

National Workshop on Indian Astronomy Before Common Era

Lecture 1

PRIMARY SOURCE LITERATURE

Introduction

The Vedas, the most ancient known literature of India, carry interesting astronomical information of historical importance. The *Samhitā*, *Brāhmaṇa*, *Āraṇyaka*, texts of all the four Vedas (*R̥k*, *Yajus*, *Sāma* and *Atharva*) describe the visible sky, seasons, lunar and solar phenomena and a variety of natural events including felt effect of axial precession of earth in either figurative or matter-of-fact language. Many of the Vedic rituals derive inspiration for their concept, design and execution from natural phenomena described in the above texts. A particular topic that is often invoked, discussed and pondered upon by Vedic seers is **Time**, both the abstract and the concrete, in its various implications. This preoccupation with **Time** is closely related with *ṛtam*, the natural rhythm associated with the visibility cycles of celestial bodies, and their spatial location in the sky as seen from earth. That **Time** is continuous like a flowing river but experienced in terms of discrete elemental units such as *nimeṣa*, *muhūrta*, *ahorātra*, *pakṣa*, *māsa*, *ṛtu*, *ayana*, *saṁvatsara*, *yuga* is stated in several Vedic texts. It is very likely that the major rituals in the Vedas were originally designed to measure or distinguish between time periods, whereas some rites were prescribed to be observed on specific dates, predicted possibly in advance.

The subject of *Jyotiṣa*, that included the study of celestial bodies, was traditionally one among the six *vedāṅga* or the six ancillaries of the Vedas. This points to the existence of astral observations and legends in the Vedic *Samhitā* and *Brāhmaṇa* texts that may appear cryptic and even unintelligible, but for our ancients such language might have been just an emic communication style about time measurement, divination and prognosis of anomalous events. Any measurement would demand an instrument, either natural or manmade. The supports for marking time in the earliest period were naturally the sun and the moon, gradually expanding to naked eye observation of the night sky in more detail, out of wonder or due to some special necessity driven by the conviction that such information would be useful to lead a peaceful life on earth. The Ṛgveda in many places unambiguously refers to the visible sky although the celestial picture will not always be clear without further analysis and comparative study with the help of ancillary texts denoted by the generic word *vedāṅga*. For example, the Vedic *Soma* did not always mean a drink of that name to be extracted from a herb of the same name. In the marriage hymn (RV 10.85) *Soma* refers to the visible moon. This is clarified by Yāskācārya in his *Nirukta* which is a traditionally recognised *vedāṅga* text. *Soma* as one of the names of moon is listed in Sanskrit lexicons and is also widely prevalent in the regional languages of the subcontinent.

Another instance is in deciphering what is meant by Indra drinking thirty lakes of *Soma* in a single draught (RV 8.77). Again, from the *Nirukta*, we understand that this is the Vedic way of explaining the natural phenomena of the digits of moon decreasing, without break, for fifteen

days and fifteen nights adding to thirty, in the dark fortnight. Sāyaṇācārya in his commentary on RV specifically says as per the authority of the *Nirukta*, Indra represents time. These are two examples just to point out the importance of comparative studies among different Vedic ancillary texts before the astral backdrop of the *Samhitā* and *Brāhmaṇa* can be uncovered.

Vedic Source Texts

Vedic texts available today in each *śākhā* tradition, has been listed by **Satyashrava**, a Vedic scholar of repute in his book *A comprehensive history of Vedic literature*:

Samhitā, Brāhmaṇa, Āraṇyaka and important Upaniṣads

Ṛgveda	
Śākalya <ul style="list-style-type: none"> ▪ <i>Śākalya samhitā</i> ▪ <i>Aitareya brāhmaṇa</i> ▪ <i>Aitareya āraṇyaka</i> ▪ <i>Aitareya upaniṣat</i> Śāṅkhāyana <ul style="list-style-type: none"> ▪ <i>Śāṅkhāyana samhitā</i> ▪ <i>Śāṅkhāyana brāhmaṇa</i> ▪ <i>Śāṅkhāyana āraṇyaka</i> ▪ <i>Kauṣītaki upaniṣat</i> 	Bhāṣkala <ul style="list-style-type: none"> ▪ <i>Bhāṣkala samhitā</i> ▪ <i>Kauṣītaki brāhmaṇa</i> ▪ <i>Ṛgveda khila</i> Āśwalāyana <ul style="list-style-type: none"> ▪ <i>Āśwalāyana samhitā</i>
Yajurveda	
Kṛṣṇa Yajurveda (KY) Taittirīya <ul style="list-style-type: none"> ▪ <i>Taittirīya samhitā</i> ▪ <i>Taittirīya brāhmaṇa</i> ▪ <i>Taittirīya āraṇyaka</i> ▪ <i>Taittirīya upaniṣat</i> KY Maitrāyaṇī <ul style="list-style-type: none"> ▪ <i>Maitrāyaṇī samhitā</i> ▪ <i>Maitrāyaṇīya āraṇyaka</i> ▪ <i>Maitri upaniṣat</i> KY Caraka katha <ul style="list-style-type: none"> ▪ <i>Caraka bṛhadāraṇyaka</i> ▪ <i>Maitreyi upaniṣat</i> ▪ <i>Śvetaśvataropaniṣat</i> 	KY Kapiṣṭhala katha <ul style="list-style-type: none"> ▪ <i>Kāṭhaka upaniṣat</i> ▪ <i>Kaṭhaśikṣā upaniṣat</i> Śukla Yajurveda (SY) Kāṇva śākhā <ul style="list-style-type: none"> ▪ <i>SY Kāṇva samhitā</i> ▪ <i>Kāṇva śatapatha brāhmaṇa</i> ▪ <i>Kāṇva Bṛhadāraṇyaka</i> SY Mādhyandina <ul style="list-style-type: none"> ▪ <i>Mādhyandina samhitā</i> ▪ <i>Mādhyandina śatapatha brāhmaṇa</i> ▪ <i>Mādhyandina Bṛhadāraṇyaka</i>
Sāmaveda	
Kauthuma & Rāṇāyanīya <ul style="list-style-type: none"> ▪ <i>Samhitā</i> ▪ <i>Tāṇḍya brāhmaṇa</i> ▪ <i>Ṣaḍvimśa brāhmaṇa</i> ▪ <i>Mantra brāhmaṇa</i> ▪ <i>Daivata brāhmaṇa</i> ▪ <i>Ārṣeya brāhmaṇa</i> ▪ <i>Sāmavidhāna brāhmaṇa</i> ▪ <i>Samhitopniṣat brāhmaṇa</i> ▪ <i>Vamśa brāhmaṇa</i> ▪ <i>Chāndogyopaniṣat</i> 	Jaimini <ul style="list-style-type: none"> ▪ <i>Jaiminīya samhitā</i> ▪ <i>Jaiminīya brāhmaṇa</i> ▪ <i>Ārṣeya brāhmaṇa</i> ▪ <i>Kena upaniṣat</i> ▪ <i>Talavakāraāraṇyaka</i> ▪ <i>Jaiminīyopaniṣat brāhmaṇa</i>
Atharvaveda	
Śaunaka <ul style="list-style-type: none"> ▪ <i>Śaunaka samhitā</i> ▪ <i>Gopatha brāhmaṇa</i> 	Paippalāda <ul style="list-style-type: none"> ▪ <i>Paippalāda samhitā</i>

The Vedic texts are the oldest available literature in India. They primarily comprise of the various *saṃhitā* texts associated with each of the *Ṛgveda*, *Yajurveda*, *Sāmaveda* and *Atharvaveda*. Multiple recensions or *śākhā* traditions are extant today in each of these Vedas with one or more texts. From older traditions we know that there existed many more *śākhā* traditions and corresponding ancillary texts which are not available to us today. Traditional lists of Vedic texts vary because *Āraṇyaka* and *Upaniṣat* may sometimes be considered as part of the *Brāhmaṇa* texts themselves.

Vedāṅga Texts

there are six subjects called *Vedāṅga*-s (“limbs of the Vedas”) with numerous texts as part of the Vedic tradition. Of the six, the *Nirukta* (etymology), *Vyākaraṇa* (science of words), *Cchandā* (prosody) and *Jyotiṣa* (astronomy) have one or two texts only. The subjects of *Śikṣā* (phonetics) and *Kalpa* (application) have large number of texts as part of the different *śākhā* traditions.

Study of Vedic Texts

Ṛgveda holds primacy in understanding ancient history and cultural practices. The other texts are also important but are considered as successors of the *Ṛgveda* and inherit its world view. Thus, in the last 100-200 years in academia, the understanding of the *Ṛgveda* has been pursued with great vigour, with Western scholars approaching it mainly from the linguistic point of view. In India historically there has been a strong view that Vedas are meant for conducting *yajña*-s (also known as sacrifices). Hence, in India pre-modern and modern writers have focused their study of Vedic mantras in their ritualistic interpretation. **Pt. Satyashrava** points this out in his book (1977) clearly;

“Interpretation of the hymns had been confined only to their ritualistic significance by the writers of the mediaeval periods, whose works were easily accessible to the Western scholars. It was expressed that the hymns are confined to the ritualistic *yajña*-s only as: *vedā hi yajñārtham pravṛttāḥ*. *Sāyaṇa* expressed the same idea in his preface to his commentary on *Kāṇva-Saṃhitā*. The translations of the Vedas as well as writings on the vast Vedic Literature by these scholars have, therefore, to be treated as one sided and incomplete. On the other hand, the interpretation of a hymn is to accord to its, *devatā*, metre etc. In the Vedic literature, threefold meaning of a hymn is prescribed by *Durgāchārya* in his *vṛitti* on the *Nirukta* 1.8: *adhyātm-ādhidāivat-ādhiyajñābhidhāyinā mantrāṇām arthā vijñāyante*”.

In *Nirukta* (4.13), *Yāska* explains one meaning of the Vedic word ***divya***, as ***divyāḥ divijāḥ*** (***divyāḥ*** = **born in the sky**). Thus, the *mantras* are known to contain information about physical celestial objects especially when the location context in the text is internally said to be *divya* or *dyauh*. We can infer that, at least from the time of *Yāska* (c 1000 BCE) onwards, the followers of Veda inherited and practiced a blend of *adhiyajña* or ritualistic, *adhidāivata* or celestial and *adhyātma* or introspective knowledge, as interpretations of *Ṛgveda* and other texts.

The seventh chapter of the *Nirukta* is dedicated to explaining the Vedic *devatā* (deities), and in the seventh section¹ shows that the concept of *devatā* have numbers as their basis, and translated by **Laxman Sarup** (1927) as,

“There are three deities only, say the etymologists: (1) *Agni*, whose sphere is earth; (2) *Vāyu* or *Indra*, whose sphere is atmosphere; (3) the sun, whose sphere is heaven. Of these, each receives many appellations on account of his super eminence, or the diversity of his function, just as a priest, although he is one, is called the sacrificer (*hotṛ*), the director of the sacrifice (*adhvaryu*), the possessor of the sacred lore (*brahmā*), and the chanter (*udgatṛ*). Or else they may be distinct, for their panegyrics as well as their appellations are distinct. As to the view that (one receives many appellations) on account of the diversity of functions, (it may be remarked) that many men also can do the actions, having divided them among themselves. With regard to it, the community of jurisdiction and enjoyment should be noted, as for instance, the community of men and gods with regard to earth. Community of enjoyment is seen in the following, i.e. the enjoyment of earth by the cloud, together with air and the sun, and the other world together with *Agni*. There everything is like the kingdom of man also.”

The above passage explains that the role of a *devatā* is to represent or be responsible for a particular phenomenon on one of the three locations, namely, *Prthivī* (*Earth*), *Antarikṣam* (*Atmosphere*) & *Dyauh* (*Sky*). There needs to be a minimum of three *devatā* representing the three locations, but based on diversity of action, placement and interactions, thirty-three or even more *devatās* can be counted. Further it is said that the actions in the sky is similar to what happens among humans on earth. **Satyashrava** explains

“Over centuries the rituals have attained a steady state as seen in the *Brāhmaṇa* and the *Sūtra* texts with the background sky observations rarely mentioned or assumed to be known to the priests. It is the *adhidaivata* interpretation that provides some clues to understand the Vedic sky.”

This is an insightful statement that many names/entities/concepts/principles would be needed to explain the Vedic cosmological world view.

We study two or three instances arising in the Ṛgveda, from the above point of view, to demonstrate that there is *Vedic Astral Science* encoded in these hymns with numbers, that can be verified from modern astronomy.

From a purely bibliographic consideration the Veda-Vedāṅga corpus consists of nearly one hundred primary titles of differing bulk and many secondary works such as commentaries and explanatory texts composed on different dates. Apart from its vastness we have to recognize that Vedic literature has a long time line from an unknown past before 3000 BCE to *circa* 500

1 तिस्र एव देवता इति नैरुक्ताः । अग्निः पृथिवीस्थानो वार्युर्वन्द्रो वान्तरिक्षस्थानः सूर्यो द्युस्थानः । तासां माहाभाग्यादेकैकस्या अपि बहूनि नामधेयानि भवन्त्यपि वा कर्मपृथक्त्वाद्यथा होताध्वर्युर्ब्रह्मोद्गातेत्यप्येकस्य सतोऽपि वा पृथगेव स्युः पृथग्घ स्तुतयो भवन्ति । तथाऽभिधानानि यथो एतत्कर्मपृथक्त्वादिति बहवोऽपि विभज्य कर्माणि कुर्युः । तत्र संस्थानैकत्वं संभोगैकत्वं चोपेक्षितव्यम् । यथा पृथिव्यां मनुष्याः पशवो देवा इति स्थानैकत्वम् । संभोगैकत्वं च दृश्यते । यथा पृथिव्याः पर्जन्येन च वाय्वादित्याभ्यां च संभोगः । अग्निना चेतस्य लोकस्य । तत्र एतत् नरराष्ट्रम् इव ॥ *Nirukta* (7.5)

BCE by which time the important primary texts including that of *Vedāṅga* had attained their present form.

Post-Vedic, BCE Astronomy Texts

Available literary evidences when analyzed dispassionately show that sky observation; description and knowledge of comets, meteors, eclipses and other celestial events and objects emerged in early Vedic India in the form of hymns and legends, to traverse further in terms of ideas, postulates, similarity arguments, space-time measures, geometrical and number congruencies, into the *kalpa* rites by way of the associated Brāhmaṇa works. This paved a parallel path for the development of the matter-of-fact astronomy of the schools of Parāśara, Vṛddhagarga and Lagadha before the Common Era, with adherence to the preceding Vedic tenets.

Quite interestingly, the Jaina (*Sūrya-candra Prajñapti*) and the Bauddha (*Śārdūla-karṇāvadāna*) BCE astral texts, without allegiance to Vedic rites or rituals, share some numerical constants with Vedic astronomy, at the same time differing in their models of the sky and the universe.

Objective

The objective of the present workshop is to introduce a few ancient literary sources which may be assigned to a date before the Common Era, for putting together a picture of astronomical knowledge that existed in India from the remote periods of the Ṛgveda meandering through several major and minor Vedic texts, early Purāṇas and the schools of Parāśara and Vṛddhagarga to reach the beginnings of the Common Era.

Although there is a vague timeline for the texts as **Vedic**, **Vedāṅga**, **post-Vedic**, and **Purāṇic**, many of the texts are not internally homogenous. As is well known, the texts were transmitted in oral tradition, scripted by different hands at different times, further copied repeatedly till published in print in the modern period. No specific date line and unique authorship can be assigned to the texts in their present form. Hence, the effort here is not to review each and every text to extract Hindu astronomy in some unknown order. Instead, following popular perception about astronomy as study of stars, sun, moon, eclipses, planets, comets, meteorites and anomalous events, the present workshop addresses the question: what celestial objects were observed and followed; what natural phenomena were known; in what detail and probably when?

National Workshop on Indian Astronomy Before Common Era

Lecture 2

CREATION, COSMOGONY, MERU-COSMOGRAPHY

Shankar Balakrishna Dixit (1853-1898) is the pioneer in the study of history of astronomy in India. His original Marathi book in two parts, translated into English and other languages,

<https://archive.org/details/BharatiyaJyotishSastra1>

is an important basic reference for all later history of Indian science literature. The first part is about Vedic, Vedāṅga and a bit of Smṛti, and Mahābhārata texts. The second part of his book is on the Siddhāntic astronomy that is roughly from the beginning of Common Era. Hence, the first part of BJS by SB Dikshit is a starting point for this workshop. I urge all of you to download the above book for personal study. In his preface he writes;

The present work has no parallel in Sanskrit literature. Our people are not much inclined to assess the merit of different works in the light of chronological sequence ; an author born a couple of centuries ago is, in their eyes, almost on a par with one who flourished a thousand years ago. Again, they are not disposed to trace the history of any science nor have they developed the habit of recording the lives of ordinary men. These appear to be some of the reasons why the like of this book was never produced in the past.

In recent years the above perception has changed. History of science is accepted as an important research front of IKS. This workshop is aimed at demonstrating that an improved and more complete history of Indian astronomy before common era (IABCE) can be brought out following broadly the same textual analytical approach of SB Dikshit. He starts with the Vedas:

Even a cursory glance at the Vedas will at once show that our ancient ancestors had a great liking for the observation of natural phenomena, particularly the wonders of the sky. If one looks into any of the Vedas or even any part or any chapter thereof, it would not generally happen that one does not come across some passages describing the sky, the moon and the sun, the dawn and the sun beams, the stars and asterisms, the seasons and months, the day and night or the wind and clouds. The description itself is enchanting, life-like, beautiful, amazing and awe-inspiring. The author refrains from giving specimens of such descriptions for that would be a digression needlessly leading us far afield.

ORIGIN OF THE UNIVERSE

Let us now see what description do we find in the Vedas about the “creation of the world” and the “structure of the universe”.

There are hymns and legends about creation of the Universe right from the Ṛgveda (RV), passing through almost all of Vedic literature and the Purāṇas.

RV 10th BOOK

(तृतीयोऽध्यायः ॥ वर्गाः 1-28)

(9)

72

(म.10, अनु.6)

ऋषिः लौक्यः बृहस्पतिः, आङ्गिरसः वा, दाक्षायणी अदितिः वा छन्दः अनुष्टुप् देवता देवाः

देवानां नु वयं जाना प्र वोचाम विपुन्यया	उक्थेषु शस्यमानेषु यः पश्यादुत्तरे युगे ॥ 1 ॥
ब्रह्मणस्पतिरेता सं कुमारंइवाधमत्	देवानां पुर्व्यं युगेऽसत्तः सदजायत ॥ 2 ॥
देवानां युगे प्रथमेऽसत्तः सदजायत	तदाशा अन्वजायन्त तदुत्तानपदुस्परि ॥ 3 ॥
भूर्जज्ञ उत्तानपदो भुव आशा अजायन्त	अदितेर्दक्षो अजायत् दक्षाददितिः परि ॥ 4 ॥
अदितिर्हर्जनिष्ट दक्ष या दुहिता तव	तां देवा अन्वजायन्त भद्रा अमृतबन्धवः ॥ 5 ॥
यद्देवा अदः सलिले सुसंरब्धा अतिष्ठत	अत्रा वो नृत्यतामिव तीव्रो रेणुरपायत ॥ 6 ॥
यद्देवो यतयो यथा भुवनान्यपिन्वत	अत्रा समुद्र आ गूळहमा सूर्यमजभर्तन ॥ 7 ॥
अष्टौ पुत्रासो अदितेर्ये जातास्तन्वरेस्परि	देवा उप् प्रैत्सप्तभिः परां मार्ताण्डमास्यत् ॥ 8 ॥
सप्तभिः पुत्रैरदितिरुप् प्रैत्पुर्व्यं युगम्	प्रजायै मृत्यवे त्वत्पुनर्मार्ताण्डमाभरत् ॥ 9 ॥

७६. १०. ७९.

