमुत्पादयति। क्षुद्रजन्तु प्रादुर्भावं करोत्यतिमात्रकालदृष्टः इति॥ अथ दक्षयज्ञे रुद्रक्रोधोद्भवः कलिकेतुः त्रीणिवर्षशतानि नवमासान् प्रोष्योदयते। पूर्वेण वैश्वानरपथे अमृतजस्य मणिकेतोश्चारान्ते श्यावरूक्षताम्रारुणां शूलाग्रकारसदृशीं शिखां कृत्वा नभसस्त्रिभागचारी शस्त्रभयरोगदुर्भिक्षनवृष्टिमरकैर्विद्रावयन् दिशान्ते दृश्यते। यावन्मासान् दृश्यते तावद्वर्षाणि त्रिभागशेषां प्रजां कृत्वा अर्धंचशारदधान्यस्याष्टाढकं व्रजति इति॥

At the end of Kapālaketu's transit, Maṇiketu is seen in the west for a night, subtle like the star Arundhatī (Alcor in U.Major), with its milky white sharp and stationary crown bent towards east. Starting from its rise, for a period of two-and-half months it produces health and abundant food for people. If seen for a longer period it increases generation of inferior life forms (insects and worms). Kaliketu, born out of Rudra's anger during the sacrifice of Dakṣa, rises after 300 years and 9 months. From the east, along the ecliptic, with a harsh copper-red colour head like the tip of a trident, it travels one-third (three parts?) of the sky to be seen at the horizon. For years, equal to the number of months seen, the comet having reduced the population to one-third, leaves eight measures of the grain yield.

अथ पैतामहः चलकेतुः। पञ्चदशवर्षशतं प्रोष्योदितः पश्चिमेनांगुलिपर्वमात्रां शिखां दक्षिणाभिनतां कृत्वा कलिकेतोश्चारान्ते नभस्त्रिभागमनुचरन् यथायथा चोत्तरेण व्रजति तथातथा शूलाग्रकारां शिखां दर्शयन् ब्राह्मनक्षत्रमुपसृज्यात्मना ध्रुवं ब्रह्मराशिं सप्तर्षीन् स्पृशन् नभसः अर्धमात्रं दक्षिणमनुक्रम्यास्तं व्रजति। यः स्ववर्गे दारुणकर्मा स्ववर्गप्राप्तत्वादेवं कृत्स्नमभिहिनस्ति। लोकमपि वा भूमिं कंपयित्वा दशमासान् मध्यदेशे भूयिष्ठं जनपदमवशेषं कुरुते। अन्येष्वपिच क्वचिच्छत्रुदुर्भिक्षव्याधिमरकभयैः क्लिश्नात्यष्टादशमासान् इति॥

Then (appears) Calaketu related to Pitāmaha. Having risen 115 years after Kaliketu in the west, with a crown of the size of a finger joint, bent southwards, following one-third of the sky, as it travels north exhibiting a head like the tip of a trident, it moves close to the star of Brahma (Abhijit), touches Brahmarāśi, Saptaṛṣi (U.Major), Dhruva (Pole Star) and returns half the sky to set in the south. It does horrible deeds in the sky, shakes the universe and the earth for a period ten months and destroys a populous province in madhya-deśa. It troubles other places also for 18 months by occasional fear of enemies, drought, disease and death.

Kaliketu and Calaketu are described as producing ill effects on earth. The word Kali may imply *difficulty or evil,* as in the word Kali-yuga. Calaketu means Moving-comet and aptly its movement to north and then sudden turn southwards before setting is described. This is one among the few cases where our ancients have noted the transit of the comet with respect to stars. The extent of both the comets is described by the word *nabhas-tri-bhāga.* This would mean one-third of the visible sky, approximately 60^0 in extent. The comet trail should have been spectacularly long. Calaketu is said to have risen in the west, that is after sun set. We may speculate that this could have been so because of the nearness of the comet to Sun and consequent invisibility in daylight. This may imply that Calaketu could have traversed between Sun and Earth. Among the background stars mentioned, Saptarsi refers to U.Major, without much confusion. Dhruva can not be taken as α- U.Minor, since before *c*1500 B.C. the pole star was α-Draconis (Thuban). After this period till about 500 B.C. there was no recognizable pole star. Mention of both *Brāhma-nakshatram* and *Brhama-rāśi* brings in difficulties in interpretation. From the context, these should be indicating two different stations of the comet. Following Varāha-mihira (*BS* 11.33-36) if we take one of this to be star *Abhijit,* the other may refer to the region around star Rohiṇī (Aldebaran), since this has Prajāpati or creator as its deity. Presently, following medieval Indian astronomy, *Abhijit* is identified with star Vega[14], which is far north of the ecliptic. But, in more ancient times, *Abhijit* was well recognized to have been along the ecliptic, between stars *Utaarāṣādhā and Śravana*[15]. Mahābhārata metaphorically records the vanishing of *Abhijit* from the sky[16]. Madhyadeśa, literally means middle country and its boundaries have changed over long periods of time. As per Varāha-mihira this includes Prayāga, Avanti, Ujjayini and Pushkara forest in present day Rajasthan. In the north this region was up to River Devikā. What constituted the middle-land before Varāha's time? Bharadwaj[17] identifies the *madhyadeśa* of Vedic times to have been between Rivers Sarasvati and Drishadvati, including Kurukshetra. This

matches with the description of *madhyadeśa* as per *PS*, given in a later chapter on astro-geography[18]. Not all comets brought in misery, some of them were benevolent like *Jalaketu.*.

अथ जलकेतुः पैतामहस्य चलकेतोर्नवमासावशिष्टे कर्मणि कृतं प्रवर्तयति। पश्चिमेनोदितः स्निग्धः सुजाततारः पश्चिमाभिनत शिखः स नवमासाभ्यन्तरे क्षेमसुभिक्षारोग्याणि प्रजाभ्यो धत्ते। अन्यग्रहकृतानां चाशुभानां व्याघाताय इति॥ अथ जलकेतोश्चारसमाप्तौ ऊर्म्यादयः शीतान्ता अन्ये प्रादुर्भवन्ति। ते त्रयोदशचतुर्दशाष्टादशवर्षान्तरिता दृश्यन्ते। स्निग्धाः सुभिक्षक्षेमाय विपर्याय विपरीताः। क्षुद्रजन्तूनां वधाय च इति॥ तेषामष्टानां कर्मण्यतीते भवकेतुर्दृशते पूर्वेणैकरात्रम्। या कृत्तिकानामुत्तरतारा तत्प्रमाणया स्निग्धया (रूक्ष) प्रभया सिंहलांगूलसंस्थानया प्रदक्षिणनताग्रया शिखयोदितः स यावन्मुहूर्तान् दृश्यते तावन्मासान् भवत्यतीव सुभिक्षम्। रूक्षः प्राणहराणां रोगाणां प्रादुर्भावायच इति॥

Jalaketu (Water-comet) having appeared when nine months of work of Calaketu is still remaining initiates Kṛta. Rising in the west with its head bent to the west, with a well-formed star it gives within nine months health and plenty of food to the people. It compensates for the bad effects of other celestial objects. Comets Ūrmī and others ending with Śīta appear at intervals of 13, 14 and 18 years. If they are sharp they produce good effects, otherwise the opposite (effects are indicated). They destroy inferior life forms. After the work of eight of these, Bhavaketu is seen in the east for a night. It is of the size of the north star of the Kṛttikā cluster (Pleiades) with the crown bent clockwise, like the tail of a lion. It produces plenty of food for months equal to the muhūrtas it is seen. If it is harsh (to look at) it produces fatal diseases.