“(1 and 2) We describe the births of gods in plain words—the (assembly of) gods which even though born in a former *yuga* sees the reciter (*stotā*) in the latter part of the *yuga*, while *śāstras* were sung (in sacrifices) like the *Karmār Brahmanaspati* created the gods. The *sat* (real) was created from *asat* (non-existent) in the first half of the divine *yuga*.

(3) The *sat* was created from *asat* in the first divine *yuga*; then the directions came into existence and then the *uttāna-pada* followed.

(4) The *uttāna-pada* gave birth to the earth, which in its turn gave birth to directions. *Dakṣa* was born of *Aditi*. *Aditi* was born from *Dakṣa*.

(5) Oh *Dakṣa* ! The praiseworthy and immortal gods were born after your daughter *Aditi*.” *Rk Samhitā*, X, 72.

This means, in a general way, that some kind of Being or Existence arose first, then came into existence the directions and then the earth.

The following lines from the *Rk Samhitā* may be seen :—

ऋतंच सत्यं चाभीद्वात्तपसोऽध्यजायत ॥ ततो रात्र्यजायत ततः समुद्रो अर्णवः ॥१॥

समुदावर्णवादिषसंवरसरो अजायत ॥ अहोरात्राणि बिदधद्विद्वस्य मियतो वक्षी ॥२॥

सूर्याचंक्रमसौ धाता यथापूर्वमकल्पयत् ॥ दिवं च पृथिवीं चांतरिक्षमथो स्वः ॥३॥

ऋ. सं. १०. १६०.

“(1) Truth (of thought) and truthfulness (of speech) were born of ardour penance, thence was night generated, thence also the watery ocean.

(2) From the watery ocean was the year afterwards produced, ordaining nights and days, the ruler of every moment.

(3) Dhatri in the beginning created the sun and the moon, the heaven, the earth, the firmament and the happy (sky)”.

There is considerable difference of opinion in the interpretation of the RV hymns. Sāyaṇa Bhāṣya takes “uttānapada” as ‘trees’.

वभूः^१ वउत्तानपदः^१ वृक्षात् वज्जे । तथा वभुवः सकाशात् वभाशाः वअजायन्त । तथा वअदितेः वदक्षः वअजायत उत्पन्नः । वदक्षाद् दक्षादपि वअदितिः वपरि अजायत । न स्वोत्पन्नं कार्यं स्वस्यैव कारणमपि भवतीति विप्रतिषिद्धमिति वाच्यम् । यास्काचार्य इदमेव^२ वाक्यमुदाहृत्य विरोधमाशङ्क्य पर्यहरत् । तथा हि—‘अदितेर्दक्षो अजायत दक्षाद्ददितिः परीति च । तत्कथमुप-पद्येत समानजन्मानौ^३ स्यातामित्यपि वा देवधर्मेणैतरेतरजन्मानौ स्यातामितरेतरप्रकृती’ (निरु. ११. २३) इति ॥

[10-072] HYMN LXXII. The Gods.

1. LET US with tuneful skill proclaim these generations of the Gods,
That one may see them when these hymns are chanted in a future age.
- 2 These Brahmanaspati produced with blast and smelting, like a Smith,
Existence, in an earlier age of Gods, from Non-existence sprang.
- 3 Existence, in the earliest age of Gods, from Non-existence sprang.
Thereafter were the regions born. This sprang from the Productive Power.
- 4 Earth sprang from the Productive Power the regions from the earth were born.
Daksa was born of Aditi, and Aditi was Daksa's Child.
- 5 For Aditi, O Daksa, she who is thy Daughter, was brought forth.
After her were the blessed Gods born sharers of immortal life.
- 6 When ye, O Gods, in yonder deep closeclasping one another stood,
Thence, as of dancers, from your feet a thickening cloud of dust arose.
- 7 When, O ye Gods, like Yatis, ye caused all existing things to grow,
Then ye brought Surya forward who was lying hidden in the sea.
- 8 Eight are the Sons of Aditi who from her body sprang to life.
With seven she went to meet the Gods she cast Martanda far away.
- 9 So with her Seven Sons Aditi went forth to meet the earlier age.
She brought Martanda thitherward to spring to life and die again.

RV Griffith translates the word ‘uttānapada’ as “Productive Power”. The literal meaning would be ‘lifted-foot’ and this ‘name’ is famous as King Uttānapāda, father of Dhruva who became the Polestar, in the Brahmāṇḍa, Viṣṇu and other Purāṇas.

There are several different models about creation. For example; the Puruṣa Sūkta, Asyavāmīya Sūkta, Hiranyagarbha Sūkta. The other Vedic texts have similar, but not same, creation legends. Śatapatha Brāhmaṇa says at first, it was neither *sat*, nor *asat*, it was only the *Manas*

मानसाग्न्युपासनं ब्राह्मणम् ।

नेव वा इदमग्रेऽसदासीत्, नेव सदासीत् । आसीदिव वा इदमग्रे नेवासीत् । तद् तन्मन
एवास ॥ १ ॥

Sun naturally occupied prominent status and position in the descriptions. But in measurements at least in the initial phases Moon was perhaps the support. This also changed as it was understood that seasons, rainfall are caused by Sun. But picturesque sky descriptions were possible only during the night. Hence, when sun and nakṣatras are described, we have to surmise this to be in the background of the early morning eastern sky. RV 1.50.2

उदु त्यं जातवैदसं देवं वहन्ति केतवः । दृशे विश्वायु सूर्यम् ॥ 1 ॥
अपु त्ये तायवां यथा नक्षत्रा यन्त्युक्तभिः । सूराय विश्वचक्षसे ॥ 2 ॥

पक्षे पतयथो पथथा प्रसिद्धास्तस्करा इव पनक्षत्रा नक्षत्राणि देवगृहस्थाणि । 'देवगृहा वे नक्षत्राणि' (तै. ब्रा. १. ५. २. ६) इति श्रुत्यन्तरात् । यद्वा । इह लोके कर्मानुष्ठाय' ये स्वर्गं प्राप्नुवन्ति ते नक्षत्ररूपेण दृश्यन्ते । तथा च श्रूयते—'यो वा इह यजतेऽमुं स लोकं नक्षते तन्नक्षत्राणां नक्षत्रत्वम्' (तै. ब्रा. १. ५. २. ५) इति । यद्वा । तेषां सुकृतिनां ज्योतीषि नक्षत्राण्युच्यन्ते, 'सुकृतां वा एतानि ज्योतीषि यन्नक्षत्राणि' (तै. सं. ५. ४. १. ३) इत्याजानात् । यास्करवाह—'नक्षत्राणि नक्षतेर्गतिकर्मणो नेमानि क्षत्राणीति च ब्राह्मणम्' (भिरु. ३. २०) इति । तथाविधानि नक्षत्राणि पञ्चभिः रात्रिभिः सह अपु यन्ति अपराच्छन्ति । विश्वचक्षसे विश्वस्य सर्वस्य

The above refers to early morning stars before sunrise.

RV 1.123.8 (Uṣas=Dawn)

सृष्टशीरुद्य सृष्टशीरिदु श्वो दीर्घं संचन्ते वरुणस्य धाम ।
अनुवद्यास्त्रिंशतं योजनान्येकैका क्रतुं परि यन्ति सृद्यः ॥ 8 ॥

8. Of the same appearance today, just the same appearance also tomorrow, they follow the long(-standing) ordinance of Varuṇa. The faultless ones make a circuit through *thirty* "wagon-treks" [=days of the month], each one encompassing her purpose in a single day. (S.W. Jamison)

Thirty Yojana is taken as a distance measure by Sāyaṇa and also in the Purāṇas.

RV1.155.6 Viṣṇu)

चतुर्भिः साकं नवति च नामभिश्चक्रं न वृत्तं व्यतीरवीविपत् ।
बृहच्छरीरो विमिमान् ऋक्भिर्युवाकुमारः प्रत्येत्याहवम् ॥ ६ ॥
चतुर्भिः । साकम् । नवतिम् । च । नामभिः । चक्रम् । न । वृत्तम् । व्यतीन् । अवीविपत् ।
बृहत्शरीरः । विमिमानः । ऋक्भिः । युवा । अकुमारः । प्रति । एति । आहवम् ॥ ६ ॥

अगमाङ्गिवाय्मा विष्णुः पचतुर्भिः पसाकं सहितां पनवति पच । चतुर्नवतिमित्यर्थः^१ । एतरसंख्याकान् कालावयवान् पनामभिः स्वकीयमनप्रकारैः प्रेरणविशेषैः पवृत्तं यथा भवति तथा पव्यतीन् विविधातनस्वभावान् वृत्तं पचक्रं पन बहुरोपेतं चक्रमिव तं यथा शत्रोरुपरि प्रक्षेपेण^२ भ्रमयति^३ तद्बहुकसंख्याकान् कालावयवान् पअवीविपत् कम्पयति भ्रमयति^४ ॥ 'दुवेषु कम्पने' । पयन्तात् छुडि चछि रूपम् ॥ के पुनस्ते उच्यते । सर्वस्वर एकः । अयमे द्वे । पञ्चत्तैव । द्वादश मासाः । चतुर्विंशत्यर्धमासाः । त्रिंशद्द्वयोरात्राः । अष्टौ यामाः । एकस्मिन् दिने पर्यावर्तमानानि मेघादीनि द्वादश कर्मान्तीति मिलित्वा चतुरधिकनवतिसंख्याकानवीविपत् । नन्वादित्यः स्वयमपि इतरणपरिभ्रमति कथं भ्रमयति^५ इत्युच्यते । नैष दोषः । एतेषां आभकस्य भ्रुवस्य विष्णोः मूर्त्यन्तरत्वात्^६ । अथवा स्वभ्रमणाधीनत्वादितरेषां परिभ्रमणस्य अतः स्वर्ध भ्रमयति^७ इत्युच्यते । एवं कालात्मकः^८ विष्णुः पबृहच्छरीरः विराडात्मना सर्वदेवमनुज्यादिशरीराणां स्वशरीरत्वात् । बृहच्छरीरत्वमेवोपपादयति । पविमिमानः विविधमायानं मिमानो देवतिर्यगात्मना विभज्य स्थापयन् । यद्वा । पचक्रभिः स्तुतिभिः मन्त्रवज्रैः^९ वा विमिमानः^{१०} । यद्यपि विभ्रुस्तथापि भ्रमत्वाधीनत्वात्^{११} स्तुत्या मीयते । पयुवा सर्वत्र मिश्रणशीलो नित्यतरुणो वा अत एव पअकुमारः अनल्पः पूर्वभूतो महाविष्णुः पआहवम् आह्वानं पप्रथेति गच्छति यज्ञदेशम् ॥ ॥ २५ ॥

6. With the four times ninety names [=days], he has caused the paired (horses) [=days and nights] to quiver like a wheel set rolling. Having a lofty body, measuring out (the realms?) with verses, the youth who is no boy returns to the challenge? (Jamison)

Should the number be taken as $90+4=94$ or $90 \times 4=360$?

About Sun in the Aitareya Brāhmaṇa. He never sets, never rises!

स वा एष न कदाचनास्तमेति नोदेति। तं यदस्तमेतीति मन्यन्तेऽह एव तदन्तमित्वाऽथाऽऽत्मानं विपर्यस्यते रात्रीमेवावस्तात् कुरुतेऽहः परस्तात्। अथ यदेनं प्रातरुदेतीति मन्यन्ते रात्रेरेव तदन्तमित्वाऽथाऽऽत्मानं विपर्यस्यतेऽहरेवावस्तात्कुरुते रात्रिं परस्तात्। स वा एष न कदाचन निम्रोचति। (AB 3.44)

Translation by M.Haug (available at Archive.org)

The sun does never set nor rise. When people think the sun is setting (it is not so). For, after having arrived at the end of the day, it makes itself produce two opposite effects, making night to what is below and day to what is on the other side. When they believe it rises in the morning (this supposed rising is thus to be accounted for). Having reached the end of the night, it makes itself produce two opposite effects, making day to what is below and night to what is on the other side.²⁴ In fact, the sun never sets. Nor does it set for him who has such a knowledge. Such a one becomes united with the sun, assumes its form, and enters its place.

This is better understood as a precursor to the Meru model, around which sun was supposed to rotate. We come back to this again later, in the *Mahāsalilam* book.

Sun is the primary celestial body that has been described, observed, tracked, lauded and worshipped most in our ancient texts. In the creation process also it was Āditya that appeared first before Bhṛgu and Āngiras as per the Aitareya Brāhmaṇa.

यद्रेतसः प्रथममुददीप्यत तदसावादित्योऽभवद्यद्वितीयमासीत्तद्भृगुरभवत्तं वरुणोन्यगृहीत तस्मात्स भृगुर्वारुणिरथ यत्तृतीयमदीदेदिव त आदित्या अभवन्त्येऽङ्गारा आसंस्तेऽङ्गारसोऽभवन्त्यदंगाराः पुनरवशांता उददीप्यंततद्बृहस्पतिरभवत्। (AB.3.34)

Day (*ahas*) and night (*rātri*) are the natural [light (*deva*) and dark (*asura*)] time units counted to be 720 per year. Sometimes the two were combined as *ahorātra* that would be 360 per year. Since night observations are with moon, the bright (*śukla*, *pūrvapakṣa*) and dark fortnight (*kṛṣṇa*, *asura*, *aparapakṣa*) were treated by similarity as Day and Night (of the pitrs, or by people living on moon). In extension of the above similarity concept, the Uttarāyana (northern transit from winter solstice) of Sun when the day light increased was called *daiva* and the Dakṣiṇāyana (southern transit from summer solstice) when day light decreased was known as *āsura*. In the early Vedic texts, the word *asura* did not have any negative meaning, it meant powerful/dark/strong.

Prajāpati's Choice of 15 and 30

The concept of *māsa*, the time interval from full moon to full moon and from *amāvāsyā* to *amāvāsyā* is central to Indian astronomy to this day. It is easy to note that sunrise to sunrise is one *ahorātra* and hence this can be counted in integral numbers. The *māsa* measure of sunset or sunrise as related with moon will not be a round number but will be between 29 and 30.

The naming of both the *pūrṇamāsa* and the *amāvāsya* as the Fifteenth that is *pañcadaśī* in the *Taittirīya Brāhmaṇa* (TB 1.5.10) is due to the idea of *pakṣa* synchronizing with the number 15. The *Śatapatha Brāhmaṇa* provides the heuristics for selecting the numbers 15 and 30 through a legend connected with *Prajāpati* one of his forms being the Year. After creation of the cosmos the joints of *Prajāpati* became slack at the meeting of day and night and at Full Moon and at *amāvāsya*. His joints at the syzygy were fixed by conducting the *darśa-pūrṇamāsa* rites².

The text further works out by recursion how the 360 days and 360 nights making up the year of 720 (*ahas + rātri*) can be factored into integers starting from 2 and increasing by unity at every step up to 24. The number 720 is divided by 2, 3, 4, 5, 6,8,9,10,12,15,16,18,20 to get 360, 240, 180, 144, 120, 90, 80, 72, 60, 48, 45, 40, 36. The text says, for each of these possibilities, *Prajāpati* could not envelop (*sa naiva vyāpnot*)³. When divided by 7, 11, 13, 14, 17, 19, 21, 22, and 23 *Prajāpati* could not manifest himself (*na vyabhavat*)⁴. Then, He sat there in that 15 boxed figure. Since he settled in the Fifteen, there are 15 forms (for moon) in the waxing and 15 forms in the waning fortnight⁵. Twenty-four is the number of *ardhamāsa* (half-months) in a year⁶. In similarity with the *śukla-* and the *kṛṣṇa-pakṣa* (bright- and dark- fortnight) being presided over by the number 15, the day and the night in an *ahorātra* are equated with 15 *muhūrta* of time.

The above legend is important to note that the basic time division of a day (sunrise to sunrise) as 30 *muhūrta* (like the present day 24 hours) was a fundamental concept, based on similarity between *ahorātra* and *māsa*. The sexagesimal base of ‘sixty’ for a cycle is just twice 30, since 12 *māsa* x 30 = 360; or 24 *ardhamāsa* x 15 = 360. In BCE; 1 *muhūrta* = 2 *nāḍikā*, 1 day-night = 60 *nāḍikā*. In the later *siddhānta* period the same relation was kept up except *nāḍikā* was replaced by *ghaṭikā*, indicating the measurement method. We come to this point again when we discuss, how time was measured.

The numbers occurring in the Vedas should not be treated lightly as figurative or as fanciful. A systematic investigation on the physical significance of numbers in relation to the *devatās* Indra, Sūrya, Viṣṇu, etc is yet to be done.

² प्रजापतेर्ह वै प्रजाः ससृजानस्य पर्वाणि विसस्रंसुः । स वै संवत्सर एव प्रजापतिस्तस्यैतानि पर्वाण्यहोरात्रयोः संधी पौर्णमासी चामावास्या चर्तुमुखानि ॥ स विस्रस्तैः पर्वभिः न शशाक संहातुं तमेतैर्हविर्यज्ञैर्देवा अभिषज्यन्नग्निहोत्रेणैवाहोरात्रयोः संधीतत्पर्वाभिषज्यंस्तत्समदधुः पौर्णमासेन चैवामावास्येनच पौर्णमासीं चामावास्यांच तत्पर्वाभिषज्यंस्तत्समदधुश्चातुर्मास्यैरेवर्तुमुखानि तत्पर्वाभिषज्यंस्तत्समदधुः । SB (1.6.3)

³ स द्वेधात्मानं व्यौहत् षष्टिश्च त्रीणि च शतान्यन्यतरस्येष्टका अभवन्नेवमन्यतरस्य स न व्याप्नोत् । त्रीनात्मनोऽकुरुत तिस्रस्तिस्रोऽशीतय एकैकस्येष्टका अभवन्त्स नैव व्याप्नोत् । [...] विशतिमात्मनोऽकुरुत षड्विंशदिष्टकान्त्स नैव व्याप्नोत् ॥ SB (10.4.2; 2-14)

⁴ न सप्तधा व्यभवत् । [...] नैकविंशतिधा व्यभवन्न द्वाविंशतिधा न त्रयोविंशतिधा ॥ SB (10.4.2; 8-16)

⁵ चतुर्विंशतिमात्मनोऽकुरुत त्रिंशदिष्टकान्त्सोऽत्रातिष्ठत पञ्चदशे व्यूहे तद्यत्पञ्चदशे व्यूहेऽतिष्ठत तस्मात्पञ्चदशापूर्वमाणस्य रूपाणि पञ्चदशापक्षीयमाणस्य ॥ SB (10.4.2; 17)

⁶ अथ यच्चतुर्विंशतिमात्मनोऽकुरुत तस्माच्चतुर्विंशत्यर्धमासः संवत्सरः । SB (10.4.2; 18)

National Workshop on Indian Astronomy Before Common Era

Lecture 3-4

SOMAPĀNA, NUMBER SYMBOLISM, INDRA, PRAJĀPATI, TIME

SOMA is a common word in many Indian languages; usually referring to Moon. But when Somapāna is mentioned, the attention goes towards 'drinking' Soma, some type of juice. Further, some would say that in Vedic Sacrifices, the priests consumed a drink distilled from a herb called Soma. Many have taken this to be an intoxicating drink, even though there is no evidence for this, since this is not Surāpāna.