Ten out of the twenty-six comets of Paraśara are covered in the above paragraph. The word *Kṛta*, here means *good-period* in contrast with the word *Kali.* Utpala also quotes *PS* giving the names of comets between *Urmi* and *Śīta*. No year number is given for *Jalaketu* and *Bhavaketu*. But indirectly the eight comets starting with *Urmi* account for an interval of nearly 120 years between the above two comets.

अथ उद्दालिकीश्वेतकेतुः दशोत्तरं वर्षशतम् प्रोष्य भवकेतोः चारान्ते पूर्वस्याम् दिशि दक्षिणाभिनतशिखो अर्धरात्राकले दृश्यः। तेनैव सह द्वितीयः प्रजापतिसुतः पश्चिमेन कनाम ग्रहः केतुः युगसंस्थायी युगपदेव दृश्यते । तावुभौ सप्तरात्रदृश्यौ दशवर्षाणि प्रजाः पीडयतः। कः प्रजापतिपुत्रो यदा द्व्यधिकम् दृश्येत तदा दारुणम् प्रजानाम् शस्त्रकोपम् कुर्यात्। तावेव स्नेहवर्णयुक्तौ क्षेमारोग्यसुभिक्षदौ भवतः॥

Then, Śvetaketu offspring of Uddālaka is seen, 110 years after Bhavaketu's transit, in the east at midnight, with its crown bent southwards. Along with it is seen in the west a comet named Ka, second offspring of Prajāpati, staying like a yoke. Both, visible for seven nights, trouble people for ten years. If Ka is seen for twice the duration (14 nights) it will

cause horrible effects of weapon on people. The two turning to oily colour give good health and plentiful food.

Śvetaketu or White-comet is the nineteenth member in this list. It is said that along with this was seen another comet denoted by the single syllable *Ka*. Utpala's text is similar except for some grammatical peculiarities. *PS* describes *Ka* as *yūpa-sansthāyī.* Yūpa is a technical word, in Vedic parlance, indicating a column in the sacrificial altar. Varāha-mihira describes the comet *Ka* as *yugākṛti.* The intended meaning appears to be that *Ka* looked straight like a yoke or a column. It is qualified as being both a *graha* (planet or seizer) and a *ketu* (comet). Astronomers may like to comment on the possibility of two comets such as the above being simultaneously observed. The names of the two comets are equally intriguing. Śvetaketu the son of Uddālaka is a famous name in Vedic literature, particularly the Upanishads[19]. His name appears in Mahābhārata also as a social reformer living before the time of Pāndavas[20]. His relation with his eponymous comet is not known. The word *Ka* is usually used as a pronoun meaning *Who.* However in the Vedas *Ka* has been used as the name of a deity also[21]. This raises the important question about the possibility of some of *PS* comets being linked with Vedic deities.

अथातः पद्मकेतुः श्वेतकेतुफलसमाप्तौ पश्चिमेनाह्लादयन्निव मृणालकुमुदाभया शिखयैकरात्रं चरन् सप्तवर्षाण्युच्छ्रितं हर्षमावहति॥ अथ काश्यपः स्वधिकेतुः पञ्चदशवर्षशतं प्रोष्य ऐन्द्र्यां सोमसहजस्य पद्मकेतोश्चारान्ते श्यावरूक्षो नभसस्त्रिभागमाक्रम्य अपसव्यनिवृत्तो ऊर्ध्वप्रदक्षिणाकारशिखः। स यावतो मासान् दृश्यते तावन्ति वर्षाणि दुर्भिक्षमावहन्ति। मध्यदेश आर्यगणानामादानं औदीच्यैश्च भूयिष्ठां सत्रिभागशेषां प्रजामवशेषयति इति॥

At the end of the effects of Śvetaketu (after 10 years) Padmaketu rises in the west with its crown coloured like a lotus stalk. Moving one night, it brings immense happiness for a period of seven years. Kāśyapa Svadhiketu is seen, 115 years after the transit of Padmaketu, with star Jyeṣṭhā (Antares). It is dark and harsh occupying one-third of the sky recedes anti-clockwise, with a crown rotating clockwise above, like a lock of hairs. For years equal to the number of months seen, it reduces the population of the Aryan groups in the middle region and north to one-third.

अथावर्तकेतुः स्वधिकेतोः कर्मण्यतीते अपरस्यामर्धरात्रेण शंखोदरारुणाभया प्रदक्षिणनताग्रया शिखयोदितः स यावन्मुहूर्तान् निशि दृश्यते तावन्मासान् भवत्यतीव सुभिक्षं नित्यं यज्ञोत्सवश्च जगतः॥ अथ रश्मिकेतुः विभावसुजः प्रोष्य वर्षशतं आवर्तकेतोश्चारान्ते कृत्तिकासु धूम्रशिखः श्वेतकेतोः सदृश फलः॥ अथ संवर्तकोवर्षशतमष्टोत्तरं प्रोष्य पश्चिमेनास्तंगते सवितरि सन्ध्यायां दृश्यते। तन्वीं ताम्ररूक्षशूलाभां धूमं विमुञ्चन्तीं सुदारुणां शिखां कृत्वा नभसस्त्रिभागमाक्रम्य स यावन्मुहूर्तान् निशि तिष्ठति तावद्वर्षाणि परस्परं शस्त्रैर्घ्नन्ति पार्थिवाः। यानि नक्षत्राणि धूपायति यत्र चोदेति तानि दारुणतरं पीडयति तदाश्रितांश्च देशान् इति॥

Āvartaketu rises in the latter half of the night, after the work of Svadhiketu with a head like the trunk of a conch, bent clockwise, portending happiness to the world. For months equal to the muhūrtas seen, it produces happiness and daily celebration in the world. Raśmiketu born of Vibhāvasu, 100 years after Āvartaketu, appears in the star cluster Kṛttikā (Pleiades) with a smoky head. Its effects are similar to that of Śvetaketu. Samvartaka is seen, after a lapse of 108 years, in the evening after the sun has set in the west. It occupies one-third of the sky, with a thin dreadful copper coloured spear-like head, ejecting a jet of smoke. For years equal to the muhūrtas of its stay, kings fight among themselves. Whichever star it covers with its smoke, the countries associated with those stars are troubled.

धूमकेतोः प्रागुदयनिमित्तानि। अवनेर्विचलनं अग्नेः प्रभामान्द्यं प्रधूमनं दिशां शीतोष्णविपर्यासः अतिरूक्षवायुसम्भवश्च॥ अथ अनियतकालरूपवर्णसंस्थानो धूमकेतुः पराभविष्यतां देशानां राज्ञां जनपदानां च वृक्षपुरपर्वतवेश्मध्वजपताकाशस्त्रवर्मायुधावरण रथनागोष्ट्र पुरुषशय्याभांडेषु वा दृश्यते। स एव च दिवि स्निग्धो विमलः प्रदक्षिण जटाकारशिखः गोगजनागवीथीं चोत्तरेण व्रजन् सुभिक्षं क्षेमारोग्यं चावहति ॥

The precursors of Dhūmaketu are, earthquake, dullness of fire, dust veils, exchange of heat and cold (seasons), and very harsh wind. Dhūmaketu having no fixed colour, shape, location and time, appears on the trees, towns, mountains, houses, flags, chariots, elephants, camels, men, bedstead and vessels of the loosing countries and their kings. It portends good when it is clear, sharp, with a clockwise shaped crown leaving the Go, Gaja and Nāga paths to its north.

Dhūmaketu or the smoky-comet is the last in the list of Parāśara. Varāha-mihira calls this *Dhruvaketu*. Utpala's text of Parāśara also gives the same name. However, considering the popularity of the word *Dhūmaketu* in the sense of a comet, the text of *AS* appears more acceptable. Vr.Garga, to be discussed later, also names the last in the sequence as *Dhūmaketu.* The paths called *Go, Gaja* and *Nāga* are specific regions in the night sky defined with respect to the stars[22]. For example the region to the north of stars Krttikā, Rohinī, Maghā and Viśākhā is called *Nāga-vīthī.* The above celestial objects described by Parāśara are unambiguously comets. Varāha-mihira in *BS*, has only repeated in verse form whatever Parāśara had already said about comets. Since he explicitly held the view that comets were beyond mathematics (BS 11.1), he appears to have omitted the year numbers, even if he knew them. Utpala some four hundred years later commenting on *BS* quotes *PS* at length including the chronology starting with the Flood, pin pointing the original source of Varāha. However, since Varāha wrote about comets in an arbitrary order, Utpala's *PS* text does not read in the correct sequence. For example, Utpala mentions Kapālaketu, which is supposed to be seen after Kumudaketu at verse 11.31 of *BS.* But *BS* presents Kumuda after several other comets in verse 11.43. Fortunately Ballāla-sena has preserved *PS* in the correct sequential order. Thus one has to note that while Parāśara's comet list in *AS* is internally consistent, Varāha's list in *BS* is not consistent. The mentioned year numbers are perhaps approximate time intervals between two sightings, expressed as elapsed time. How Parāśara was able to obtain this list is not

apparent. It should have been only a tradition, which interestingly started its initial point with the Flood.

The Flood

As per internal evidence in the text, the *samhitā* of Parāśara should have started around 1400 BC. The statement about the twenty-six comets and the interval between some of them could be a chronological artifice to link the initial time of *PS* with the *Samplava* or the Flood. The total number of years in the list adds to about 1300 years, which indicates that the Flood (inundation or deluge) should have occurred before 2500-2700 BC. These figures can be easily in error by a few centuries. The oldest evidence to the Flood appears in Śatapatha Brāhmaṇa, which is later than Ṛgveda but belongs properly to Vedic literature[23]. The primary contents of this ritualistic text can be dated to *circa* 3000 B.C. based on the statement that Kṛttikā (Pleiades) were not moving from the east[1]. The comet tradition preserved in *PS* supports this dating. The Atharvana Veda mentions about the breaking of a boat, which may also be an indirect reference to the above Flood[24]. There is a tradition that the Floods occurred around 3100 B.C., the starting of Kaliyuga. There have been efforts to show that this event might have been backdated based on the conjunction of two or more planets, particularly Saturn and Jupiter[14,25]. However, *PS* connects this Flood of about the same date, with the simultaneous appearance of two comets, with no reference to planets. The Flood story connected with Manu's escape from the deluge and a boat being tied to a peak in the Himalayas is recounted in the Mahābhārata also, but as belonging to a bygone era[26]. Hence the Flood of *PS* should be taken to have occurred several centuries before the inundation of Dvārakā, the capital city of Kṛṣṇa. The present author has shown that the passing away of Kṛṣṇa and hence the inundation of his city is dateable to 1443 B.C. based on information provided in the Mahābhārata, Harivamśa and the Skanda-purāṇa[27,48].

Vṛddha Garga

Among the various Garga related authors quoted by Utpala and Ballāla-sena, Vṛ. Garga stands out as being different and interesting. He recounts almost all of *PS*, in verse form, but with additional information that seems based on observations. A few further details about comets that help one to understand *PS* better are presented here. He accepts the same grouping as in *PS*, but lists all the sixteen comets of the *Mṛtyu* group, naming one of them as *Parāśara*[28]. This indicates that his composition belongs to a date later than that of *PS*. He does not state the initial era of the observations, but mentions that *Asthiketu,* as soon as it is sighted, inundates earth with water[29]. He adds here and there more details to the descriptions in *PS*. For example, the interval between *Kaliketu* and *Śankha* is given as eighteen years and six months. Similarly, *Agniketu* was seen three-and-half years after *Āvartaketu* near star *Jyeṣṭhā* (Antares) remaining visible for one-and-half months. Vṛ.Garga mentions about *Gadāketu* (Mace comet) seen on *Mārgaśira amāvāsya* (November-January) in the region of stars *Ārdrā* (Betelgeuse), *Punarvasu* (Pollux)*, Puṣya* (Asellus) and *Āśleṣā* (Minhar) but gives no year number[30]. Probably this was seen during his lifetime, after the close of the list of *PS*. For *Calaketu,* the orbit is more explicitly stated as starting from west and proceeding along stars *Brāhmam* (near Vega), *Brahma-hṛdayam* (Aurige), *Dhruva* the Polestar and then *Saptarṣi* or U.Major to turn south before setting. The total years as per Vṛ.Garga adds up to nearly same as 1300

years, but he specifically mentions thousand year as the elapsed period before the last two comets namely, *Samvartaka* and *Dhūma* to be seen. The descriptions of these two are also somewhat different from that given in *PS.*

नक्षत्रचक्रमाकाशे यथैव परिवर्तते । केतुचक्रं तथैवेदमाकाशात् परिवर्तते॥
ततो वर्ष सहस्रान्ते दृश्येते चोदितौ दिवि । केतुमालाग्रहस्यान्ते धूमसंवर्तकौ ग्रहौ॥

Like the stellar wheel rotating (repeating) in the sky, the comet-wheel also repeats in the sky. At the end of 1000 years, at the end of the comet strand, two comets Dhūma and Samvartaka appear together.

Vṛ. Garga gives in detail, the tragedy that these two bring on earth. These lead to fall of meteorites, with the ten directions becoming air-less. Earthquakes occur with oceans and mountains getting disturbed. He should have been a keen observer, as he says *Dhūma-ketu,* before setting, sends a jet of smoke away from the Sun (*astamana-kāle tu raveḥ dhūmam vimuñcati*). He seems to be wary of myths and folklore, when he states 'those with ignorant eyes do not see the starry nature of this object' *(nāsya tārāmayam rūpam paśyanti ajñāna-cakṣuṣaḥ).* He describes the other comet *Samvartaka* as the one famous for reducing the world *(samvartaka iti khyātaḥ kṣayāya jagatām iti*).