Purānas also describe Indra and other *devatas* drinking Soma (Somapāna) in many places. The modern academic discipline of Indology/Indic studies mainly promoted by western scholars of Sanskrit, Soma is discussed as a weed, herb, fungus, mushroom that Vedic people used to make a ritual drink to get into some type of heightened experiences. The above has become a standard to the extent the original Vedic concepts are almost forgotten.

The reasons for this are many..... Practice of Vedic concepts/tenets/principles; Puranas and Shastras have diffused into daily life of Indians for centuries with many variations, interpretations, sampradaya and Parampara. There are persons who insist that all of the RV is to be interpreted as *adhyatma*. There are traditional sayings that 'Vedas' are meant only for carrying out *yajna*. I will not go into such arguments.

My intention is to demonstrate with examples how, the *devata* → *daivata* → *adhidaivata* leads from cosmological ideas to astronomical observations. This is closely linked to explain or experience or understand TIME that eventually merges with *adhyātma*.

SOMAPANA LEGEND: INDRA DRINKS 30 LAKES OF SOMA

एकंया प्रतिधा विचत्साकं सरंसि त्रिशतम् ।
इन्द्रः सोमंश्च काणुके ॥

RV. 8.77.4 In a single draught Indra drank 30 lakes full of Soma. Indra is lover of Soma.

एकेन प्रतिधानेनापियत् । साकं सहस्रार्थः । इन्द्रः सोमस्य काणुका । कान्त-
कानीति वा । कान्तकानीति यो । कृतकानीति वा । इन्द्रः सोमस्य कान्त इति वा ।
कणेघात इति यो । कणेहतः । कान्तितहतः ।

तत्रैतद् याज्ञिको वेदयन्ते । विशादुक्थपात्राणि माभ्यन्दिने सवन एकदेशतानि ।
साथैतस्मिन् काल एकेन प्रतिधानेन पियन्ति । तान्यत्र सरांस्युच्यन्ते । विशद-
परपक्षस्थादोरात्राः । विशदपूर्वपक्षस्येति विदक्ताः । तद् वा एताभ्याम्भ्रमस्य आमा-
मिन्य आपो भवन्ति रक्षमयस्ता अपरपक्षे पियन्ति । तथापि निगमो भवति ।

Nighantu & Nirukta by
Lakshman Sarup

यमक्षितिर्मक्षितयः पियन्ति । इति ।
तं पूर्वपक्षे आप्यायन्ति । तथापि निगमो भवति ।
यथा देवा अंशुमाप्यायन्ति । इति ।

The imperishable one whom the imperishable drink
As the gods cause the moon to grow.

Sayana Bhashya:

नैरुक्त्यप्रसिद्ध्या तु कालाभिमानि इन्द्रः

In the *adhidaivata* sense Indra's drinking Soma that is Moon is passage of time. The interesting point is about quantification as 30 = 15 days+15 nights

Surya Vivaha Sukta

N&N by Lakshman Sarup

सोमं मन्यते पवित्रान्यत्संपिपन्त्योपधिम् ।
सोमं यं ब्रह्मणो विदुर्न तस्याभ्राति कश्चन ॥

RV 10.85.3

सोमं मन्यते पवित्रान्यत्संपिपन्त्योपधिमिति यजुःसुतमसो-
ममाह । सोमं यं ब्रह्मणो विदुर्न तस्याभ्राति कश्चनादेव इति ।
अथाधिदेवतम् । सोमं मन्यते पवित्रान्यत्संपिपन्त्योपधिमिति यजुःसुतमसो-
ममाह । सोमं यं ब्रह्मणो विदुर्न तस्याभ्राति कश्चनादेव इति ।

अथैवापरा भवति । चन्द्रमसो वा । एतस्य वा ॥ ४ ॥

यत्रां देव प्र पिबन्ति तत् आ प्यायसे पुनः ।
वायुः सोमस्य रक्षिता समानां मास आकृतिः ॥

RV 10.85.5

यत् त्वा देव प्रपिबन्ति तत् आप्यायसे पुनरिति नाराशंसानभिप्रेत्य । पूर्व-
पक्षापरपक्षाविति वा । वायुः सोमस्य रक्षिता । वायुमस्य रक्षितारमाह । साह-
चर्यात् । रसहरणाद्वा । समानां संवत्सरणां मास आकृतिः सोमः । रूपविशेषै-
रोपधिः । चन्द्रमा वा ।

Ayajva ← → Adeva.

Soma is moon in the *adhidaivata* sense.
Somapana is the decrease in the digits of
moon's orb in the dark fortnight.

Because they grind the herbs together, one thinks that he has drunk the soma. Of the soma which the Brāhmanas know, none whatsoever partakes.⁴

The hemistich, 'Because they grind the herbs together, one thinks that he has drunk the soma', refers to the uselessly-pressed soma, which is not soma at all. Of the soma which the Brāhmanas know, none whatsoever, i. e. no one who does not offer sacrifice, can partake. This is with reference to sacrifice.

Now with reference to the deity. The hemistich, 'Because they grind the herbs together, one thinks that he has drunk the soma', refers to the soma pressed with the Yajus formula, which is not soma at all. Of the soma which the Brāhmanas know, i. e. the moon, none whatsoever, i. e. no one who is not a god, can partake.

The following, another stanza, is addressed to him, or to the moon.

(Here ends the fourth section.)

O god, when they drink thee, forth thenceforward thou thriveest again. Wind is the protector of soma; the month is the maker of years.

O god, when they begin to drink thee, forth thenceforward thou again thriveest; this refers to some particular libations, or to the first and second fortnights of the lunar month. Wind is the protector of soma. The seer calls wind its protector on account of companionship or extracting the juice.⁴ The month is the maker of years, of annual periods, i. e. the plant soma on account of its (assuming) particular shapes, or the moon.

Eclipse cycle number 3339 in the *Rgveda*

In the *RV* we come across many small numbers and also a few fairly large numbers. The small ones such as 3, 7, 12, 27, 49, 360 can be explained as having some physical significance and are also easily countable. A notionally large number appearing in a sacred text due to chance is more apt to be in hundreds and thousands in round figures. Curiously enough 3339 is a large number but is too precise and specific to be taken as an arbitrary count of *Viśvedeva* (VD) due to chance. It can be shown that this number is connected with lunar cycle of 18 years when the moon gets eclipsed near the same nakṣatra.

Hymn *RV* (10.51) is in the form of a conversation between *devāḥ* and *agni*, where in (v.2), *agni* wonders 'how many gods have clearly beheld my form'. There is also an allusion, [like in *RV* (3.9)] to *agni* hiding in secret places. The legend outlined in the hymn is briefly as follows. *Agni* had three elder brothers who were doing the work of carrying sacrificial offerings to gods. The three died due to the harsh *vaṣaṭ*, sounds uttered during the sacrifices. Hence the youngest fire known as *Saucika* fearing the same treatment will befall him was hiding in waters, till *viśvedevāḥ* found him and requested him to come out and help in carrying sacrificial offerings to gods.

(6)	52	(म.10, अनु.4)
ऋषिः सौचीका अग्निः	छन्दः त्रिष्टुप्	देवता विश्वे देवाः
विश्वे देवाः शास्तनं मा यथेह होता वृतो मूनवै यज्ञिषद्य		
प्र मे वृत भागुधेयुं यथा वो येन पृथा हव्यमा वो वहानि		1
अहं होता न्यसीदुं यजीयान् विश्वे देवा मरुतो मा जुनन्ति		
अहरहरश्चिनाध्वर्यवं वां ब्रह्मा सुमिन्द्रवति साहुतिर्वाम्		2
अयं यो होता किरु स यमस्यु कमप्युहे यत्समुज्जन्ति देवाः		
अहरहरजायते मासिमास्यथा देवा दधिरे हव्यवाहम्		3
मां देवा दधिरे हव्यवाहमपम्लुक्तं बहु कृच्छ्रा चरन्तम्		
अग्निविद्वान्युजं नः कल्पयाति पञ्चयामं त्रिवृतं समतन्तुम्		4
आ वो यक्ष्यमृतत्वं सूवीरं यथा वो देवा वरिवः कराणि		
आ ब्राह्मोर्वच्यमिन्द्रस्य धेयामथेमा विश्वाः पृतना जयाति		5
त्रीणि शता त्री सहस्राण्यग्निं त्रिंशच्च देवा नव चासपर्यन्		
औक्षन्धृतैरस्तृणन्वर्हिरस्मा आदिद्धोतारं न्यसादयन्त		6

The verse (v.3) alludes to counting of days or nights, where the reference is to one *who springs to life month by month and each day (aharaha jāyate māsi māsi).*

The conclusion that this should be a reference to moon is natural. *Agni* being honoured by 3339 gods (300+3000+39) is the theme of the last verse of this hymn.

A literal translation as by Sri Aurobindo is

“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.”

This verse is the famous *nivid* that specifies the number 3339 as the count of *Viśvedevas*.

In Hymn(10.53): not fully discussed here it is said

“Agni has arrived with the life (TIME) given to him by the gods and has made our offerings to the gods auspicious. We have obtained (UNDERSTOOD) the secret of the sacrifice.”

Bṛhaddevata Ch. 7 provides more details of the legend

तवाग्ने यज्ञ इत्येतत् प्रत्याग्निं स्विरकृच्च सः ।
यस्य चीष्णि सहस्राणि नव चीष्णि शतानि च ॥ ७५ ॥
त्रिंशच्चैव तु देवानां सर्वानेव वरान्ददुः ।
ततोऽग्निः सुमनाः प्रीतो विश्वेर्देविः पुरस्कृतः ॥ ७६ ॥

In the Vedas directly we do not get a physical explanation for this number. But the Purāṇas have maintained the meaning. Brahmanḍa Purāṇa Ch 23 has the astronomical information.

भक्तार्थममृतं सोमः पौर्णमास्यामुपासते
एकां रात्रिं सुरैः सर्वैः पितृभिः सर्षिभिः सह ६६
सोमस्य कृष्णपक्षादौ भास्कराभिमुखस्य तु
प्रचीर्यते पितृदेवैः पीयमानाः कलाः क्रमात् ६७
त्रयश्च त्रिंशत्त्रयश्च त्रयस्त्रिंशत्त्रयश्च च
त्रयश्च त्रिसहस्राश्च देवाः सोमं पिबन्ति वै ६८
इत्येतैः पीयमानस्य कृष्णा वद्धन्ति वै कलाः
चीर्यन्ति तस्माच्छुक्ताश्च कृष्णा आप्यायन्ति च ६९
एवं दिनक्रमात्प्राति विवृधेस्तु निशाकरे
पीत्वाद्धमासं गच्छन्ति चामावास्यां सरोत्तमाः ७०

Three hundred and three, then thirty-three and again three thousand and three gods drink soma. (33+303+3003=3339) Being drunk this way, the dark digits increase with corresponding decrease in the bright digits.

The above number is the number of *Viśvedevāḥ* of the *Ṛgveda*! These deities are important in ancestral rites even now. The ritualistic correlation between moon and *pitṛs* is well known but the astronomical link is intriguing!

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. This number is the count of *moonrises* in the dark fortnights summed up as 3339 sequentially for a special purpose. If both the fortnights were to be included, this count would be $3339 \times 2 = 6678$ *tithis*.

$6678/30 = 222.6$ lunations, in round figures is the eclipse cycle of 223 synodic months. Vedic months were lunar but the year was solar. It is known one solar year was taken to have 371-372 *tithis*. There are 241 sidereal months in this period.

$3339 \times 2 = 6678 = 371 \times 18$. Hence 3339 is a proxy for the 18-year eclipse period, when a lunar eclipse occurs near the same nakshatra in the visible sky. This is also the length of *Rāhu-daśa* in Hindu astrology!

If the *Sāvana* year of 360 days is taken, $6678/360 = 18.55$ years. This is the Lunar node (*pāta*) period in *siddhānta* astronomy.

Yajurvedic sages perhaps knew the following relation to propose the Five Year Yuga

$223/18 \rightarrow 12/1, 25/2, 37/3, 62/5$; (Five solar years = 62 synodic months, *māsa*)
 $241/223 \rightarrow 13/12, 27/25, 40/37, 67/62$ (67 sidereal month = 62 *māsa*)

Sidereal month: moon starting from a nakṣatra comes back to the same nakṣatra = 27.3 days
Synodic month: FM/NM to FM/NM interval = 29.5 days or equal to 30 *tithi*.

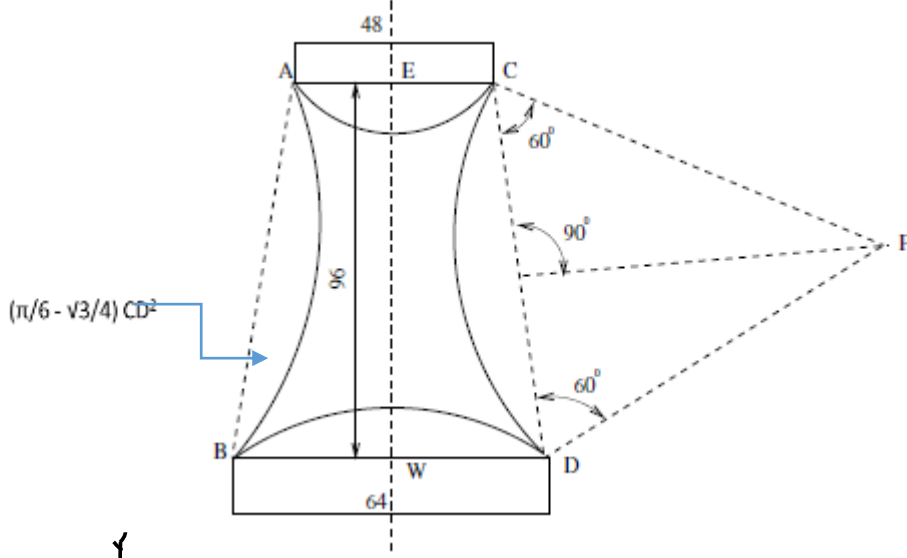
From the above analysis a physical connection between the 3339 *viśvedevāḥ* and an *agni* who can cause eclipses is seen to exist. Even if the hymns were to be taken as mystical poetry the reference to the waxing and waning of the moon and further eclipse imagery is too conspicuous to be overlooked.

How did the ancients count the above large number? It was mentioned above that *Prajāpati* became lax in his joints and that was set right by *Darśa-pūrṇamāsa* (DP) rites. the *Darśa-pūrṇamāsa-iṣṭi* (Newmoon-fullmoon rite) is directly connected with lunar astronomical events as the name indicates. The ritual is described to varying levels of detail in the *Yajurveda Samhitā*, the *Brāhmaṇa* and the *Sūtra* texts. The constructions of the *vedis* or altars in which the sacrificial offerings are done are described in the *Śulba Sūtra* texts which are formulaic and hence cryptic but preserve the scientific developments of the Vedic period.

Altar (DP-vedi)

The construction of the DP-altar invariably called the *vedi* or the *antarvedi* is described in the various *Śulba-sūtra* texts (*ed.* Sen and Bag). The details are same in all the texts except for minor differences. An isosceles trapezium ABCD as shown in Figure1 is constructed

symmetrically about the east-west line. The eastern and the western sides AC and BD are respectively 32 and 64 *angula* long. The height of the trapezium is 96 *angula*. With points C and D fixed, a rope of length 2CD is stretched in the southern direction till point F. With F as the centre and FC as the radius an arc of a circle is made to pass through points C and D. This is repeated symmetrically on the northern side AB. Similar arcs are drawn on the eastern and western sides. The trapezoidal figure with arcuate sides is the *DP-vedi* in plan. Significantly there are no prescriptions about the shape of the bricks or layers.



Area of the *DP* altar

An important concept associated with Vedic altars is their shape and area. The principle of equivalence of the areas of the circular *gārhapatya*, square *āhavanīya* and the semicircular *dakṣiṇāgni* altars has been discussed in the past by several persons and hence will not be detailed here. Vedic symbolism equates the *gārhapatya* altar with the earth and the *āhavanīya* in the east with the sky (Śatapatha Brāhmaṇa 7.1.1.13 and 8.2.1.2). All texts are clear that the three fire altars should have equal area of one *vyāma* and built in five layers using burnt bricks of prescribed numbers and sizes. The *DP-vedi* is situated within the space enclosed by the above three as shown in Figure 2, but is neither built in five layers nor with any special bricks. No fire is lit on the *DP-vedi* even though it is as important as the others in the DP-rites. The ritual manuals discriminate the *DP-vedi* from the other three altars for some special reason. What strikes the eye is the peculiar shape of the altar which is deliberate and painstakingly explained in the manuals. The principle of equivalence of the areas encourages us to find the area of the *vedi*, the construction of which is clearly given in the Baudhāyana śulba sūtra⁷. The area of the basic trapezium is 5376 square units. Since by construction CDF is an equilateral triangle, the area of the curved region cut out from the trapezium is $(\pi/6 - \sqrt{3}/4) CD^2$. The length of the side CD is $96\frac{1}{3}$ units, which is slightly more than the height of the trapezium. From these considerations the area cut out on the four sides of the trapezium can be found to be 2261 units. This gives the exact area of the *vedi* to be 3115 units. It is to be noted here the above value is based on the presently known accurate values of the irrational numbers π and $\sqrt{3}$. However, in the Vedic period the sages handled these irrational numbers rather

⁷ ७१. अपरेणाहवनीयं यजमानमात्री भवतीति दार्शपौर्णमासिकाया वेदेर्विज्ञायते। ७२. तस्यास्त्रिभागोनं पश्चात्तिरश्ची । तस्या एवार्धं पुरस्तात् तिरश्ची ।

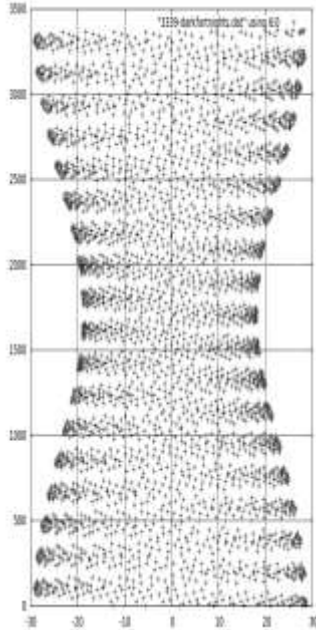
एवं दीर्घचतुरस्रमेकतोऽणिमद्विहृत्य स्रक्तिषु शङ्कुनिहन्त्यात् । ७३. यावती पार्श्वमानी द्विरभ्यस्ता तावती रज्जुमुभयतः पाशां कृत्वा मध्ये

लक्षणं करोति । दक्षिणयोः पार्श्वयोः पाशां प्रतिमुच्य लक्षणेन दक्षिणापायम्य लक्षणे शङ्कुं निहन्त्यात् । तस्मिन्पाशाौ प्रतिमुच्य लक्षणेन दक्षिणं पार्श्वं परिलिखेत।

७४. एतेनोत्तरं पार्श्वं व्याख्यातम् । ७५. पूर्वं पार्श्वं तथा द्विरभ्यस्तया परिलिखेत । एवमपरम् ।

approximately and perhaps computed the area of the arc by dividing it into squares and triangles. What area the manuals aimed at for the *vedi*?

The best of the ancient approximations were $\pi = 3.0885$ and $\sqrt{3} = 26/15$ as explained in detail by Sen and Bag. Hence the area they implied to remove from the trapezium was equal to 2032 square units making the area of the *vedi* to be 3345 units. There is one unknown step here in

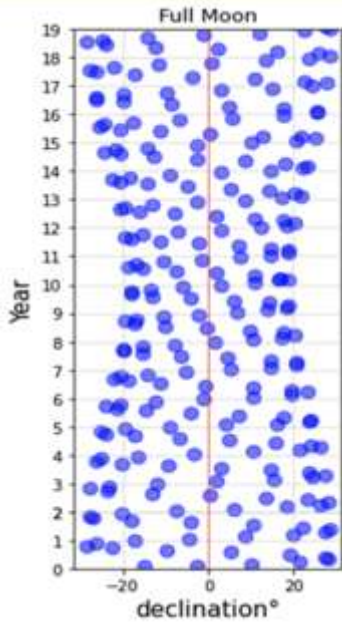


that we do not know whether the priests took the length of CD as 96 or more correctly as $96\frac{1}{3}$. In the former case the area of the *DP-vedi* would become 3334 units. The above two numbers are the best estimates of the area of the *DP-vedi* of the Vedic period. This result is remarkable since the average of the two values happens to be close to 3339, a number stated in the *Rgveda* for invoking a special fire known as *saucikāgni*.



Moon's Path

Moon is the fastest celestial object for viewers on earth. The orbit is known to be complex. Hence naked eye observations are not easy and such results are usually not accurate. Additionally, in the bright fortnights moon can appear in day time making observations still more difficult. It is in this context the Vedic concept of deities drinking Moon only in the dark fortnight has to be appreciated as a model of scientific naturalism adopted as fundamental by Hindu culture. Moon will be visible in the night sky all through the dark fortnight and hence observing moon at a fixed time, say before sunrise, would be possible except under bad weather conditions. From modern astronomy it is known that moon's orbit is inclined to the ecliptic by about $\pm 5^\circ$. Since the ecliptic and the equator are inclined at about 24° with each other, for an observer on earth moon will appear wandering north-south in the range of $\pm 29^\circ$. If one were to start with a major standstill of moon and mark the declination for a period of 18.6 years or 230 lunations till the next major stand still, the resulting figure will be very similar to the shape of the *DP-vedi*. The minor standstill will be in between at the central part of the figure giving a pinched shape. However, we have not been able to locate statements about lunar standstills in the Vedic texts. Moreover, the *DP-vedi* relates to the eclipse period number 3339 which is equal to 223 lunations. Nevertheless, lunar standstills provide a clue to how the Vedic people might have arrived at the *DP-vedi* in keeping track of the long count 3339. Suppose the Vedic astronomers started with a lunar eclipse very near a major standstill and marked moon's declination approximately, in the dark fortnights for a period of 3339 *tithi* by placing a piece of stone on the ground, the shape of the resulting figure would have been similar to the *DP-vedi*. A verification of this claim is provided in the figure above.



In this figure the declination position of moon for exactly 3339 consecutive observations in the dark fortnights are shown. The plot starts from the bottom with an eclipse on 7th September 2006 and ends with the New Moon on 13th September 2024. A lunar eclipse is possible on the next Full Moon. This figure though modern, clarifies several features of the ancient *DP-vedi*. Firstly, the serpentine path of the moon in the sky as transferred to the ground is very robust. The shape emerges by just marking the visible Full Moon rising positions as shown in the figure on the left. Even with many misses the symbolic shape of moon's location in the sky is unaltered. The symmetry about the E-W line is striking and is clearly maintained in the *DP-vedi*. The enveloping boundaries are not circular arcs, but the figure described in the Śulba texts is a good approximation.

Evidence available so far, points out that the long count number was discovered with the help of lunar eclipses. This is implied by the counting of the 3339 *tithis* starting from a full moon and carrying this count only during the dark fortnights, to end on an *amāvāsyā*. The expectation would have been that the subsequent full moon would be an eclipse night. Duncan Steel in his famous monograph on eclipses discusses how ancient civilizations could have arrived at the 18-year cycle by observing the moon rather than marking solar eclipses. (*Eclipse- The celestial phenomenon that changed the course of history*, by D. Steel; National Academy of Sciences, USA, 2003. <https://books.nap.edu/catalog/10123.html>)

In the present case the *BrahmāṇḍaPurāna* preserves a simple explanation for the above number. This leads us to the conclusion that 3339 represents the *tithis*, in the dark fortnights, separating two lunar eclipses with roughly the same celestial circumstances and features. *Tithi* is a time unit well known and continues to be used in India. The present study indicates that this concept has come down to us from the times of *RV*, even though how it was originally measured is not yet completely understood. But it may be noted, the word *tithi* in the sense of date in a year is used in the *Śatapatha Brāhmaṇa*. Unfortunately, those who read only the English translation of this important Vedic text miss this word since Eggeling in his translation left out this word⁸. This appears in the legend of Manu's Flood (ŚB I. 8.1).

स यत्तिथिं तत्समां परिदिदेश तत्तिथिं समां नावमुपकल्प्योपासां चक्रे॥

This alludes to the promise of the Fish to come on a specified *tithi* in a specified year and that Manu awaited the arrival of the Fish on that *tithi* in that year with a boat ready for travel. Although no specific year or day is mentioned the word *tithi* has been used in this early Vedic text in the sense of date.

The above points lead to the question, whether the DP-altar, its correlation with moon and the number synchrony of 3339 was used for eclipse prediction in the most ancient times. There

⁸ The *Śatapatha Brāhmaṇa* (English Translation in 3 vols. *SBE series*) by J. Eggeling. (MLBD) N. Delhi, 1963. 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." (SB I. 8.1)

are no direct textual evidences found so far. But indirect evidence exists in the hymns that are prescribed in the DP-rites, that are observed by *āhitāgnis* even now.

Number symbolism of meters, measures, areas appear in Vedic texts almost everywhere. The *Taittirīya Saṃhitā* starts with the DP rite hymns, elaborated in 14 *anuvākas* (sections). The number of syllables in these hymns adds to between 3339 and 3349. The 9th *anuvāka* is about the preparation of the *vedi* or the DP altar with interesting etiology. The legend of an *asura* named *Araru* and his shadow falling on earth is cited. The altar is enjoined to be dug for only four *aṅgula*, because a deeper altar belonged to the ancestors. This appears in the *Taittirīya Brāhmaṇa* (III. 2.9), where it is said that the *Vedi vanished from the devas*.

पितृदेवत्याऽतिखाता । इयंतीं खनति । प्रजापतिना यज्ञमुखेन संमिताम् । वेदिदेवेभ्यो निलायत । तां
चतुरङ्गुलेऽन्वविन्दन्न । तस्माच्चतुरङ्गुलं खेयाम् । चतुरङ्गुलं खनति । चतुरङ्गुले ह्योषधयः प्रतितिष्ठन्ति । आप्रतिष्ठायै
खनति । यजमानमेव प्रतिष्ठां गमयति । दक्षिणतो वर्षीयसीं करोति । देवयजनस्यैव रूपमकः ॥ ३ । २ । ९ ॥

(If the vedi should be) excessively (i.e. too deeply) excavated, it would belong to the Fathers (i.e. the deceased ancestors) (and it would not be fit for the sacrifice to the gods). He (the Adhvaryu) excavates it to such an extent that it is equal to Prajāpati, the mouth of the sacrifice. (Formerly) the vedī hid itself from the gods. They found it four aṅgulas deep (in the earth). That is the reason why it should be excavated four aṅgulas deep⁹.

There is a hint here that such altars were in use for a long time before the DP ritual got fixed. Even more interesting is the further laudation of the altar:

पुरा क्रूरस्य विसृपां विराडिन्द्रदादाय पृथिवीं जीरदानुयां ऐरयन् चन्द्रमसि स्वधाभिः तां धीरासा
अनुदृश्य यजन्ते ॥ TS (I.1.9)

...you are the self-law....you the glorious one, take the earth.... by means of its self-law and place it on the moon.

पूर्वे यजमाना वेदिरूपं यां पृथिवीं कृत्स्नभूमेरासुर्याः सकाशादूर्ध्वमादाय चन्द्रमस्यमृतकिरणैः
सार्धं स्थापितवन्तः इदानीन्तनास्तु धीमन्तः तामिमां वेदिं मनसानुचिन्त्य तस्यां यजन्ते ॥
Sāyaṇa Bhāṣya (TS I. 1.9)

As per *Sāyaṇa*'s interpretation also the altar was used by the ancestors of the current practitioners to establish earth on the moon as per natural self-law (*svadhā*).

We can surmise that the shadow of the earth falling on the moon was perhaps known to be the natural reason for the eclipse, the legends related to the DP altar, its shape and area perhaps directly point towards the pervasive influence of the Ṛgvedic number 3339 and its hidden meaning connected with eclipses, in the proceedings of the DP rite.

⁹ Dumont P. E., *The full-moon and new-moon Sacrifices in the Taittirīya Brāhmaṇa* (I Part, Text with Translation) Proc. Am. Phil. Soc., 101, 2, 1957, pp. 216-243.

While legends, folklores and beliefs were plenty, observation, explanations and physical models were not lagging behind. The various *Purāṇas* allude to the mythical eclipse demon *Rāhu* but unequivocally equate this with the shadow of the earth, as in the *Brahmāṇḍa Purāṇa*.

तुल्यस्तयोस्तु स्वर्भानुः भूत्वाधस्तात् प्रवर्तते। उद्धृत्य पृथ्वीच्छायां निर्मितो मण्डलाकृतिः॥
Brahmāṇḍa Purāṇa (I Pt. 23.101)

Importance of the Legend of Dhruva for Indian Chronology

Lecture 5-6

The story of the child prince Dhruva who by his penance became the Pole Star is a captivating children story. This can be traced to the Brahmāṇḍa Purāṇa (BP) and the Viṣṇu Purāṇa (VP) which were scripted into their present form in the early centuries of the Common Era (CE). But, there was no visible star at the North Celestial Pole (NCP) during the above period that could have been called *Dhruva* meaning fixed or constant. From where did the Purāṇas inherit such an astral legend so vividly? There by hangs a piece of Indian history of seminal importance going back to early Vedic times when the star *Abhaya* (Fearless) was stationary, at the tail end of a group of fourteen stars, looking like a four footed aquatic animal called *Śiśūmāra*. This northern polar constellation forgotten over millennia, except for its laudation in the Vedic *Taittirīya Āraṇyaka* text of the *Kṛṣṇa Yajurveda*, is recognizable as the modern constellation Draco. *Abhaya* the fourteenth star on this whale-like animal figure is α -Draconis (Thuban) which was the Pole Star during 3200-2400 BCE. In this long period, the declination of this star varied from $87^{\circ} 56'$ to $87^{\circ} 36'$, reaching NCP at $89^{\circ} 53'$ in 2830 BCE. Such closeness to the North Celestial Pole made the star look stationary with reference to its neighbours in the night sky. This property of fixity got embedded into Vedic marriage rituals, where the bride had to be shown ceremonially the Pole Star reciting a special hymn, invoking the fixity of the star *Dhruva*. Due to the effect of earth's axial precession, this sky picture changed over generations with a Vedic text wondering why even *Dhruva* is moving. Irrespective of when the *Taittirīya Āraṇyaka* and the *Purāṇa* got fixed, these texts carry layers of cultural astronomy from *circa* 3000 BCE as long term societal memory. Even as late as 11th cent Alberuni wrote that his Hindu informants claim their Pole Star to be seen at the tail end of a group of fourteen stars looking like an aquatic animal called *Śākvara Śiśūmāra*. The famous astronomers, Brahmagupta (7th cent) and Bhāskara-II (12th cent) remained silent about the ancient star *dhruva*, but knew the northern constellation U. Minor by the name *Dhruva-matsya* or Polar-fish. The star α -U.Minor (Polaris) was almost at the NCP in 17th cent seemingly stationary to naked eye observers. Another famous scientist Kamalākara Bhaṭṭa of Vārāṇasi in his astronomy text (1658 CE) declared, probably responding to some ceremonial controversy, that the star seen at (90° Long, 66° Lat) should be the one to be shown to the bride in Hindu marriages. This star happens to be Polaris, which is the Pole Star even now. Thus the legend of *Dhruva* provides two stars α -Draconis (Thuban) and α -U.Minor (Polaris), stationed at the north celestial pole as the bookends of five thousand years of Indian chronology.

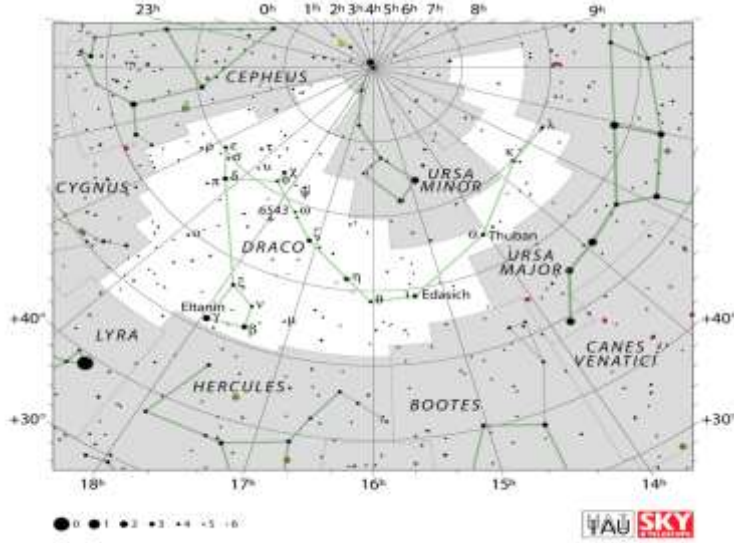


Figure 1. Upper constellation: Ursa Minor composed of seven stars with the present Pole Star (Polaris). Lower constellation: Draco with modern star names. Vedic *Śiśumāra* constellation counted two stars at the two bends and stopped at the fourteenth α -star (Thuban) named *Abhaya* in the *Taittirīya Āraṇyaka*; later popular as Dhruva.

Introduction

Apart from the diurnal and the yearly rotation cycles, earth undergoes a very long period rotation of about twenty-six thousand years known by the term axial precession. The effect of this slow wobbling of the north-south axis of the globe is generally not felt by humans over short periods. However, cultures that historically observed the sky for forming their world view, would have felt the effect of this slow change over a few generations. From the geocentric point of view, the effect of precession will be in the form of seasonal stars, named and identified by previous generations, seen to be shifting their positions or new ones coming to the desired station on the horizon before or after sunset. At particular locations, such experience could have even led to legends of vanishing stars. Another felt effect of precession for ancient societies would have been the change in the shapes and movements of star groups in the northern sky. Since the changes are too slow, a sure way to trace ancient chronology would be to search for descriptions of the same sky part in an array of texts that have maintained a clear semblance of cultural continuity and to decipher the emerging patterns within the constraints of modern astronomy. The present paper is motivated by the above points to study and investigate the legend of *Dhruva*, widely spread all over India in the form of an astral legend deeply embedded in the vast Purāṇa literature in Sanskrit. The word *dhruva* in Sanskrit primarily refers to an object having the quality of fixity, constancy, certainty, stationarity. Hence the context of the use of the word is important to understand whether the texts mean a star in the sky personified or otherwise, but not a firm object like a hill or a tree. The methodology followed here, is to first briefly review the Vedic texts and then pass on to the Purāṇa literature. The cultural and astronomical resultants about *Dhruva* the Pole Star of these texts are compared with the later mathematical *siddhānta* and other literature of the well constrained historical period. The existence of two north constellations in the astronomy literature of India, both attested to be carrying the fixed Pole Star is demonstrated. The two stars due to their observed quality of fixity have the same name *Dhruva* but are separated by nearly five thousand years.

Taittirīya Āraṇyaka (TA)

The *Taittirīya Āraṇyaka* (TA) is an accented Vedic text, belonging to the Kṛṣṇa Yajurveda branch. This text contains several interesting astronomical information that should be of interest to historians of science. The first section of the text is about the six seasons and how they are recognized taking note of social behavior and some natural changes. The text declares,

the knowledge of Sun's station to be available to everyone using the four tools; memory, direct observation, history and inference¹⁰. Time is explained as flowing out of Sun and that *Time* flows like a river continuously. Two meteoritic showers spaced at six-month interval find place (TA I.3; I.4) as help in recognizing the two felt seasons *grīṣma* (summer) and the *hemanta* (dewy).

The concept of *mahāmeru* the imaginary tower-like axis connecting earth with the heavens appears for the first time in Vedic literature in TA. The text alludes to seven suns and one more, the eighth called *Kaśyapa*, who does not leave *meru* but goes round the *mahāmeru*¹¹. This concept of a celestial body going round *meru* evolved into a physical cosmological model in the *Brahmāṇḍa Purāṇa*. *Kaśyapa* having another name *Prajāpati*, appears in TA as a star in the description of the celestial *Śiśumāra*, a constellation in the form of an aquatic animal (whale or dolphin), with a star named *Abhaya* at its tail end, which over time acquired the legendary name *Dhruva*, due to its property of being fixed in position as seen from earth.

Celestial Śiśumāra

The second *prapāṭhaka* of TA known also as the *Svādhyāya Brāhmaṇa*, gives the hymns used in the daily prayers of those initiated into Vedic rites. The nineteenth hymn of this book known as the *Brahmopasthāna mantra* is used at the conclusion of the evening meditation. This astronomical text in a near literal translation reads¹²:

Whom we bow is the Crown. Dharma is the forehead; Brahma is the upper jaw, Yajña is the lower jaw, Viṣṇu is the heart, Samvatsara is the genital, Aśvins are the forelegs, Atri is the center, Mitra and Varuṇa are the hind legs. Agni is the first stem of the tail, then Indra, then Prajāpati and then Abhaya is the fourth. This [He] is the shining celestial śākvara (powerful animal) Śiśumāra. One who knows this will win death, will win heaven, will not die while travelling, will not die in water, will not die without offspring, will get food easily. You are fixed (dhruva), you are the place of Dhruva, you are the Lord of Beings; you are the best among them. (All) Beings go around you. Namaste! Salutations Śiśukumāra!