The other authors quoted in Adbhuta-sāgara namely, Garga, Gārgya, Gārgīya, Atharva-muni, Devala, Bhārgava and Varāha-mihira have nothing seriously original to add to the comets of Parāśara and Vṛ.Garga. They increase the total number of objects to 1000 and add new groups such as Jupiterian (65), Saturnian (60) etc. Association of comets with planets might have had an observational basis but the numbers appear to be arbitrary. Whether the mentioned objects were comets is also unclear. For example, *Guru-sutāḥ* (Jupiter's offspring) are described as white stars without hair (*Vikacāh)* seen in the south. Similarly, the Venus group is a cluster of 84 white-stars called *Visarpaka*, seen in the northeast direction. *Āṅgiras* is a form seen on Sun, like a person sitting in a chariot. Comet *Aruṇa* is not starry, but dark red in colour and dust like, with diffused light. *Kaṅka* is a comet shining like moon but clustered like a clump of bamboos. None of these authors gives the era of appearance or the time interval between any two of the comets. Their main contribution is in preserving a tradition of celestial objects, other than naksatras and planets, being known as *Aruṇa, Āṅgirasa, Ka, Kaṅka, Kabandha, Kiraṇa, Viśvarūpā, Brahma-daṇḍa, Taskara, Tvaṣṭā, Ttriśiras, Triśikha, and Vibhāvasu.*

Discussion on Parāśara's Samhitā

The text of Parāśara, even though available in fragments as quotations by later authors, represents an ancient observational tradition of Hindu astronomy which got merged into the algorithmic siddhāntic astronomy of later centuries. Internal evidences point to the tradition starting around 1400 BC, but evolving over centuries. A critical appraisal of *PS* and its successors is at present not possible. Once the texts attributed to Parāśara and Garga available only in manuscript form are edited and published the structure of this pre-siddhāntic astronomy could be better understood. From whatever that has been presented above, it appears that Parāśara and Vṛ. Garga were preoccupied with comets

rather than planets. This is in contrast to later astronomers such as Āryabhata, Varāha-mihira, Brahma-gupta who remained silent about even a few comets they might have observed in their own lifetime. We may surmise that in ancient India comets should have been observed with some care, much before the systematic observation of planets including Rāhu, started. The rudimentary nature of planet data given in *PS* supports this inference. However, the only way we can discuss this issue further is with reference to Vedic literature, which is not astronomical in the modern sense, but would have had a strong correlation with the then visible sky. Sun, moon and *Svarbhānu* causing solar eclipses find place in the Ṛgveda (RV). Even though the name *Rāhu* is absent, quite interestingly, the word *Ketu* and its derivatives appear more than seventy times in the Ṛgveda, with conspicuous absence in the second *Maṇḍala*. All the celestial objects named previously, such as *Ka, Tvaṣṭā, Viśvarūpā, Triśikhā, Taskara, Angirasa, Vibhāvasu* are in fact deities sung in the Vedas. The popular word for comet in Sanskrit is *Ketu* often referred as *Dhūma-ketu*. Currently this word is used in almost all Indian languages in the sense of a comet. *Ketu* originally could have meant a hairy flag like object, synonymous with words such as *śikhī* and *keśī*. Amara-kośa a standard reference on ancient meanings provides two meanings; namely *agni* (fire) and *utpāta* (anomalous phenomenon) for the word *dhūma-ketu*[31]. The first meaning is obtained by interpreting fire as smoke-bannered. It is obvious the latter meaning of *utpāta* refers to a comet. In what sense the word *Dhūma-ketu* could have been used in RV? We speculate that since *Fire* is only a derived meaning, the word *Dhūma-ketu* appearing in some places of RV could have comet imagery in the background. Atharva-veda has a famous prayer for peace to the shaking earth hit by meteorites and to Sun, Moon, planets, Rāhu and Death named Dhūmaketu[32]. Still more detailed reference to the nine planets and their worship is available in Atharva-veda-pariśista (AVP), which is an appendix to the Atharva Veda[33]. It is a guidebook for Vedic religious observances. It includes topics like earthquakes, eclipses and comets, the purported ill effects of which were to be mitigated through prescribed rituals. This appears to have been compiled over a period of time and parts of it may be later than Pāṇini and Garga, who are cited with reverence. There appears to be a popular opinion that Ketu in the Nava-graha-pūja (worship of nine planets), which is still in vogue widely, is the descending lunar node. This is a misunderstanding due to wrong equation of astrological mythology of later dates with the ancient Hindu religion based on observable celestial concepts. This is clear from AVP (52.12.1), which states the ninth *graha* as

नवमश्चैव विज्ञेयो धूमकेतुर्महाग्रहः।

The ninth should be understood as Dhūmaketu the mahāgraha.

Further, the Śāntikalpa of Atharva veda has the following canonical hymn for invoking *Ketu* during religious worship[34].

यस्य दीर्घा शिखा मुखं च परिमण्डलं । तमहं ब्रह्मणः पुत्रं केतुं आवाहयामीह ॥

I invoke here, Ketu son of Brahma, who has a long lock of hair and whose face is circular.

In contemporary worship following the Rigvedic branch, the prayer for *Ketu* is in plural number as[35]

पालाशधूम्रसंकाशान् तारकाग्रहमस्तकान् । रौद्रान् रुद्रात्मकान् घोरान् तान् केतून् प्रणमाम्यहम् ॥

I bow to Ketū who are of the color of palāśa smoke, who have starry heads, are ferocious, awesome and have Rudra for their soul.

There is a version of the above verse using the words in singular, without affecting the meter. In any case it should be clear that the most ancient practice of *Nava-graha-pūja* included in its fold the visible *Ketu* the Comet and not the imaginary lunar node. Both Parāśara and Vr.Garga in line with Vedic belief, after the Rigvedic period, mention Rāhu as the sole cause of both solar and lunar eclipses. The other ancient materials, roughly belonging to the period of *PS* and available for comparative study are archaeological artifacts. *PS* in its classification mentions about a single comet born out of the anger of Brahma, but in the description it is not clear which this means. But Garga mentions Brahma-daṇḍa, offspring of Brahma as being three coloured and three headed[36]. In *PS Calaketu* is said to have had a trident like (*śūla-sadṛśī*) head. In reality this *śikhā* or head could be referring to the comet split in three parts. *Trishikhā* and *Trishirā* are also celestial objects listed by all the ancient authors. In the Yajurveda we read that *Viśvarūpa* son of Tvaṣṭra had three heads hinting at a comet imagery[37]. This *Triśiras* has a parallel in the Harappan seal of a three-headed animal (Figure 1). The painted grey ware pottery unearthed from Hastināpura and other Mahābhārata sites by B.B. Lal[38] show designs of circles attached to hair or tail like extensions resembling comets (Figure 2).

The Number 3339 in the Ṛgveda

Ancient Vedic and Purāṇic literature of India exhibits an intimate relationship with eclipses that is although mythological in many respects, is still pervasive in its cultural influence. Shama Shastri[39], the celebrated editor of *Arthaśāstra*, has made a detailed study of the subject, to find clues to knowledge about eclipses in Vedic literature. He emphatically points out '…the whole of our Indian culture is derived from the cycle of eclipses'. He makes a case for taking several numbers appearing in the *Ṛgveda* (*RV*) and elsewhere as somehow connected with eclipse periods. He points out a few hymns, which are remarkable in their poetical imagery and probable reference to eclipses. But the question whether or not the Vedic Indians knew an eclipse period remains unanswered, in the absence of numerical evidences. This can be attributed at least partly to a strong tradition that explains every Vedic hymn as related to a sacrifice or to a mystical practice. At the other extreme, many modern scholars have tried to interpret *RV* hymns in the most mundane manner possible in terms of class conflicts, ethnic differences and migratory patterns. However there should be no difficulty in accepting *sūkta RV* (5.40) as referring to a solar eclipse. Hence, it would follow that the specific word *āsura* used in this hymn

is celestial in purport, referring to the eclipse shadow figuratively. While this may not be the implied meaning of the word at all the places where it occurs, possibility of an eclipse being meant in a few hymns by this metaphor need not be over looked.

RV mentions not only small numbers such as one, two, three but also large ones like 1000, 4000, 60,000. For our purpose here, the most intriguing number is 3339. This occurs twice in the *Ṛgveda*, first in the third *maṇḍala* (3.9.9) and again later in the tenth *maṇḍala* (10.52.6)[40]. The text and two translations are provided below to bring out the fact that numbers can not be interpreted differently even when their basis are not understood.

त्रीणिशता त्रिसहस्राण्यग्निं त्रिंशच्च देवा नवचासपर्यन्।
औक्षंघृतैरस्तृणन् बर्हिरस्मा आदिद्धोतारं न्यसादयन्त॥

"Three times a hundred Gods and thrice a thousand, and three times ten and nine have worshipped Agni / For him spread sacred grass, with oil bedewed him, and stablished him as Priest and Sacrificer" (Griffith[41]).

"Gods three thousand and three hundred and thirty and nine waited upon the Fire / They anointed him with many streams of the clarity, they spread for him the seat of sacrifice, and seated him within as Priest of the call" (Aurobindo[42]).

This hymn has *Agni* as its deity, which from the overall context of the hymn can be seen to be celestial. This of course does not preclude the interpretation or application of the hymn to terrestrial rituals, as indicated by the later Brāhmaṇa literature. *Sūkta* (10.52) is about *Viśve-devās,* by *Saucika Agni.* The context of this Sūkta is seen to be, some type of time measurement. This is implied from hymn 10.52.3, where the reference is to one *who springs to life month by month and each day (aharahaṛ jāyate māsi māsi).* The suspicion that this could be a reference to Moon is unavoidable. *Agni* being honoured by 3339 Gods is the theme of the last hymn (10.52.6) of this *sūkta*. An interesting feature of *sūktās* 51 to 56 of the 10th *maṇḍala* is their apparent homogeneity. The implied themes of these *sūktas* are similar and they appear linked even as inspired poetry. *Sūkta* 10.51 is a conversation between Agni and Gods, where in hymn (10.51.2), Agni wonders 'how many (number of) Gods have clearly beheld my form'. There is also an allusion to *Agni* hiding in secret places. *Sūktās* 53, 54, 55 and 56 contains the word *asura*(s), or its derivatives, which could be an allusion to the eclipse shadow. In hymn (10.55.5) there is reference to *vidhu* that is, Moon, being 'woken up from his slumber, who runs his course with many around him'. The hymn further observes, 'he who died yesterday is living today' and goes on in its poetic language to note, 'the ancient red bird has had no nest to dwell in'. Mention of the red colour of Moon makes a strong case for taking this hymn to be describing a total lunar eclipse. Duncan Steel[43] in his monograph on eclipses provides the scientific explanation as to why Moon's orb turns blood red during a total lunar eclipse. However, meanings of many *RV* hymns and related practices have remained obscure due to break or differences in traditions. Nevertheless, one wonders why the specific number 3339 was enunciated in *RV* to be preserved religiously over several millennia. Sāyaṇa the great commentator of 14th century AD, in his gloss on the Taittirīya

Brāhmaṇa (T.B. II.7.12.2), where this number occurs, declares that over and above 33 the remaining Gods are supernumeraries. Shama Shastri[39] takes 3339 to be the number of year gods and looks for a link for this number with a 33-year cycle. K.V.Sarma[44] feels that this number 'apparently refers to a period of 30 years consisting of 371 lunar months.' Subhash Kak[45], thinks that 3339 is the total number of gods in a year, personified as Agni. He breaks the number into its factors 9 and 371 to identify the first as the *bhāmśā*s in a *tithi* and the latter as the number of *tithi*s in a solar year. While these authors have at least attempted to find a rationale for this peculiar number, others have presumed this to be just a part of variable Vedic mythology, wherein the number of Gods increased from 33 to higher figures with time. For example, Wilson[46] a translator of *RV*, referring to the hymn (10.52.6), writes '… a solitary passage, and one of which the commentator has given no satisfactory explanation, raises the number of deities, which is wholly incompatible with the ordinary enumeration.' How invalid this understanding is, can be realized if Purāṇas, preceding Sāyaṇa by more than 1500 years, are taken into consideration for interpreting this Vedic number. It has to be remembered that Purāṇa texts are the prime claimants for having preserved ancient traditions outside the canonical Vedic literature.

Purāṇic Interpretation

There are eighteen major and eighteen minor *purāṇās*, making up an enormous body of Sanskrit literature, not easy to read, much less to synthesize to see the common cultural thread linking them with the *Ṛgveda*. Here, only Brahmāṇḍa Purāṇa[47] is considered briefly to show the possible rationale existing behind the specific number of Gods of *RV* (3.9.9) and *RV* (10.52.6). Brahmāṇḍa, considered as one of the earliest Purāṇa, explains this as

आपूरयन् सुषुम्णेन भागम् भागमहः क्रमात् ।
सुषुम्णा आप्यायमानस्य शुक्ला वर्धन्ति वै कलाः ॥ (२३.६१)

Sun having filled up the phases by his suṣumṇā ray, in daily sequence, the bright parts (of Moon) increase in the śukla pakṣa.

भक्षार्थम् अमृतं सोमः पौर्णमास्यां उपासते ।
एकां रात्रिं सुरैः सर्वैः पितृभिः सर्षिभिः सह ॥
सोमस्य कृष्णपक्षादौ भास्कराभिमुखस्य तु ।
प्रक्षीयन्ते पितृदेवैः पीयमानाः कलाक्रमात्
त्रयश्च त्रिंशतश्चैव त्रयःत्रिंशत् तथैव च ।
त्रयश्च त्रिसहस्रश्च देवाः सोमं पिबन्ति वै ॥
इत्येतैः पीयमानस्य कृष्णा वर्धन्ति वै कलाः ।
क्षयन्ति तस्मात् शुक्लश्च कृष्णा आप्याययन्ति च ॥ (२३.६६–६९)

Moon is approached by all the gods, manes and ṛṣis for a night on Full moon, for partaking amṛta. From the beginning of the dark fortnight, phases of Moon facing Sun,

decrease being drunk by pitṛ-devatās digit by digit. Three and three hundred, then thirty-three and again three and three thousand (3339) gods drink soma. Being drunk this way, the dark digits increase with corresponding decrease in the bright digits.

The above is a clear enunciation of the model behind the 3339 gods of the Ṛgveda and what their role could have been. The connotation *pitṛ-devāḥ* in verse 67 indicates that these were not the general deities (33 or otherwise of the Sāyaṇa-bhāṣya) but were special and that their count was sequential, in the order of the decreasing phases of Moon (*kalā-kramāt*) adding to 3339.