The above hymn lists fourteen stars, *Dharma, Brahma, Yajña, Viṣṇu, Samvatsara, (Twin) Aśvins, Atri, Mitra, Varuṇa, Agni, Indra, Prajāpati, Abhaya*, along the body of the figure of the *Śiśumāra* unequivocally said to be in the sky. Both Bhatta-bhāskara (10th cent) and Sāyaṇa (14th cent) describe the esoteric import of the hymn, along with the parts and form of the animal figure in the sky. The former commentator takes *Prajāpati* to be *Kaśyapa* the eighth sun, mentioned previously in TA as not leaving the *meru*¹³. This hints at the circumpolar nature of some of the stars of this constellation, which finds prominent mention in the later *Purāṇas*. The hymn is more about the constellation figure as a group of stars, but the equivalence of *Abhaya* with the Pole Star later known as *Dhruva* is evident from the context. The text of TA is among the special texts to be learnt in the seclusion of a forest, as it contains secret mystical and

¹⁰ smṛtiḥ purāṇamaitiḥyam anumānaścaturṣṭayam| etairādityamaṇḍalam sarvaireva vidhāsyate|| TA (I.2.1)

¹¹ kaśyapo'ṣṭamaḥ sa mahāmerum na jahāti|[...]na hi śekumiva mahāmerum gantum iti| apaśyam aham etat sūryamaṇḍalam parivartamānam | gārgyaḥ prāṇatrātaḥ |gacchanta mahāmerum|| TA (I.7.1-3)

¹² yasmai namaḥ tacchiro dharmo mūrdhānam brahmottarāhanuḥ yajño adharā viṣṇurhrdayam samvathsaraḥ prajananam aśvinau pūrvapādāu atrirmadhyam mitrāvaruṇau aparapadāu agniḥ pucchasya prathamam kāṇḍam tata indrastath prajāpatiḥ **abhayam** caturtham |savā eṣa divyaḥ śākvaraḥ **śiśumāraḥ** tamha| ya evam vedāpa punarmṛtyuṃ jayati jayati svargaṃ lokaṃ| nādhvani pramīyate nāganau pramīyate nāpsu pramīyate nānapatyāḥ pramīyate laghvāno bhavati |dhruvastvamasi dhruvasya kṣitamasi tvam bhūtānām adhipatirasi tvam bhūtānām śreṣṭho'si tvām bhūtāni upaparyāvartante namaste namaḥ sarvaṃ te namo namaḥ| śiśukumārāya namaḥ|| (TA. II.19.1)

¹³ TA with the Commentary of Bhaṭṭabhāskara Miśra (Ed. A.M.Shastri and K.Rangacharya) Mysore 1900.

naturalistic meanings at the same time. The play on the word *Śiśumāra* finally concluded as *śiśukumāra* (boy-child) should have been the inspiration for the Viṣṇu Purāṇa legend of the fear less child Dhruva, placed in the sky as the Pole Star near Viṣṇu, reigning at the heart of the *Śiśumāra*.

In the accented text *Ekāgni-kāṇḍa*, also belonging to the *Kṛṣṇa Yajurveda*, hymns to be used in Vedic marriage rites are given. The hymn for observing and addressing the Pole Star Dhruva is;

*dhruvakṣitiḥ dhruvayoniḥ dhruvamasi dhruvataḥ sthitam | tvam nakṣatrāṇām methyasi sa
mām pāhi pṛtanyataḥ || (Ekāgnikāṇḍa I.9)*

Here the quality of *Dhruva* as a star is said to be fixed. *Dhruva* is praised as the *methī* or the fixed column to which the *nakṣatras* are bound. The commentator Haradatta explains the word *methī* as *khalevālī*, a thick wooden peg fixed in the ground, to which animals are tied so that they do not stray away¹⁴. This *methī* became the *medhī* a pole or column in the Purāṇas, highlighting the fixity of the star *Dhruva* and the importance of *Meru* in the development of early astronomical models. Beyond reasonable doubt the composers of the above Yajurveda texts knew by direct experience or by inherited memory *Abhaya alias Dhruva* as the Pole Star; that is a stationary star farthest in the northern sky, to which other celestial bodies were imagined to be tied to be kept in their path.

The word *dhruva* occurs in many texts starting from the Ṛgveda. The accepted meaning of this word is *fixed, true, stationary, unchanging* with shades of meaning very similar to these. For example, in the Ṛgveda hymns (I.73, IV.5, VI.52, VII.88, X.173) the word is used as an adjective to indicate the *firmness* of objects such as the earth, the mountain, and the sky. In the 10th book the hymn (X.173) extols Varuṇa the King, as being true and steadfast. From the context of the hymn, this is a prayer to a universal force, with the sky and a star probably called *Varuṇa*, in the background. When a star is qualified as *dhruva*, and this special quality of fixity continues for generations to become the ingrained name of that star as *Dhruva* and *Achyuta*, in the daily life of a society in harmony with its surroundings including the sky, it should have been a belief shattering first order anomaly in the cosmic order to find such a star to be drifting.

Precession Effect

The effect of precession on the ancient observers would have been in the form of trees, peaks of hills and signposts aligned with respect to some known stars seeming to be drifting. The phenomenon being too slow, we have to first ask how fixity of the Pole Star would be understood by a lay observer. This is best explained with reference to Figure 1, where star Polaris is the current Pole Star. The stationarity of this star will be experienced in the night sky, if the observation happens for several nights from sun set to sunrise, when the imaginary figure of the constellation along with the bright γ and β stars seem to swing from right to left, while the star Polaris remains at the same place. In the morning no stars are visible, but the scene remains same in consecutive nights, impelling one to surmise that the figure executes a circle in the vault of heavens, with the Pole Star as the controlling central point. Change in this scenario is extremely slow to be observed with the naked eye, but could be felt over generations in comparison with past records and traditional narrations. Today with the knowledge of earth as just another planet in the solar system, the fixity or otherwise of a star at the NCP may not mean much. But for our ancients with a geocentric world view, any change in the behavior of the Pole Star in the *Śiśumāra* constellation would have had strong repercussions on their belief

¹⁴ *Ekāgnikāṇḍa with the Commentary of Haradatta* (Ed. L.Srinivasacharya). G.O.L. Mysore 1902.

systems and the way their life on earth related itself to the visible sky. Available Yajurveda texts richly attest the experiential effect of precession on the rituals, social practices and the spiritual quest of the Vedic people.

The *Śisumāra*, based on the vivid description of the position of the fourteen stars and the importance attached to its four legged form matched by the two bends in the asterism is to be identified with the constellation Draco. We meet this constellation with fourteen stars ending with *Dhruva* again in the *Brahmāṇḍa Purāṇa* with nearly the same names and description. It follows; *Dhruva* in its earliest nomenclature as *Abhaya* was the present day α -Draconis (Fig. 1). From modern Celestial Mechanics it is known that α -Draconis was the Pole Star during 3200-2400 BCE. In this long period, the declination of this star varied from $87^{\circ} 56'$ to $87^{\circ} 36'$, reaching nearest to NCP with $89^{\circ} 53'$ in 2830 BCE. To get an idea of how close this might have been to the Pole for our ancient naked eye observers, it is noted that the current (2000 CE) Pole Star Polaris is $15'$ away from the NCP but still looks stationary in relation to other nearby stars. In Figure 2, the variation in the declination of the Vedic star *Dhruva* in time is shown to highlight how the foot prints of the star are seen in the cultural history of India. The star was a mere seven arc minutes away from the NCP around 2830 BCE and hence all regions in India would have experienced this as stationary to be named *Dhruva*.

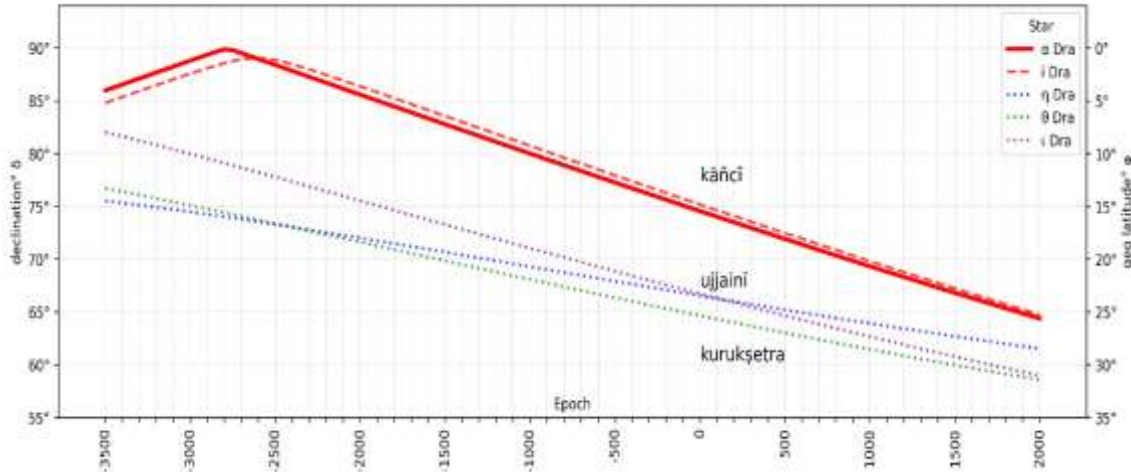


Figure 2. Variation of the declination of the Vedic Pole Star Abhaya-Dhruva (α Dra), Sunīti (ι Dra) and the four stars immediately behind; Prajāpati (τ Dra), Indra (θ Dra), and Agni (η Dra). The terrestrial latitudes are shown on the right side to indicate the epoch when a star loses its circumpolar nature to exhibit visibility property of rise and set in the yearly cycle at a particular location.

Dhruva Graha

The stability of the star *Dhruva* in the sky is reflected in the Vedic *Agniṣṭhoma* rite, where *Soma* juice is drawn in the morning in nine cups (*graha/sthāli*) the ninth being the *dhruvagraha*. In the *Taittirīya Saṁhitā* (TS) we come across the hymns for invoking the *dhruvagraha* in TS (1.4.13) and the reasons for this in the (Brāhmaṇa) part TS (6.5.2). In the first place the TS text adopts RV (6.7.1) for invoking *vaiśvānarāgni* overhead in the sky as *samrāt* (emperor) and to laud the *dhruva* cup in the sacrifice as the abode of fixity, firm among the most firm, and the most permanent among permanents¹⁵. In TS (6.5.2) the explanatory *Brāhmaṇa* part of

¹⁵ mūrdhānam divo aratim pṛthivyā vaiśvānarāya jātamagnim | kavim samrājamatithim janānāmāsannā pātram janatanta devāḥ||[...]dhruvosi dhruvakṣithi dhruvāṇām dhruvatamaḥ| acyutānām acyutakṣittama[...]| (TS 1.4.13)

the mantra, the relation between the *dhruva* cup on the ground and the eponymous star is made clear through a characteristic legend¹⁶;

The asuras from north attempted to turn the earth around; the gods firmed it up with Dhruva; that is how Dhruva gets the name; for Dhruva is placed in the north for fixity.

The fixity of the star Dhruva must have had many social and religious implications for the Vedic people. The period c 2800 BCE was ideal for the seeding of Meru-Dhruva centric astronomy which is cursorily hinted in TA, but elaborated in the *Brahmāṇḍa Purāṇa* to be considered later in the sequel.

The *Maitrāyaṇīya Saṁhitā* (MS) belongs to the group of *Taittirīya*, *Kaṭha* and *Kapiṣṭhalakaṭha Saṁhitā* of the Kṛṣṇa Yajurveda. Like with the TS text, *Agniṣṭhoma* and *somagraha* (Soma cups) are met with in the MS also. The explanation part for the *dhruvagraha* appears in the fourth *khila-kāṇḍa* section. The broad picture is same in all the Yajurvedic texts, but some special information is available in MS about the *dhruvagraha* and its connection with the star of the same name. *Dhruvasthālī* is an earthen pot filled with *Soma* kept in the northern shed unlike the others which are kept the southern shed. It is not placed on bare ground whereas the others are kept on the ground directly. MS (4.6.6) is a long text with more details, of which an extract is given here.

Dhruva is verily length of life (āyuh)..... [the priest] holds [Dhruva] by the cup (sthālī).....This [Dhruva cup] should be kept on a piece of gold for one desiring long life..... Rājaputra [the prince] protects the Dhruva vessel, this way he protects the life of all the people; hence he [the prince] becomes the strongest. If the patron (yajamāna) likes to do black magic (abhicaret), he [the priest] says 'hereby for so and so I disturb the life' by turning the Dhruva [cup]..... 'I displace you Dhruva from this fixed abode'; this way he displaces him [the targeted individual] from his exalted seat; he is liable to perish when Dhruva is displaced, all the worldly beings are prone to be displaced. The patron (yajamāna) may also be displaced. He touches the Dhruva cup and prays 'protect the celestials in the sky, intermediaries in the atmosphere and humans on the earth'.

In the above, there is a hint that Dhruva known for his fixity can also get disturbed. The *abhicāra* (black magic) principle of turning and displacing the *dhruva-cup* (*dhruva-graha*) can be inferred to be based on direct observation of the north polar region. This felt effect gets substantiated in the *Maitrāyaṇīya Āraṇyaka Upaniṣat* (MAU) where King Bṛhadratha expresses his anguish at the transient nature of the phenomenal world, and asks Sage Śākāyana, among many other questions¹⁷

[.....] why the oceans are getting dried up, why the peaks of mountains are falling down, why Dhruva is drifting, why the air strings (holding celestial bodies) are cut and dipped, why earth is moving from its place [.....]

¹⁶ āyurvā etad yajñasya yaddhruv uttamo grahāṇām grhyate|| [...] asurā vā uttarataḥ pṛthivīm paryacikīrṣan tāndevā dhruveṇa adṛṇhanta taddhruvasya dhruvatvam yaddhruvaḥ uttarataḥ sādyate[...]

¹⁷ [...] atha kimetaivārṇyānām śosaṇām mahārṇavānām śikhariṇām prapatanam| **dhruvasya pracalanam** vraścanam vātarajjūnām nimajjanam pṛthivyāḥ sthānādapasaraṇam [...] || MAU (I.4)

Implicit in this question is the statement; *the North Star understood by us as fixed has changed its position*; an unmistakable reference to the effect of precession as noticed by King Bṛhadratha. In another section, MAU contains astronomical statements to the effect that the southern course of sun (summer solstice) started at the beginning of the *maghā nakṣatra* to end at the middle of the *śraviṣṭhā* sector¹⁸. This statement has been recently shown to be compatible with the equinoctial full moon observations at $\frac{3}{4}$ -*viśākhā* and $\frac{1}{4}$ -*kṛttikā* sectors mentioned in the *Brahmāṇḍa Purāṇa*. These astronomical statements correspond to 1980-1610 BCE¹⁹. From Fig.2, it is seen that by 1900 BCE the declination of Dhruva star would be about 85° and the diurnal rotation around the NCP must have been visible to the naked eye. Thus, the observation and question of King Bṛhadratha about the movement of the Pole Star must be reckoned as realistic.

Reference to *Śiśumāra* as a celestial body is found in several Vedic texts. In the first book of the Ṛgveda (I.116.18) we come across Aśvins bringing riches to Divodāsa in a cart to which were yoked a *śi(m)śumāra* and a *vṛṣabha*. Griffith famous as the translator of RV, overlooking the astronomical metaphors of the Vedas, has translated this literally to mean a *cart drawn by a porpoise and a bull yoked together*²⁰. In the commentary of Sāyaṇa, the word *śiśumāra* is identified as a variant of the word *śiśumāra*. Sāyaṇa recognizes the impossibility of an aquatic animal and a land animal yoked together to drag a cart on earth and explains this as the special act of the *divine twins* the Aśvins exhibiting their extraordinary powers²¹, which as inspired poetry makes the locus of the cart to be in the visible sky. Even if Divodāsa were to be a human king, favouring whom the above is mentioned, it should not be difficult to recognize that the verse alludes to an event in the sky in which the constellations Draco and a group of stars resembling the head of a bull (*Vṛṣabha, Taurus*), was meant by the poet.

The *Pañcavimśa* and the *Jaiminīya Brāhmaṇa* have interesting stories about the cosmography behind the name *Śiśumāra*. It is said that originally this was a Ṛṣi or sage of the same name in the terrestrial ocean. He did not praise Indra fully and hence got stranded on the sands. After having praised Indra fully by the *śarkara sāman* song he could get into the waters again. Later he attained the sky as a constellation of the same name. The text further says that the *śarkara sāman* chant is meant for crossing the oceans²². Indra stands for phenomenal time in many places in the Vedas²³ and hence the stranding of the sage could be a reference to the unchanging position of the star *Dhruva* on the body of the *Śiśumāra*. The crossing of the oceans appears to be an allegory for the circumpolar nature of the stars of the constellation that would have helped ancient mariners in navigating the seas.

The various Gṛhya Sūtra (GS) texts which were fixed much later than the accented core Vedic texts are prescriptive in nature about the religious customs to be followed by house holders. The religious practices which were prevalent since the most ancient times, among the different

¹⁸ sūryo yonirvai kālasya|tasyaitadrūpam yannimeṣādikalāt sambhṛtam dvādaśātmakam vatsarasya āgneyamardhamardham vāruṇam **maghādyam śravisthārdhamāgneyam**| krameṇotkramena sārpaḍyam śraviṣṭhārdhāntam saumyam|| MAU (VI.14)

¹⁹ Iyengar R.N. Chakravarty S., Equinoctial full moon of the *Brahmāṇḍa Purāṇa* and the *nakṣatra* solar zodiac starting from summer solstice, *Ind. J History of Science*, November 2023.

²⁰ When to his house ye came, to Divodāsa, hasting to Bharadvāja, O ye Aśvins,

The car that came with you brought splendid riches: a porpoise and a bull were yoked together. (RV I.116.18; Translation by Griffith R.T.)

²¹ tasmai divodāsāya prāpayāmāsa| apica tasmin rathe vṛṣabhaḥ anaḍvān śiśumāraḥ grāha ca paraspara viruddhāvapi svasāmarthya prakāṣanāya yuktā vāhanatayā samyuktāvāstām || (Comm. of Sāyaṇa, RV I.116.18)

²² Caland W. English Translation of the *Pañcavimśa-Brāhmaṇa*, Bibliotheca Indica Series, 255, Calcutta, 1932.

²³ nairuktya prasiddhyā tu kālābhīmānī indraḥ (Sāyaṇa's commentary on RV 8.77.4)

Vedic clans, are codified in the formulaic GS literature. These not only canonize the hymns to be used in the rites, but also fix the actions to be followed by the principal performers, participants and the priests. There are several different GS texts attached to the four Vedas demonstrating their lateness and spatial spread accounting for some regional variation in the practices. However, the common feature of all these texts, in historical context, is the memory of *Dhruva* as a fixed star to be invoked, seen and shown to the bride in the marriage rite. In all cases, the hymn for addressing *Dhruva* is same as or very close to the one in the *Ekāgni-kāṇḍa* (I.9) mentioned previously.

Axial precession would have slowly but surely changed the shape of the constellation making the star *Dhruva* to be progressively at lower altitudes and to eventually go below the horizon at some places even if one were to know where to look for the *Śiśumāra* constellation. For example, at Kāñcīpuram (12.8° N), ancient city famous for Vedic studies, the star would have started setting around 500 BCE. Nevertheless, the ceremony of showing the star *Dhruva* continued in Hindu marriages over millennia coming down to this day as a formal ritual. Before we discuss the cultural impact of the Vedic Pole Star in the Common Era, it would be appropriate to review cursorily the Purāṇa literature, the most important being the *Brahmāṇḍa Purāṇa*.