Eclipse Cycle of 18 Years

Gods drinking Soma is a recurring theme in the Ṛgveda. That this was linked with Moon is more than apparent in several places. One example is the celestial marriage *sūkta* 10.85, where the 5th hymn reads

यत् त्वा देव प्रपिबन्ति तत आप्यायसे पुनः ।
वायुः सोमस्य रक्षिता समानां मास आकृतिः ॥ (१०.८५.५)

"The Gods drink you, but later you become bright again/ Vāyu is the protector of Soma, Moon is the maker of years" (S.B.Dikshit[1]).

Griffith[41] translates the first half of this verse as '*When they begin to drink thee then, O God, thou swellest out again.'* This meaning is seen to be wrong in the light of Purāṇic evidence. The symbolism of particular gods drinking away the digits of Moon, obviously refers to the dark fortnight and their total number being 3339 has its origin in the Ṛgveda. For this characteristic number the above Purāṇic model has to be accepted as the most likely explanation. The count started on a Full Moon to proceed till *amāvāsya* and stopped till the next Full Moon, to repeat again in the same fashion with gaps in the bright fortnight. In other words, this number is clearly the number of *tithi*s in the dark fortnights counted as 3339 sequentially for a special purpose. If both the fortnights were to be included, this number would have been 6678 *tithi*s. Now, at the rate of thirty *tithi*s per lunation, this number is equal to 222.6, which in round figures is the eclipse cycle (popularly, but wrongly, known as the *Chaldean Saros*) of 223 lunations. It is known that the Vedic calendar was luni-solar. The months were lunar but the year was solar. From Vedāṅga Jyotiṣa, it is known that one solar year was taken to have 371 *tithi*s. Hence, the *RV* number 3339, which is half of 6678, stands for 18 solar years, with a fantastic imagery behind it. *RV* (10.52) after giving this number refers in subsequent *sūkta*s to *asura*s and *sūkta* 10.55 is indeed a description of a total lunar eclipse with Moon turning red. Thus, this number was linked with eclipses. There are sufficient clues to infer that special ordinals were also associated with eclipses. For example, Atri got back the Sun engulfed in darkness by means of the *fourth Brahma* (*RV* 5.40.6). Atri alone could restore the Sun whom the *asura Svarbhānu* had engulfed with darkness. (*RV* 5.40.9). Association of the ordinal *fourth* with this eclipse is here noteworthy. Another hymn, in the same *maṇḍala* belonging to Atri family reads,

प्रतिप्रयाणमसुरस्य विद्वान् त्सूक्तैर्देवं सवितारं दुवस्य ।
उप ब्रुवीत नमसा विजानञ्ज्येष्ठं च रत्नं विभजन्तमायोः ॥ (५.४९.२)

Knowing full well the Asura's time of coming, worship God Savitar with hymns and praises / Let him who rightly knoweth speak with homage to him who dealeth out man's noblest treasure.

This beautiful hymn uses a technical word, *prati-prayāṇam*, which can only mean return journey or return period. Reference to *Savitar* (Sun) *asura* (eclipse shadow) and his return journey leaves one wondering, why this may not pertain to a predicted solar eclipse. Moreover, this *sūkta* has *Viśvedevāḥ* as its deities in common with *sūkta* (10.52) which declares the special number 3339. *Sūkta* (10.56) to which reference has already been made is also related with *Viśvedevāḥ* and it contains reference to *asura who finds light by the* ***third*** *act.* Association of an ordinal number here, as in hymn 5.40.6, perhaps refers to the return journey or recurrence of an eclipse.

Yajurvedic Texts

Vājasaneya Samhita (33.7) and Kāṇva Samhita (32.7) of Śukla Yajurveda repeat the *RV* hymn (3.9.9; 10.52.6). Taittirīya Brāhmaṇa records the same hymn at (II.7.12.2). Thus, the number 3339 was wide spread and its solar year equivalent 18 was well known in Vedic literature. Shama Shastri claims that TB (III.11.3.25) mentions the number of Gods to be 3349. The present author has not been able to trace this in the currently available versions of TB. If the above claim were to be correct, this would be an evidence for efforts to fine-tune the number of *tithi*s in the eclipse cycle, to a better figure. In any case, TB (I.3.10) describes the legend of Indra returning on an *amāvāsya* after having defeated *asuras,* which may be taken as a solar eclipse. It further refers to the arrival of *pitṛ*s at that time and they being given a boon to drink *soma* on *amāvāsya*. Their number is said to be six as being related to six seasons;

षट् सम्पद्यन्ते । षड्वा ऋतवः। ऋतवः खलु वै देवाः पितरः।

This is most probably a legendary reference to the shortage of six *tithi*s in the previous count of 3339 for an observed eclipse. Further, TB (III.10.4.1) lists the names of years in a six-year cycle, using the imagery of a bird. This perhaps denotes an attempt to divide the 18-year cycle into three shorter cycles. TB (IX.1) on Aśvamedha in the very first hymn introduces *eighteen* as the primary symbolic cosmic number of the ritual. Several other descriptions of what look like eclipse related imagery are found in Yajurvedic texts as discussed by Shama Shastri[39]. Tradition holds that *RV* is about Sun, called *Arka,* literally one related to Ṛk. Naturally, one expects the contents of the *RV* text to have some information about eclipses. The discussion so far brings out, besides actual observations of a few eclipses, the periodicity of a celestial apparition (called *Rāhu* in later literature), is mentioned in the Ṛgveda. In the absence of physical records, it has to be surmised that this discovery would have been based on long observations, as Taittirīya āraṇyaka (1.4) says,

स्मृतिः प्रत्यक्षमैतिह्यं अनुमानः चतुःष्टयम् ।

एतैः आदित्यमण्डलं सर्वैरेव विधास्यते ॥

Memory (of past records), direct observation, anecdotes and inference form the quartet. With these, Sun's cycle is understood by all.

Evidence available so far, points out that the number was discovered with the help of lunar eclipses. This is implied by the counting of the 3339 *tithi*s starting from a Full Moon and carrying this count only during the dark fortnights, to end again on an *amāvāsyā*. The expectation would have been that the subsequent Full Moon would be eclipsed. Modern astronomers discussing how ancient civilizations could have arrived at the 18-year cycle, opine that observation of lunar rather than solar eclipses as the more natural possibility. This brings up the interesting question, whether *RV* contains more astronomical information than what meets the eye, in a symbolic or mystical fashion.