Brahmāṇḍa Purāṇa (BP)

This tradition of observing *Śiśumara* and *Dhruva* was not restricted to the closed Vedic groups but was available to everyone as depicted in the Purāṇas, which have preserved some aspects of cultural astronomy. The story of the young boy Dhruva, who by his penance got the boon of being fixed in the north as the Pole Star, is a popular legend widely known all over India. The origin of this story can be traced to the *Viṣṇu Purāṇa* (VP) and repeated in several other texts. However, the related background astronomy is preserved better in the *Brahmāṇḍa* and the *Vāyu Purāṇa* in near matter-of-fact language. In some places it is said that Dhruva is stationary and the celestials are controlled by him. It is implicit that the child prince Dhruva was identified with the eponymous Pole Star. However, BP also declares that Dhruva is circling at the same place. This is clearly the observed daily self-rotation of the Pole Star. This rotation is taken as the driving force for other celestial bodies to move around the NCP. This theory of Dhruva, takes us to the most ancient form of Indian astronomy which was *dhruva-centric*, or *meru-centric*. This is also an indication of the branching of the Purāṇas from a nucleus which lies in the Vedic texts such as the TA and the *Ekāgni-kāṇḍa* which knew the prominent constellation *Śiśumara* with fourteen stars, the fixed *Dhruva* and the *Meru* linking earth with the NCP. As far as ancient astronomy and cosmology are concerned, BP preserves the original concepts better than the *Viṣṇu*, the *Vāyu*, the *Matsya* and the *Bhāgavata Purāṇa*²⁴. The *dhruva-centric* model of the sky can be best appreciated in the BP as an outcome of direct observation. In the first chapter of BP a list of the contents to be covered is provided. This promises astronomy related to Dhruva as²⁵

The movement of sun and other moving celestial bodies is explained as impelled by Dhruva only. The constellation Śiśumāra, at the tail of which Dhruva stays, is also described. (BP I.1; v 84)

²⁴Iyengar R.N., Dhruva the Ancient Indian Pole Star: Fixity, Rotation and Movement. *Indian J. of Hist. of Science*, 46.1 pp.23-39, 2011.

²⁵ sūryādīnām syandanānām dhruvādeva pravartanam | kīrtiyate śiśumāraśca yasya pucche dhruvaḥ stithaḥ ||

This theory is further elaborated in chapters 21 to 24, totaling 520 verses, with many ancient concepts about sun, moon, eclipses and planets. Here, we restrict our attention only to a few important statements concerning *Śiśumāra* and *Dhruva*²⁶.

Like a lump of clay at the middle of the potter's wheel moves slowly sitting at the navel, Dhruva rotates. Dhruva moves in circles, day and night consisting of thirty muhūrtas, at the middle of the two directions (north and south). Like the nave of the potter's wheel stays in the same place, so also Dhruva should be known to be rotating there itself. (BP I. 21; v 94-96)

Chapter 21 containing 176 verses gives an account of sun's motion, with definitions of seasons, equinox and solstice. It introduces the cosmography of *Mt. Meru* connecting the earth and the heavens like a vertical pole in the north, around which all celestial bodies are modeled to move in circular paths. The star *Dhruva* is said to be at the tip of the *Meru*. The starry space in the sky between the *Nakṣatras* of *ajaveethi* and star *Agastya* (Canopus) is said to be the *pitṛloka* (abode of manes), whereas the corresponding region in the north between *nakṣatras* of *nāgaveethi* and *Saptaṛṣi* (U.Major) is the *devaloka* (abode of gods)²⁷. The chapter ends by declaring the famous third step of Viṣṇu to be in the north above the *Saptaṛṣi* wherein *Dhruva*, *Dharma* and others are located²⁸.

Chapter 22 starts with a description of the position of *Dhruva* as²⁹

Listen to this explanation of mine which is real and observable but mystifying people. He, who is at the tail of the fourteen stars looking like a śiśumāra; Dhruva the son of Uttānapāda, has become the main pivot of the pole in the sky. Verily, he rotates the sun, the moon and the planets continuously. The stars follow him who is himself circling like a wheel. (BP I. 22; v 5-7)

In the above the narrator *Sūta* is appealing to people to observe the sky and understand the ancient theory of *Dhruva* as the controller of the motion of the celestial bodies. Since *Dhruva* as a north star is said to be in a figure looking like *Śiśumāra*, this group of stars should be same as the constellation meant by the Vedic texts discussed already. BP further elaborates the self-circling motion of *Dhruva* and that of the stars (*tārāḥ*) and the *nakṣatras* around the NCP. There are 84 verses in this chapter, presenting a physical model for the motion of sun seen in the day but, linked to *Dhruva* seen only in the night. The northern and southern sojourn of the sun also had to be explained within this model. Without going into the details, we note that Sun's chariot is said to have only one wheel the axle of which is connected to *Dhruva* by two strings of light which take care of the change in the orbit of sun around the earth. Since the older analogy of the potter's wheel was unable to mimic the observed apparent lateral motion of the sun the two axle model and connection to *Dhruva* with two air strings was proposed to

²⁶ tatomandatarān nābhyām cakram bhramati vai tathā|mrtpiṇḍa iva madhyastho dhruvo bhramati vai tathā ||
trimśanmuhūrtānevāhuḥ ahorātram dhruvo bhraman|ubhayorkāsṭhayormadhye bhramte maṇḍalāni tu ||
kulāla cakranābhiśca yathā tatraiva vartate|dhruvastathāhi vijñeyastatraiva parivartate||

²⁷ uttaram yadagastyasya hyajaveethyāśca dakṣiṇam|pitṛyānaḥ savai panthāḥ vaiśvanarapathādbahiḥ|| (v 156)
nāgavītyuttaroayaśca saptarṣiṇadakṣiṇaḥ|uttaraḥ savituḥ panthā devayānaśca sa smṛtaḥ || (v 168)

²⁸ ūrdhvottaram ṛṣibhyastu dhruvo yatra savai smṛtaḥ |etadviṣṇupadam divyam tṛtīyam vyomni bhāsvaram ||
yatra gatvā na śocanti tadviṣṇoḥ paramam padam |dharmadhruvādyaḥ tiṣṭanthi yatra te lokasādhakāḥ || (v 175,
176)

²⁹ bhūtasammohanam hyetad vadato me nibodhata |pratyakṣamāpi dṛśyam ca sammohayati yat prajāḥ||
yo'yam caturdaśarṣeṣu śaiśumāre vyavasthitaḥ |uttānapādaputro'sau meḍhībhūto dhruvo divi||
sa vai bhramāyate nityam candrādityau grahaiḥ saha |bhramantaṁ anugacchanti nakṣatrāṇi ca cakravat||

simulate action at a distance. This change is also seen in the example of the animal driven oil mill proposed as another physical model for understanding the motion of the stars around *Dhruva*³⁰.

There are as many air-strings as there are stars. All (strings) are tied to Dhruva; themselves rotating; they make the stars to go round. As in an oil press, the wheel goes round and makes the other (the pole) rotate; so do the luminaries held by the air-strings, revolve. (BP I. 23; v 96,97)

In the oil mill, the central pole is rotated by the motive force provided by one or more bullocks moving in a circular path. In the Purāṇic sky model, the roles are reversed, such that the locally spinning *Dhruva* can make the celestial bodies at a distance to move around in their circular path, the connection being through strings (or rays) of wind (or light).

Chapter 23 of BP is indispensable to anyone interested in the history of Indian astronomy as it explains the astronomical symbolism behind the legend of 3339 gods drinking *Soma*, first appearing in the Ṛgveda. Towards the end of this chapter the text describes the location of *Dhruva* along with other companion stars making up the animal figure *Śiśumāra*³¹.

Thus, centered in Dhruva, the circle of luminaries revolves. And this Śiśumāra, fixed in the sky, is to be understood as made of stars. Whatever sin one commits during day, one is divested of it upon seeing Śiśumāra in the night. As many stars as there are associated with Śiśumāra in the sky, so many years more, does one live on. (For this) the form of the Śiśumāra should be known in terms of its parts. (BP I. 23; v 99-101b)

The chapter ends with a good description of the *Śiśumāra* constellation enumerating the constituent stars numbering fourteen³². This is the earliest example of a star group being represented and named by an animal figure in Sanskrit literature outside the Vedas.

His (Śiśumāra's) upper jaw should be understood as Uttānapāda. Yajña (Kratu) is known as the lower jaw and Dharma as the head. At the heart is Nārāyaṇa (Sādhyā). The twin Aśvins occupy the forelegs while Varuṇa and Aryamā are at the hind legs. Samvatsara is the genital and Mitra occupies the seat. In the tail are Agni, Mahendra, Mārīca-Kaśyapa and Dhruva. These (previous) four stars of the Śiśumāra never set. It is remembered that Dhruva is the last star after Agni, Indra and Kaśyapa. (BP I. 23; v 102-104, 105b, 107b)

This listing of stars on the body of the *Śiśumāra* is same as in the Vedic *Taittirīya Āraṇyaka* except for minor variations in the names, but the geometrical picture of the animal figure is same in both the texts.

³⁰ yāvatyāścaiva tārāśca tāvanto vātaraśmayah| sarvā dhruve nibaddhāśca bhramantyo bhrāmāyanti tāḥ||
tailapīḍā yathā cakram bhramanto bhrāmāyanti ha| tathā bhramanti jyotīṃṣi vātabaddhāni sarvaśah||

³¹ evam dhruva nibaddho'sau sarpate jyotiṣāṅgaṇah| saiṣa tārāmayah proktaḥ śiśumāro dhruvo divi ||
yadahā kurute pāpam dṛṣtvā tanniśi muñcate| yāvatyāścaiva tārāstāḥ śiśumārāśritā divi ||
tāvantiyāiva tu varṣāṇi jīvitābhyadhikāni tu | sākārah śiśumāraśca vijñeyah pravibhāgaśah ||

³² uttānapādistasyātha vijñeyah sottarā hanuḥ |yajño'dharastu vijñeyo dharmo mūrdhānamāśritah ||
hr̥di nārāyaṇah sādhyo aśvinou pūrvapādayoh |varuṇāścaryamācaiva paścime tasya sakthinī ||
śiśnam samvatsarastasya mitraścapānamāśritah |pucche agniścamahendraśca mārīcaḥ kaśyapo dhruvaḥ ||
tārakāḥ śiśumārasya nāstam yāti catuṣṭayam || agnīndra kaśyapānam to caramo'sau dhruvaḥ smr̥taḥ ||

The other Purāṇas narrate the legend of Dhruva more by personifying the astral picture. The *Viṣṇu Purāṇa* provides an interesting constraint on Dhruva namely, that his mother Sunīti stays near him as a companion star. The names of some of the Vedic stars can be easily identified with their modern equivalents. Behind α -Draconis (Thuban) are ι , θ , η stars that can be recognized as *Prajāpati*, *Indra* and *Agni*. The name *Samvatsara* literally *Year*, for one of the stars (5th or 6th from Dhruva) is interesting. It is said to be the genital, meaning thereby in Vedic parlance, the generator of the yearly cycle. It would be interesting to investigate this further to see whether a star of this constellation that exhibited visibility phenomena (rise and set) could have been used as a marker for recognizing the beginning of the Vedic Year in 3rd - 4th millennium BCE. The stars *Dharma* and *Brahma* of TA can be identified as γ - and β -Draconis (magnitude 2.24 and 2.79) respectively. The Purāṇas changed *Brahma* to *Uttānapāda* so that his son *Dhruva* (*Abhaya*) remains at the end of the same figure, along with his mother *Sunīti* identifiable as star 10-Dra of magnitude 4.5. The forelegs with the two *Aśvins* and hind legs with *Mitra* and *Varuṇa* are identifiable at the two bends in the figure.

Apart from the shape of the figure, the circumpolar nature of the last four stars and closeness of star Sunīti (ι Dra) would have helped the identification of the star Dhruva for a long time, all over India, to become a constant ritual practice in Vedic marriages. But, in a country like India that stretches north to south for nearly thirty degrees in latitude, the visibility pattern of the stars would have surely changed over centuries. This gradually changing pattern is best followed by the changes of declination of the five stars of Draco (α , ι , θ , η Dra) as shown in figure 2. This figure shows the geographical latitude on the right side to indicate from which epoch the above stars would have stopped being circumpolar and started setting and rising at particular latitudes. For example, at the historical south Indian town of Kāñcī (12.8° N), starting from 500 BCE, star Dhruva would not have been visible all through the year, even if one were to identify the constellation Śiśumāra and know where to look for Dhruva.

Tradition vs Precession

The inviolable effect of precession started taking its toll on the prime position *Śiśumāra* enjoyed as a constellation in the cardinal north with *Abhaya-dhruva* as the Pole Star during the first half of 3rd millennium BCE. Nevertheless, the star *Dhruva* and the imaginary *Meru* have influenced the religious beliefs and socio-cultural practices of Vedic Hindus for more than four thousand years. We have already seen mention of moving of *Dhruva* in the *Maitrāyaṇīya Āraṇyaka* at the beginning of 2nd millennium BCE. As we progress in time, effect of precession is reflected in the nuances of revering a past tradition. The Epic *Mahābhārata* refers to the constellation, when King Drupada announces the marriage of his daughter Draupadī. The place for holding the famous archery competition was named *Śiśumārapura* and this was located to the northeast of the capital city (*Ādi Parvan* 176, v 15-16)³³. The name and the specific mention of direction seem to be pointers to the shift of the constellation somewhat towards northeast in the sky also. As the figure shifted far away from its prime north position its shape altered to bring in new names such as *Nahuṣa* (serpent) and *Ajagara* (python) in the precession legends, in which the southern star Agastya (Canopus) finds a dominant role. The very first recognition of this southern star, most probably denoted as *māna* (short measure) by Vedic people happened sometime around 3500 BCE. With passage of time the visibility interval of this star increased but remained looking short without attaining height, unlike other stars. Sage Agastya who was perhaps the first to recognize the importance of this star for knowing the cardinal

³³ tataḥ purajanāssarve sāgaroddhūta nissvanāḥ| śiśumārapuram prāpya nyaviśan teca pārthivāḥ||
prāguttareṇa nagarād bhūmibhāge same śubhe| samājavātaḥ śuśubhe bhavanaiḥ sarvato vṛtaḥ||

south direction, holds a high place in Indian cultural history. Importance attached to his (Agastya's) first visibility in the annual cycle and his depiction as a dwarf in later iconography are attributable to indirect effects of earth's axial precession on Hindu culture and art³⁴.

Another popular astral legend appearing in the Mahābhārata is about King Nahuṣa desirous of usurping the heavenly powers of Indra including his spouse Indrāṇī. As per a ruse of the gods, he is coaxed to meet Indrāṇī seated in a palanquin, which in turn was designed to be carried on the shoulders of the venerable Seven Sages (U.Major) and Agastya (Canopus). During the travel when Agastya could not keep up his steps with others, Nahuṣa in his arrogance kicks Agastya for being too slow³⁵. Agastya in anger curses the heavenly Nahuṣa to lose his exalted position to become an ordinary *ajagara* (python). This legend is easily recognized as an allegory for precession being felt in the form of the Śīsumāra (Draco) constellation losing its prime northern celestial position, along with star Agastya coming into prominence as a new bright star in the south. An interesting study of the religious influence of the Nahuṣa-Agastya legend has been carried out by Hildebeitel³⁶. According to him, the identification of the heavenly Nahuṣa with the constellation Draco was first proposed by two German scholars, both Adolf Holtzmann (uncle and nephew).

First Millennium BCE

The very fact that BP first refers to Dhruva as a fixed peg to which the stars are tied, and next to a self-circling *Dhruva* driving the sun, moon and stars, is evidence of modification of a hypotheses made necessary due to the effect of precession. The further cosmological extensions with large spatial distances in millions of *yojanas* must have been inspired by the imaginary *Meru*, at the tip of which *Dhruva* was taken to reside. The *Atharvaveda Pariśiṣṭa* (AVP) considered to be an appendix to the Atharvaveda, is available in 76 Chapters³⁷. The work contains very ancient as well as later material, some added probably even around 300 BCE. AVP has long chapters on stars, planets and comets like a *jyotiṣa-samhitā*. For the present purpose it is sufficient to note that Chapter 52 titled *Grahasaṅgraha* preserves a collection of names of stars and constellations other than the well-known *nakṣatras* along the ecliptic. In this list the Seven Sages with names; *Gautama*, *Atri*, *Vasiṣṭha*, *Viśvāmitra*, *Kaśyapa*, *Ṛcīkaputra* and *Bharadvāja*, are said to be fixed in the north. This is followed by another star group fixed at the end of the middle sky, with unmistakable reference to *Dhruva* with *Śīsumāra* and a few others followed by *Viṣṇupada*³⁸. Some of the stars are named differently from the Vedas and the Purāṇas, but the constellation figure of *Śīsumāra*, the famous ancient star *Dhruva* and the station of *Viṣṇu* are same as in the TA and BP texts.

Texts of the Jain tradition fixed within a few centuries after the advent of Mahāvira (599-527 BCE) contain information in the form of omens, anecdotes, and the calendar. The Bhadrabāhu Samhitā (c 300 BCE) mentions a comet masking *śi(m)sumāra* as a bad omen³⁹, which naturally should be referring to a constellation of that name. Even though *Meru* is important to the cosmology of the Jaina tradition, there is no mention of a visible fixed star at the top of the *Meru*.

³⁴ *Parāśara Tantra* (Ed. R. N. Iyengar, Reconstructed with text, transl. notes) Jain Univ. Press, Bangalore, 2013.

³⁵ *Mahābhārata, Udyoga Parvan*, Ch.17, v. 14-18. (BORI, Pune Critical Edition).

³⁶ Hildebeitel A. Nahuṣa in the Skies: A Human King of Heaven. *History of Religions*. 16.4. pp.329-350. 1977

³⁷ *Atharvaveda Pariśiṣṭa* (Ed. G. M. Bolling & J. von Negelein) Leipzig, 1910.

³⁸ śīsumāreṇa sahitā dhruveṇa ca mahātmanā | pulastyah pulahaḥ somo bhṛgurāṅgirasā saha ||
hāhāhūhūcavijñeyau viṣṇośca padam uttamam | madhyāntasthāvarāṅāmtu niyatāviti buddhimān|| AVP
(52.10.4,5)

³⁹ śimsumāram yadā keturupāgatya pradhūmayet| tadā jalacaram toyam vradhyavakṣānsca himsati||

The various Gṛhya Sūtra texts reaching their final form around 500 BCE, fixed the Vedic rites prevalent during their time among the orthodox. It may not be wrong to say that these texts were designed as manuals for the followers of the Vedas to perpetuate the religious and socio-cultural traditions of their ancestors. These texts do not refer to the Śīsumāra constellation, but by an unbroken tradition, the location of star Dhruva, like that of star Arundhatī (Alcor) in U.Minor should have been known to the faithful.