Vedas are broadly divided into Samhita, Brāhmana and Upanisads. Rgveda Samhita is the most ancient among these belonging to 3^{rd}-4^{th} millenium BC. Samhitas are organized as *sūkta*s, made up of *mantra*s or metrical verses endowed with knowledge, that was revealed to a *ṛṣi*. What is interesting is that these contain special numbers, at least one of which, namely 3339 is connected with the 18-year eclipse cycle. Brāhmaṇās are supposed to be explanatory texts for Samhitās. However, in their available format, the explanations are too convoluted with ritualistic jargon and hence not amenable always for establishing a one-to-one relation with the original hymns. In the present case, it is the Brahmāṇḍa Purāṇa, which preserves an explanation for the characteristic number. This also provides an insight into the symbolism involved in *RV*. This leads one to the conclusion that 3339 represents the *tithis,* in the dark fortnights, separating two eclipses of the same type. *Tithi* is a time unit well known to Vedānga Jyotiṣa, Purāṇas, Siddhāntic Astronomy and continues to be used in India. The present study indicates that this concept has come down to us from *RV* times, even if the ancient method of observing the *tithi* has been replaced by sophisticated algorithms. One may wonder, why the number is stated to be that many deities and not *tithis*? The answer to this will be clear to any serious student of Vedic literature. Ancient Indians worshipped Time, notwithstanding its abstract nature. Hence, referring to time measures such as *tithi, māsa, samvatsara* as *devā* or gods is the norm in the Vedas. One may still question whether composers of *RV* were aware of the word *tithi.* The answer is in the affirmative, if the structure of Sanskrit language in which *RV* stands is any evidence. Sanskrit allows negation of almost any noun by the negative prefix (na ~ a). Use of such a prefixed negative word presupposes knowledge of the basic word, like a number with a minus sign presupposes the existence of the original positive number. *RV* uses the word *atithi*, meaning *guest; one who comes without appointment,* in profusion (*e.g. RV* 1.44.4, 1.127.8, 1.128.4, 1.186.3, 2.2.8, 2.4.1, 2.14.7, 3.2.2, 3.3.8, 3.26.2, 4.1.20, 4.2.7, 4.26.3, 4.40.5, 5.1.8, 5.1.9, 5.3.5, 5.8.2, 6.15.1, 6.15.6, 6.18.3, 6.26.3, 7.3.5, 7.8.4, 7.19.8, 7.42.4, 8.8.4, 8.9.3, 8.19.8, 8.21.16, 8.84.1, 8.103.12, 10.1.5, 10.48.8, 10.68.3, 10.122.1). The derivation and meaning of this word proves the prior knowledge of the word *tithi* in the sense of *date.* The Śatapatha Brāhmaṇa referred already specifically uses the word *tithi* in the sense of 'date' while describing the Flood of Manu[23]. Now, turning our attention to Purāṇas, there is a view that in the remote past these were fewer in number. Since the present day versions contain same or similar texts in too many places, it is logical to imagine the origin of these books from a single source,

which is not traceable now. Itihāsa and Purāṇa were known at least from Brāhmaṇa and Upaniṣadic times as evidenced in T.B (III.12.8.2) and Chāndogya Upaniṣad (3.4.1). It is possible, like Brāhmaṇas explaining the ritualistic and Upaniṣads the philosophical aspects (*e.g.*Bṛhadāraṇyaka Upaniṣad III.9), Purāṇas once explained the physical worldly meaning of the Vedas. This view is upheld by the age-old adage,

इतिहास पुराणाभ्यां वेदं समुपबृंहयेत् ।

Veda has to be understood (synthesized) with the help of itihāsa and purāṇa.

The anecdote of gods and manes partaking nectar of Moon appears in several Purāṇas. However, the number of gods mentioned in the Viṣṇu and the Linga Purāṇa are different from 3339. The number given by these texts as available in the vulgate printed versions is 36333.

त्रयस्त्रिंशत् शतश्चैव त्रयस्त्रिंशत् तथैव च।
त्रयस्त्रिंशत् सहस्राणि देवाः सोमं पिबन्ति वै ॥
एवं दिनक्रमात् पीते विबुधैस्तु निशाकरे ।
पीत्वार्धमासं गच्छन्ति अमावास्यां सुरोत्तमाः ॥ (लिंग. पु ५६.११,१२)

36333 of the first verse is not the Vedic number. The second verse above upholds the same way of counting, as in the Brahmāṇḍa Purāṇa on daily basis (*dina-kramāt*), only in the dark fortnights. In the light of the previous discussions the first verse above is wrong purely due to recording errors on the part of the scribe in copying previous versions. Scholars interested in the Puraṇas have to emend this verse in the interest of history of science in India.

Since *RV* is shown to contain the period number of 18 years, was this used for making predictions? Apart from the significant terminology of the return journey of the eclipse shadow (*prati-prayāṇam asurasya*) in *RV* (6.49), no other clue has been found in Vedic literature, as to how this number could have been used. However, a multiple of 18 finds place in the Mausala Parvan (2.19-20) of the Mahābhārata. It is mentioned that when a solar eclipse occurred, Kṛṣṇa understood that the 36th year after the war had arrived indicating his last days, as had been foretold by Gāndhārī[48]. There is an assertion that this eclipse was similar to the one at the time of the war. This is one occasion mentioned in ancient texts for possible application of the knowledge of the 18-year cycle. There is another claim for prediction, again associated with Kṛṣṇa in the Bhāgavata (10th Book, Ch.82.1-2). It is said that Kṛṣṇa along with others went from Dvāraka to Kurukṣetra for performing religious rites during a solar eclipse, which had been predicted by astronomers in advance.

Summary and Conclusion

An attempt is made in this paper to bring out some salient features of Hindu astronomy before the period of the Siddhāntas, which started with the Common Era. First it is demonstrated that the prose text of Parāśara as preserved in the works of Utpala and

Ballāla-sena represnts an ancient observational tradition of Hindu astronomy prior to the Siddhānta period. This text called here *Parāśara-samhitā,* consists of planet and more interestingly of comet observations. The date of the information appears to belong to the middle of 2nd millennium B.C. The visibility and invisibility periods of Venus are quite accurate for naked eye observations. The sidereal periods of Jupiter and Saturn and visibility of Mercury are given, even if they are approximate. Movement of Mars has been described qualitatively with no numbers given in the quoted text. The list of twenty-six comets ending with *Dhūma-ketu* should be of interest to historians and lay people to gain insight into Indian culture. It establishes a historical basis for the Great Flood, which has been the starting point of much of Indian mythology. The text of Vr.Garga, as quoted in the Adbhuta-sāgara, indicates some further developments not found in *PS*. For example, the *Saptaṛṣi* era and the Jupiter year are due to Vṛ.Garga. He was the first person to state that comets appear in a cycle and to have remarked that the tail of a comet extends away from the sun. He also gives a few observational numbers for Mars. Existence of synchronism between ancient comet names of *PS* and Vedic deities makes a case for comet observations being described in the Ṛgveda. This calls for detailed investigation of Vedic literature from the perspective of the ancient visible sky.

Interestingly enough RV refers to lunar and solar eclipses. An investigation of the Ṛgvedic number 3339, with the help of a few *RV* hymns and the Brahmāṇḍa Purāṇa has been presented in this study. It is found that this was the characteristic eclipse number of ancient India. This represents the number of *tithi*s between two similar lunar eclipses separated by nearly eighteen solar years, counting only the dark fortnights. With the help of the above new results, it may be possible to understand parts of Vedic literature in a more rational and scientific manner, without discarding the esoteric and mystical contents than has been so far possible. Once the manuscripts claiming to be texts composed by Parāśara and Garga are published with critical apparatus, it should be possible to trace the development of Indian astronomy starting from the Vedas in better detail than presented here.