Vṛddhagārgīya Jyotiṣa is an ancient text which is yet to be fully retrieved from manuscripts spread across several libraries in the country. Recently based on the solar seasonal stars listed in the earlier part of the text (*ādityacāra*; sect. 11), it has been shown that such observations are dateable to 1300-1400 BCE. The manuscripts of VGJ available now are edited over time by the followers of the School of Vṛddhagarga, so much so the text has another set of statements towards the end of the work (*ṛtuswabhāva*; sect. 59) that can be valid for c 500 BCE⁴⁰. This text mentions that passage of time can be followed by observing the rotation of Śīsumāra and *Tārā-matsya*, the latter being a new polar constellation, not mentioned in other ancient texts⁴¹. VGJ does not say anything about the stars making up the *Tārā-matsya*, but the name indicates that this must be same as the *Dhruva-matsya* of later Indian astronomers, carrying the star α-U.Minor which is the current (2000 CE) Pole Star.

First Millennium CE

As we enter the Common Era the nature of Indian astronomy changes its colour with emphasis on mathematics. The connections between the astronomical knowledge of the more ancient period and that of the *siddhānta* texts of the CE is not well investigated. There was no recognized Pole Star during CE and we do not come across specific reference to *dhruva* as a star near the NCP till the 15th century. But the terminology *dhruvaka* for polar longitude is derived from the word *dhruva*, interpreted as the pole, an imaginary point on the celestial sphere. *Meru* finds mention in the chapters on *Bhuvanakośa* (Cosmography) but not *dhruva* as a visible star at NCP.

In Hindu marriages, showing the star Dhruva continued as an important ceremony even as poet Kālidāsa (c 5th cent) immortalized the *dhruvadarśana* rite in his famous work *Kumārasambhavam* when Pāravatī is shown the star by Śiva and she raises her head to respond 'seen'⁴².

Brahmagupta (598-670 CE) while discussing the rotation of the celestial sphere uses the phrase *dhruvayoḥ nibaddham*, meaning the two geometrical north and south poles of the sphere. He knew about the circumpolar constellation named *Dhruva-matsya* (Polar Fish), which he cites to criticize the Jaina concept of two sun and two moons⁴³. But, none of the *siddhānta* texts of the period describe any constellation by name Śīsumāra. The nearest one to this animal figure is a half-verse in the context of stars (*bhagrahayuti*) by Vateṣwara (880 CE) where he hesitantly

⁴⁰ Iyengar R.N. and Chakravarti S. Transit of Sun through the Seasonal Nakṣatra Cycle in the Vṛddha-Gārgīya Jyotiṣa, *Ind. J. History of Science*, 56, pp. 159-170, 2021.

⁴¹ śīsumārasya vyāvṛtyā tārāmatsyasya dhimataḥ | jyotiṣām ca gatimvidyādārtavīm pūrvadarśanāt|| (Sect. 25, v 15)

⁴² dhruveṇa bhartrā dhruvadarśanāya prayujyamānā priyadarśanena | sā dṛṣṭa ityānanamunnamayya hrīsannakaṅthī kathamapyuvāca || (*Kumārasambhavam* 7.85)

⁴³ bhāni catuspañcāśat dvau davavarkendavau jinoktam yat | dhruvamatsyāvarto bhavati yato'hnā tatastadasat || *Brahmasphuṭa Siddhānta* 11.3

says *dhruva-tārā* is a faint star in the middle of a star group in the form of a *Timi*⁴⁴. The word *Timi* refers to an aquatic animal like a whale and not a fish. The word *dhruva* in siddhānta astronomy generally refers to the *pole*, but the appellation *tārā* above indicates a star of that name, but not the Pole Star. This is not surprising, since there was no visible star close to NCP during the first millennium of Common Era which was the prime period of mathematical astronomy.

This, of course did not mean, that the common people forgot the tradition of a purported Pole Star *Dhruva* by name in a constellation looking like a whale or a dolphin. Orthodox Hindus looked for their *Dhruva* in the *Śiśumāra* constellation only. An example of how the Vedic facts were textually recorded other than in the *Purāṇas*, is available in the commentaries on the *Viṣṇusahasranāma*, (*Viṣṇu's thousand names*) which is a part of the *Mahābhārata*. Śaṅkarācārya (8th cent) the well-known exponent of the *advaita vedānta* explains the 441st name *nakṣatranemi*, as a homonym for *Viṣṇu* with further explanation “*He (Viṣṇu) as the controller of the nakṣatras stationed at the heart-region of the (constellation) Śiśumāra, along with Dhruva sitting on the tail of this figure rotates the stellar circle.*” Śaṅkara quotes succinctly, the Vedic authority for his explanation as *viṣṇurhṛdayam*, from the *Taittirīya Āraṇyaka* hymn (II.19)⁴⁵.

Transition at the NCP

The field of mathematical astronomy flourished and grew to great heights in the first half of the second millennium of CE. Side by side, the philosophical schools of *vedānta* and efforts in the society to preserve the Vedic texts and traditions, also got strengthened even though by that time the names of the stars of the *Saptaṛṣi* constellation, considered sacrosanct, differed among the Vedic, *Purāṇic* and the general *samhitā* texts. Some star names *kratu*, *yajña* and *marīca* of the *Śiśumāra* of the *Purāṇa* got shifted to stars in U. Major. A sort of ambivalence prevailed as far as *Dhruva* as a *fixed star* was concerned. The full elision of *Śiśumāra* and its constituents, from the memory of the average Hindu, had to wait for some more years till NCP got occupied by an alternate *Dhruva* (α -U.Minor).

This transition was not devoid of contradictions and controversies, but the cultural ties to the Vedic hymns and principles continued with twists and turns. Insiders to the culture could somehow manage the controversies as regional variations or just as inherited practice. But for an outsider like Al-biruni (973-1048 CE) who was genuinely interested in Sanskrit texts and Indian science, the legend about *Dhruva* must have been perplexing. His comment is sarcastic, nevertheless interesting, since it upholds that even during his time Hindus recognized their Pole Star in the *Śiśumāra* constellation and such memory was prevalent among lay people thousand years ago. He writes⁴⁶

The Hindus tell rather ludicrous tales when speaking of the figure in which they represent this group of stars, viz. the figure of a four-footed aquatic animal, which they call Śākvāra and also Śiśumāra. I suppose that the latter animal is the great Lizard, for in Persia it is called Susmār, which sounds much like the Indian Śiśumāra...Manu had two sons, Priyavrata and Uttānapāda, the bow-legged king.

⁴⁴ timyākṛti tārāṇām dhruvatārā tanutārā madhye | *Vaṭeśwara Siddhānta*; *samāgamādhikāra* 8.16.

⁴⁵ *Viṣṇusahasranāmastotram with the commentary of Śaṅkarācārya and the gloss of Tāraka Brahmānanda Sarasvatī* (Edited by R.Rama Sastry) ORI Sanskrit Series, 106, Univ. of Mysore 1961.

⁴⁶Sachau E.C. *Alberuni's India: An Account of India About A.D.1030.* (Vols. I & II) London. 1910.

The latter had a son called Dhruva, who was slighted by one of the wives of his father. On account of this, he was presented with the power to turn round all the stars as he pleased...Fourteen of these stars he placed round the pole in the shape of a Śiśumāra, which drive the other stars round the pole...Further, the Viṣṇu-Dharma says: 'If a man reads this and knows it accurately, God pardons to him the sins of that day, and fourteen years will be added to his life, the length of which has been fixed beforehand'. How simple those people are! Among us there are scholars who know between 1020 to 1030 stars. Should those men breathe and receive life from God only on account of their knowledge of stars?

Al-biruni had no direct access to the Vedas, whatever he received was only secondary as told by his informants. The name *Śākvara* that Al-biruni quotes is typically the Vedic qualification of *Śiśumāra* as a powerful animal, found only in TA (II.19) that we have previously discussed. This is evidence that the Vedic and Purāṇic texts have preserved observations of the original Pole Star quite well. His supposition about the *great Lizard* is in fact an alternate name by which medieval observers knew Draco, that is *Śiśumāra*.

Al-biruni had admiration for Indians for the scientific approach to the subjects they cultivated. This situation perhaps prompted Al-biruni not to take the Purāṇas seriously as having preserved ancient observations of the Vedic period, in the form of legends and cultural beliefs. However, his comment is a good example of how common people carried in their collective memory the story of the child prince Dhruva, literally *one-who-is-fixed*, as the Pole Star. The “addition of 14 years of life” which Al-biruni found ridiculous, was a ploy of the narrator when BP was still orally transmitted, for encouraging people to observe and preserve the names of the constituent stars and the form of the constellation accurately⁴⁷. He translated into Arabic, apart from astronomical texts, the *Yogasūtra* of Patañjali. While explaining the aphorism *dhruve tadgati jñānam* (YS 3.28) he again discusses the constellation *Śiśumāra* and *Dhruva* the Pole Star as above⁴⁸.

Second Millennium CE

Strict followers of the Vedas and the mathematical astronomers continued to differ particularly about cosmology and the interpretation of *Dhruva*, the former holding the word to mean a visible star of that name but the other taking it to refer to an imaginary point, defined by spherical geometry. The *viśiṣṭādvaita* and the *dvaita* schools of Vedānta also attach great importance to the *Viṣṇusahasranāma*. Parāśara Bhaṭṭa (11th cent) and Rāghavendra Sūri (18th cent) in their commentaries explain the word *nakṣatranemi* as Viṣṇu, citing TA (II.19) like Śaṅkarācārya.

⁴⁷ tāvantyaiva tu varṣāṇi jīvitābhyadhikāni tu | sākāraḥ śiśumāraśca vijñeyaḥ pravibhāgaśaḥ || (BP I-23 v 101)

⁴⁸ Pines S. and Gelblum T., Alberuni's Arabic Version of Patanjali's Yogasutra: A Translation of the third chapter and comparison with Related Texts. *Bull. School of Oriental and African Studies, Univ. of London*, 2, pp.258-304, 1983.



A new iconic representation of Viṣṇu (*accompanying figure*) as a four footed aquatic animal, with *Dhruva* sitting on the upturned tail came into vogue in some temples in the Karnataka region around 1500 CE. The inspiration for this image is most likely the authority of the *Viṣṇu Purāṇa* and the Vedic *Taittirīya Āraṇyaka*.

Sāyaṇa (14th cent) the prime source for the ritualistic interpretation of the Vedic texts, commenting on the TA hymn says that one has to use this hymn for concluding the evening prayers by turning north and meditating on the *dhruva-maṇḍala*⁴⁹. One may wonder, as Polaris was approaching the NCP and since *dhruva-matsya* might have been known to the general populace, which part of the sky was meant by the *dhruva-maṇḍala*. We can be fairly certain that Sāyaṇa being a follower of Śāṅkarācārya would have known the *Viṣṇusahasranāma* interpretation correctly as also the sky part of *Śiśumāra* with the last star being the Dhruva of the TA hymn. However, any semblance of doubt that may remain was set right by Tāraka Brahmānanda Sarasvatī a monk of the Śāṅkara order. He wrote a gloss on the commentary of his mentor on the *Viṣṇusahasranāma*. His date is not exactly known, but he was after Sāyaṇa and hence can be assigned to 15-16 Century CE. He not only elaborated on the original text and the commentary of Śāṅkara but took trouble to give the new extended configuration of the ancient *Śiśumāra* in the sky. Interestingly, he pictures the form of this animal not as a whale or a porpoise, but says it looks like a lengthy lizard or Iguana⁵⁰. Next he says that *Dhruva* is residing at the tip of the uplifted tail of this figure, helping the faithful to look for the Vedic *Dhruva-maṇḍala*.

The mathematical astronomy of Āryabhaṭa, and Brahmagupta of the first millennium CE had gathered momentum to propel itself for another thousand years. In this development the felt effect of precession had to be quantitatively factored in. The *ayanāmśa* estimate, whether or not accurate, was an offshoot of precession. Similarly, the visible Polar Fish could not be overlooked. Bhāskarācārya (1114-1185 CE) in his *Siddhānta Śiromaṇi*, under the chapter on *Bhuvanakośa* refers to the mouth and tail of the Polar Fish and its synchronization with sun rise and sun set⁵¹. In the 15th Century the present Polaris or α -U.Minor was at declination 86° a mere four degrees away from NCP and a line connecting it to star *markaṭi* (β -U.Mi or Kochab) was recognized to rotate in a circular path in the night sky. This fact was used by Padmanābha to develop his astronomical instrument *Dhruva-bhrama-yantra* for finding time as in a clock⁵². *Siddhāntic* astronomers were true to their empirical scientific observations, even though they were equally well versed in the ancient Vedic and Purāṇic lore. They did not clarify their stand on the astronomical status of the legendary Dhruva of the Purāṇa. But Kamalākara Bhaṭṭa of

⁴⁹ anena manreṇa udaṅgmukho bhūtvā dhruvamaṇḍalam paśyan śiśumārārūpeṇa tamupatiṣṭhet || *TA with the commentary of Sāyaṇa* (Ed. H.N.Apte) Anandashrama Press, Pune, 1898.

⁵⁰ śiśumāro jalajantu-viśeṣaḥ sarāṭa-godhādyākāraḥ, tadākṛti jyotiścakram śiśumaracakram tasya pradakṣiṇāvarta-kuṇḍalībhūtasya unnamita-pucchāgre vyavasthito dhruvaḥ || (Ref: foot note 37)

⁵¹ yadā bharaṇīstho ravirbhavati tadā tasyāstamayakāle dhruvamatsyaḥ tiryakstho bhavati| tasya mukhatārā paścimataḥ| pucchatārā pūrvataḥ| tadā mukhatārāsūtre ravirityarthaḥ| atha nisāvasāne mukhatārā parivartya pūravato yāti| pucchatārā paścimato yāti| tato mkhatārāsūtragatsyaiva arkasyodayo dṛṣyate|| *Bhuvanakośa 10, vāsanābhāṣya*

⁵² Sarma S.R. The Dhruvabhrama-Yantra of Padmanābha. *J. Rashtriya Samskrita Samsthan*, Vol.6, pp.321-343, N.Delhi, 2012.

Vāraṇāsi (25.3° N), the author of the treatise *Siddhānta-tattva-viveka* (1658 CE), seems to have faced the question of which star should be seen by the bride in Hindu marriages. This issue should have been very relevant, since the prescribed Vedic hymns laud the fixity and the unchanging nature of Dhruva. Furthermore, even if one were to know the location of the original star in the Draco constellation, it would be at low altitudes and known to have moved away from the Pole position. True to the spirit of the Vedic mantra, he states that the star to be seen by the bride is at 90° longitude and 66° latitude⁵³. This was clearly the star at the mouth of the *Dhruvamatsya*, the new *Dhruva* that continues to be the current Pole Star.

Controversy among Indologists

European scholars started taking interest in Sanskrit language, grammar and the Vedic literature from the 18th century onwards. A topic of interest to many of these scholars was the date of the Ṛgveda the most ancient literature of India, variously assigned from 4th millennium BCE to 1500 BCE. Jacobi⁵⁴ a German scholar of repute was a proponent of archaeo-astronomy as a means of dating the Vedic culture. He pointed out the importance given by all the Gr̥hya Sūtras to show *Dhruva* as the Pole Star to the bride in Vedic marriage rites. His argument was, since there was no Pole Star during the final composition of the *Sūtra* literature (c 500 BCE), the composers of these texts should have known from inherited tradition a star which was at NCP in more ancient times, which can be none other than α-Draconis (Thuban). Thus, he was arguing for a date of c 3000 BCE for RV. Jacobi somehow depended only on the late marriage codes for presenting his case, but not the Yajurvedic texts and the detailed *meru-dhruva* astronomy of the Purāṇa. His opponents prejudiced as they were against dating the Ṛgveda to any period before 1500 BCE, treated *Dhruva* as a disjointed entity mentioned only in the Sūtras without any connection to the Vedic *Śiṣumāra*. The arguments put forth for the late date of the Ṛgveda were all focused to defend the Aryan Invasion Theory (AIT) of so called Aryans invading India around 1500 BCE. Typical was the dismissal of Whitney an American linguist and translator of Sanskrit texts when he wrote⁵⁵ “...any star not too distant from the pole would have satisfied both the newly wedded woman and the exhibitor; there is no need of assuming that the custom is one handed down from the remote period when α-Draconis was really very close to the pole, across an interval of two or three thousand years during which there is no mention of pole-star, either in Veda or in Brāhmaṇa.” His arrogance in passing judgment on Hindu practices could only match with his ignorance of not only the intricacies of Vedas but also of astronomy. Another person to oppose the high chronology for RV, based on the equation between the stars Dhruva and Thuban, was Keith. He worked in India in the Colonial Office and was known widely as the translator of the *Taittirīya Samhitā* and a few other Vedic texts. There are no independent records to support his knowledge of either the country or its culture, but as the author of a monograph on the religion of the Veda he thought he had the right to be derisive about the Hindu marriage ritual to comment “...the argument from the pole star assumes an accuracy in the demands of the primitive Indian wedding ritual which is wholly unnatural.”⁵⁶ In the same monograph, while citing the *Śatapatha Brāhmaṇa* that says the Pleiades do not slip from the east he wrote “a passage which consists of foolish reasons for preferring one or other of the Nakṣatras; we are in the same region of popular belief as when in the Sūtra literature the existence of *Dhruva*, a fixed polar star, is alleged.” As if not satisfied with the above diatribes he added a foot note on page 79 of his book - “The pole star, Dhruva,

⁵³ cale'calepi dhruvabhe svameṣādrāśitrayam taddhruvakaḥ śarastu|

ṣaṣṣaṣṭibhāgāḥ pariṇītanāryāḥ mahatphalaṁ darśanato'sti yasya// (STV Ch. Bhagrahayuti v 8)

⁵⁴ Jacobi H.G. On the date of the Ṛgveda, (Transl. from German) *The Indian Antiquary*, 23, 154-159. 1894.

⁵⁵ Whitney W.D. On a recent attempt by Jacobi and Tilak to determine on Astronomical Evidence the Date of the earliest Vedic Period as 4000 BC. *The Indian Antiquary*, 24, 361-369. 1895.

⁵⁶ B.Keith (1925) *The Religion and Philosophy of the Veda and Upanishads*, Harvard Univ. Press, USA.

appears in the Gṛhya Sutras only.” We surmise that Whitney and Keith being mere lexicon based translators had no proper understanding of the Taittirīya Āraṇyaka with no clue to the astral Vedic culture. Keith coauthored a Vedic Name Index with Macdonell⁵⁷, which is popular as a reference book even now. Under *Dhruva* there is reference to Jacobi and the controversy of this being the Pole Star. But under the entry *Śiśumāra/Śiśumāra* the word is taken just as an aquatic animal with no possible ethno-astronomical meaning ascribed to the word. This is wholly misleading, since even the Monier Williams Dictionary of 1899 listed one of the meanings for Śiśumāra as: *a part of the heavens having stars of that shape*.

Summary and Conclusion

The premise of this study has been that since ancient Indians were keen sky watchers as inferred from the Vedas, they could have felt the effect of axial precession and probably left their impressions of such experience in the Vedic texts. The study presented verifies and supports the above premise. Descriptive pictures of the northern sky starting with the Vedic literature and the Purāṇas are reviewed in some detail. These texts present the oldest description of a constellation named the *Śiśumāra* comprising of fourteen stars including the Pole Star of those days. The identification and constraints for locating *Dhruva*, the ancient Pole Star, as vividly described in the *Taittirīya Āraṇyaka* of the Yajurveda and the *Brahmāṇḍa Purāṇa* are presented in this article from a chronological perspective. It is seen that the legendary *Dhruva* has left his imprint permanently on the sands of time, starting from around 3000 BCE to the present day. The Indian practice of having a spiritual-cum-cultural dialogue between the sky and the earth (*Dyāvā-prthivī*) has passed through the Vedic Saṁhitā, Brāhmaṇa, Āraṇyaka to the Purāṇas with many twists and turns into the socio-religious rite of *dhruvadarśana* (seeing the Pole Star) in Hindu marriages. There are textual evidences for having experienced the movement of the Pole Star in the second and first millennium BCE although, the *dhruvadarśana* got frozen as a ritual. As seen in figure 2, in the early centuries of CE, α -Draconis was not even visible all through the year in southern India even if one were to know where to look for the star. Quite interestingly, some marriage manuals prescribe that the bride should say “seen” even if star *Dhruva* is not visible⁵⁸.