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"The original works of Parashara and Garga are now lost but Bhattotpala has preserved the crucial quotations (see Sir W. Jones, A.R. Vol. II p.39). In fact, Sir W. Jones has noted carefully that the text of Parashara was modulated i.e. pitch-accented and in old Vedic prose." (p.126)
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अथ मध्यदेश आर्यावर्त इति च आख्यायते। तत्र जनपदाः शूरसेनोदैहिकमद्राश्वत्थनीपकाञ्चनक–कौरवोत्तमज्यौतिषभद्रारिमेदमाध्यमिक–शाल्वसाकेतमत्स्यकपिष्ठलदौलेयमान्डव्याः।
पाण्डुनगरगौरग्रीवपारियात्रमरुकुकुरौदुम्बर–यामुनगजाह्वौज्जिहानकालकोटिमथुरोत्तरदक्षिणपाञ्चाल–धर्मारण्यकुरुक्षेत्रसारस्वताः॥
19. Upaniṣad: Brihadāraṇyaka 6.2.1-8, Chāndogya 5.3, Kauṣītakī 1.
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"Who (ka) yokes you? Let him yoke you he says. *Ka* is Prajāpati…." (I.6.8.5, I.7.6.12).
22. गजवीथी रोहिण्यादीनि त्रीणि। गोवीथी प्राक्प्रौष्टपदानि चत्वारि ।
23 Śatapatha Brāhmaṇa. I.8.1. Flood Legend. Extracts from the translation of J. Eggeling: "…Thereupon it said, in such and such a year that flood will come……when the flood has risen thou shalt enter into the ship…..And in the same year which the fish had indicated to him, he attended to (the advice of the fish) by preparing a ship; and when the flood had risen, he entered into the ship….hence that (slope) of the northern mountain is called Manu's descent. The flood then swept away all these creatures, and Manu alone remained here."

24 Atharvaṇa Veda. XIX. 39.8; यत्र नावप्रभ्रंशनम् यत्र हिमवतः शिरः ।
This reference to the abandoning of the ship near a peak of the Himalayas is linked to the flood episode in the previous reference of Śa. Br.
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ख्यातं अद्यापि कौन्तेय तद्विद्धि भरतर्षभ ॥ (म.भा. वन प. १८५.४७)
This statement in MB describes the story as ancient. Also the peak in the Himālaya where the boat was anchored is called *naubandhanam*. O.P.Bharadwaj (Ref.21) identifies this place with present day Nahān in the Sirmur region of Himachal pradesh.
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दरःस्तब्दःश्रमो मोहः श्यावः सरोऽत्ययस्तथा । पराशरस्तमोवृष्टिः शोषणो अतिप्रभञ्जकः ॥
अस्थिकेतुः वसाकेतुः शस्त्रकेतुरदर्शनः। एते निःश्वासजा मृत्योः नामतः परिकीर्तितः ॥
29. Vṛddha Garga quoted in *AS*
अस्थिकेतुर्जनान् हन्यात् दुर्भिक्षमरकाग्निभिः। स दृष्ट एव पृथिवीं आप्लावयति वारिणा ॥
30. Vṛddha Garga quoted in *AS*
मार्गशीर्ष्यां अमावास्यां गदाकेतुः प्रदृश्यते । आदित्यरौद्रसार्पाणि बार्हस्पत्यं तथैव च॥
कोष्ठागारं च शिखया धूपयन्नरुणाभया । गदानिभो गदाकेतुः हन्यात् दृश्यो नभो गतः॥
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एको ब्रह्मसुतः क्रूरः त्रिवर्णस्त्रिशिखान्वितः । सर्वास्वाशासु दृश्येत ब्रह्मदण्डो भयावहः ॥
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Figure1. Harappan seal depicting an animal with three heads. (Not to size). This seems to synchronize with the celestial object called Trishirā by Garga and the Atharva-veda-pariśiṣṭa. Could this be referring to Tvāstra Viśvarūpā (Tai. Sam. 2.5.1) who had three heads?

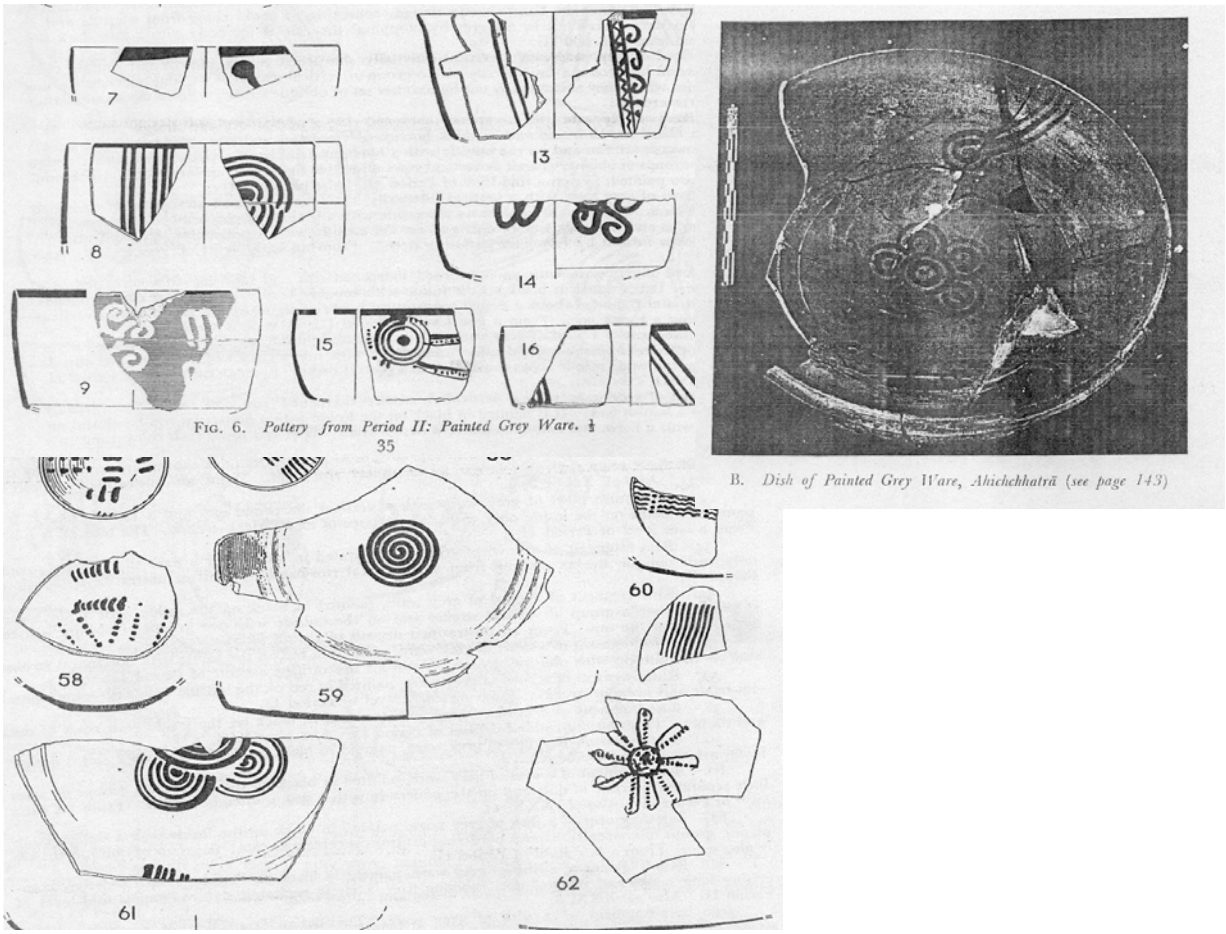

Figure 2. Excavations at the Mahābhārata sites
Hastināpura and Ahichhatra. Pottery dated to 1100-1200 BC exhibits typical
Comet motifs. (Ref: B.B.Lal)