As we approach the Common Era, even as *Śiśumāra* was altering its shape and receding towards northeast a new constellation called *tārāmatsya* likened to a starry fish in the *Vṛddhagārgīya Jyotiṣa* was circling the northern polar region (500-100 BCE). Scientific astronomers of the early *siddhānta* period avoided references to the *Śiśumāra* of the Veda and the Purāṇa but retained the term *dhruva* to mean NCP as a fixed reference point on the celestial sphere leading to the technical terminology *dhruvaka* or polar coordinate⁵⁹. Within a few centuries, the *tārāmatsya* constellation approached the NCP, to be named *Dhruva-matsya* (Polar Fish) by Brahmagupta in the 7th cent. The star approaching the pole was kept at the mouth of this animal figure, in contrast to the ancient *Dhruva* placed at the tail end of the aquatic animal *Śiśumāra*. This ambivalence must have confused an outsider like Al-biruni since the orthodox Hindus whom he knew, were holding on to their belief that the Pole Star was at the tip of the tail of the constellation *Śiśumāra*, looking more like a whale and not a fish.

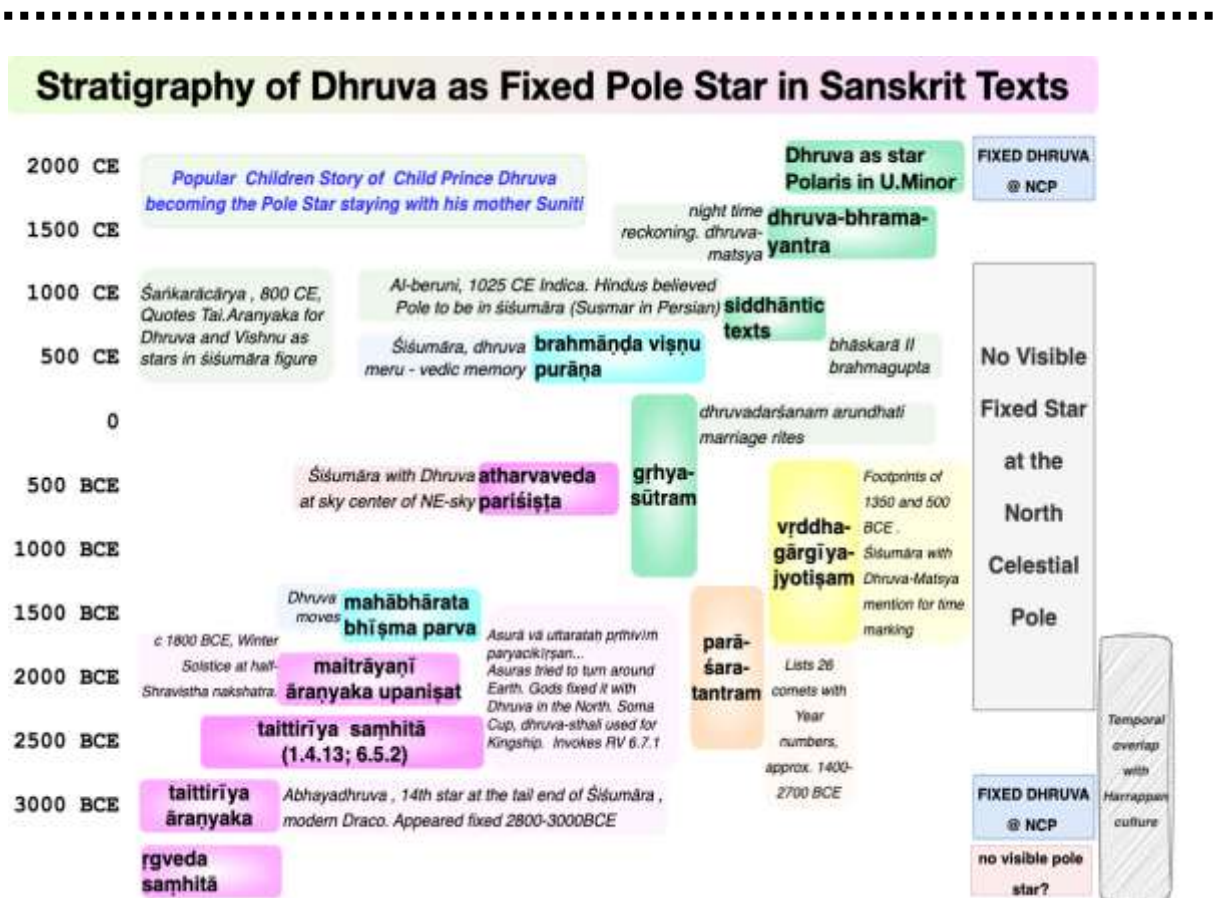
⁵⁷ Macdonell, A. A., & Keith, A. B. *Vedic Index of Names and Subjects*. J. Murray. London, 1912.

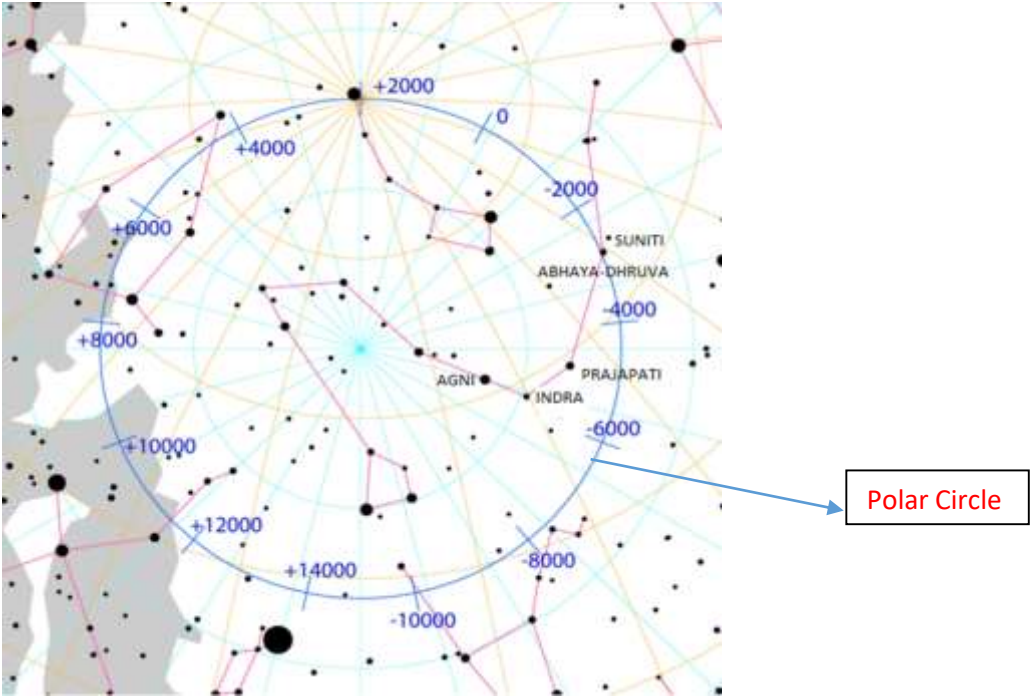
⁵⁸ *astamite dhruvam darśayati, dhruvamasi dhruvamtvā paśyāmi.....sañjīva śaradaḥ śataṁ iti| sā yadi na paśyēt paśyāmi ityeva brūyāt || (Pāraskara Gṛhyasūtram with five commentaries ed. M.G.Bākre, 2nd edn. Munshiram Manoharlal Publ. N.Delhi, 1982)*

⁵⁹ Abhyankar K.D. *Dhruvaka-vikshepa system of Astronomical Coordinates*, Ind. J. Hist. Sci. 41, pp.151-157, 2006.

There is ample evidence to verify that the legendary Dhruva of the Purāṇa derived from the Vedic *Abhaya* and instituted into the rites and rituals was indeed α -Draconis that was the Pole Star in the third millennium BCE. It is possible that professional priests made the bride see some star in the night sky just as a ritual, without concern for the meaning of the hymns. It must have been paradoxical that a star far away from the NCP with no special correspondence to the sacred hymns was still invoked in Hindu marriages. This issue was resolved by the astronomer and mathematician Kamalākara in 1658 CE by declaring the celestial coordinates of a visible star that indeed looked stationary with respect to its nearby stars, according to the prescribed Vedic hymn, in letter and spirit. This new Dhruva was α UMi, the current Pole Star.

The time line of the observation of the ancient Pole Star and the religious rituals perpetuating the fixity and also drift of this star as recorded in the primary Vedic texts and ancillaries is a pointer indicating temporal overlap between the Harappan and the Vedic cultures.





Lecture ३

Stars, Tārā, Nakṣatra

The *Darśa-Pūrṇamāsa* (DP) rite is special in several ways. From the astronomical point of view, the DP altar holds the central role. This pattern of moon's station in the sky, mapped on the ground could have been used as a calendar, for marking eclipses, but over time forgotten. But the esoteric/spiritual implications are still retained in the Yajurveda texts. The hymns used in the liturgy refer to the sky and there is always more than what meets the eye in Vedic rituals. In one place, the altar is said to be in the sky and protected in the north by *Mitra and Varuṇa*, with the invariable law.

मित्रावरुणौ त्वोत्तरतः परिधत्तां ध्रुवेण धर्मणा॥ TS (I. 1.11.12)

Naturally this makes one wonder whether *Mitra* and *Varuṇa*, the important twin-deities could have been visible stars in the northern sky, named so in the Śiśumāra constellation, of the TA and the Purāṇas. Such cryptic statements add an extra dimension to the astronomy of the Vedic times, since the practitioners did not limit themselves to physical observations but wished to attain a position in the sky. This mystical naturalism gets highlighted by the role of the *Brahman*, the presiding priest of the DP rite, who blesses the sacrificer silently,

...नाकस्य पृष्ठे यजमानो अस्तु सप्तऋषीणां सुकृतां यत्र लोकस्तत्रेमं यज्ञं यजमानं च धेहि ॥

..may the yajamāna attain a place at the base of the heaven, near the constellation Saptarṣi.

The northern sky region around the *Saptarṣi-maṇḍala* (U. Major) has always held prominent position in ancient texts as the base of the heaven and the centre of the universe. We have seen in the previous talks about Dhruva and Meru, that all the celestial bodies were considered to be linked to Dhruva, through wind-strings (*vātaraśmi*). This included the stars along the path of sun and moon (ecliptic) as well as others far away in north and south. The word *star* is derived from the base *str* used in the Ṛgveda as *str̥bhiḥ*: RV 1.68.10; 1.87.1; 1.166.11; 2.2.5; 2.34.2; 4.7.3; 6.49.3, 6.49.12.

Tārā, tārakā appears to be the more ancient general word whereas *nakṣatra* had special meaning as stars along the ecliptic band, which help to know the position of sun, moon and planets. However, over centuries in popular parlance the words are used as synonyms. Technically, nakṣatra refers to an asterism, that is a group of identifiable stars with particular geometrical form. This meaning also changed to mean a part of the sky in which the particular group of stars are observed to be located. In the Ṛgveda the nakṣatras are cited eleven times, mostly connected with the nights (RV 1.50.2; 3.54.19; 6.67.6; 7.81.2; 7.86.1; 10.22.10; 10.68.11; 10.85.2; 10.88.13; 10.111.7; 10.156.4). However, nights would cover early mornings before sun rise and hence branding nakṣatra as 'lunar mansion' cannot be taken as an appropriate interpretation.

Observing the sky and reckoning the place of moon near bright stars would have been a practice in all ancient cultures. Since moon is observed to approach the same bright star after 27-28 days, it is natural to assume that moon spends a day with each of the 27-28 nakṣatras. The naming of these single or multiple stars in a particular order is the early Vedic astronomy as a

scientific discipline. As we have seen previously that the Abhaya-Dhruva as the Pole Star was (2830±200 BCE); the 27-28 nakṣatra system must have originated in the same period. The Yajurveda texts give the list of nakṣatras along with their presiding *devatā*. In some places the number of stars included in the particular *nakṣatra* is also available. The first part of History of Indian Astronomy by SB Dikshit may be referred for some more details and variant readings in the texts.

Puṇyāha and Nakṣatra

Concrete evidence of using early morning star rise for ritualistic purpose is available in the Taittirīya Brāhmaṇa. This Vedic text belonging to the Kṛṣṇa Yajurveda has the following dictum which like texts of its genre is cryptic, almost as a mnemonic, but the sense of the hymn is very clear. The original hymn and its explanation as per the Vedic tradition preserved in the commentary of Bhaṭṭa Bhāskara (10th Century) follows:

यत्पुण्यं नक्षत्रम् । तद्वत् कुर्वीतोपव्युषम् । यदा वै सूर्य उदेति । अथ नक्षत्रं नैति । यावति तत्र सूर्यो गच्छेत् । यत्र जघन्यं पश्येत् । तावति कुर्वीत यत्कारी स्यात् । पुण्याह एव कुरुते । एव ह वै यज्ञेषु च शतद्युम्नं च माध्वस्यो निरवसाययाञ्चकार ॥ १ ।
५।२।

(भट्टभास्करभाष्यम्)

यत्पुण्यमित्यादि ॥ पुण्यकर्मणोऽनुरूपं आत्मनश्चानुकूलं यन्नक्षत्रं इष्टं तत् बद्धं कुर्वीत । बडिति सत्यनाम । तत् सत्यं चिह्नं कुर्वीत । तेन वा चिह्नमाकाशं कुर्वीत । अस्मिन् आकाशावकाशे इदं नक्षत्रमिति । उपव्युषं उषस्समीपे विवासनकाले । छान्दसो डः समासान्तः । पुनः कालं विशिनष्टि – यदा सूर्य उदेति । अथ तत्पुण्यं नक्षत्रं नैति न तिरोहितं भवति तादृशे विवासनकाले तत्पुण्यं नक्षत्रं यत्राकाशावकाशे तिष्ठति तं प्रदेशं सत्यं कुर्वीत अविपर्यस्तं जानीयात् । अथैवं ज्ञात्वा तस्मात् चिह्नितात् प्रदेशात् जघन्यं पश्चाद्भागत्वेन यत्र पश्येत् तत्राकाशप्रदेशे यावति काले सूर्यो गच्छेत् तावति ततः प्रागेव कुर्वीत अविपर्यस्तः स्वं तत्कर्म यत्कारी यत्कर्म करिष्यन् स्यात् । पुण्याह एव कुरुते । एवं क्रियमाणं सत्स्वपि दोषेषु पुण्याहे कृतं भवति । अज्ञातानामपि मुहूर्तादिदोषाणां शान्त्यै भवतीति भावः॥

One has to confirm a nakṣatra which he prefers for some auspicious work. He has to mark also in the sky 'this space is for this nakṣatra'. This has to be done before Sunrise, nearer to day break. When Sun comes up, that auspicious star will not be seen. Hence that particular space in the sky wherein the star remains still visible has to be confirmed. Or knowing this part of the sky marks may be done. The rite has to be completed before the time taken by Sun to cover that space. (Tai.Br.1.5.2)

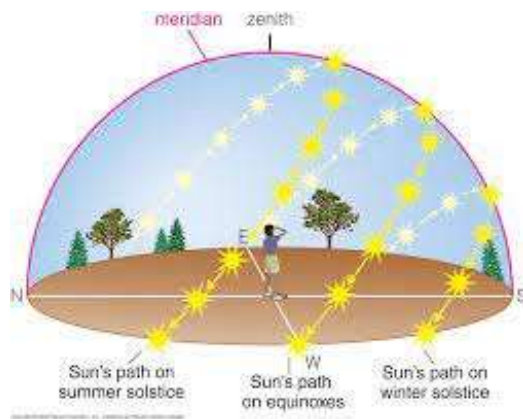
The above commentary explains the essence of the hymn. The word *baṭ* refers to fixing or confirmation. In the present context, this is marking by some means the portion of the sky for the position of the desired star. *Uṣas* is the twilight period. But *upavyuṣam* is when the sky is dimly illuminated for the star to be still visible. *Jaghanyam* is the lower point or mark so that the person is sure of the visibility interval of the star. One is asked to select a *nakṣatra* in the eastern sky before Sun rise and also to mark or make sure of a point below. This point is at a lower altitude such that as Sun reaches this point the star vanishes from sight.

The spirit of the Vedic text is to observe the rise of the prescribed *nakṣatra* early in the morning, which could be its first visibility and to have an estimation of the time taken for Sun to make the star invisible. The work done in such a period is deemed to have been done at an appropriate time without any other doubts about the auspiciousness of the time. Quite interestingly this belief in the auspiciousness of an hour and half before Sunrise continues to this day in many parts of India. This practice of heliacal auspiciousness, in the absence of any other time measuring instruments, would make the visible stars as supports for getting a sense of elapsed

time. The fast movement of Sun near the equinox as also its slowness near the solstice would be felt and Sun as the cause of Time would be experienced in more than one sense of the term.

Closer observation of the sky, theories about sun and moon in a ritualistic or anecdotal fashion staying with the nakṣatra, are available in the Maitrāyaṇīya Āraṇyaka (MAU), Taittirīya Brāhmaṇa and the Nidāna Sūtra of the Sāmaveda.

We have seen while discussing axial precession of earth in MAU, King Bṛhadratha questions why even Dhruva moves? This must be after 2800 BCE. Fortunately, a date can be put on some of the statements in MAU, since the 'ayana' of sun moving from left extreme to right extreme and return with respect to nakṣatras is mentioned.



Sunrise-Sunrise = 1 Ahorātra (day-night)

We all observe Sun rising in the East and setting in the West. Vedic Indians observed the same Sun and also noted that each day the rising point of Sun shifts to the right/left. But sunrise point reaches a limiting position in the South/North. So simply put, Sun has lateral motion also as observed from earth. This is *Ayana*. North to South= Dakṣiṇāyana

South to North= Uttarāyana

Sun repetitively rises at the northernmost and southernmost point completing the -N-S-N-S- cycle.

This is the Year counted as 365-366 *ahorātra*. Samvatsara= 2 ayana = 2x183 days. Sun appears to be slow at the extreme N-S rise points. This means, sun appears to be rising in the same sky part, w.r.t the visible early morning *nakṣatra* at the summer and winter solstice condition. At the two equinoctial points between the solstices sun moves fastest. Sun as the causer of seasons is well attested in the Vedas. The seasons (*ṛtu*) were in the early period recognized by felt effects; cold, hot, chill, rains, pleasant etc. The number of seasons got standardized as six, *vasanta*, *grīṣma*, *varṣa*, *śarat*, *hemanta*, *śiśira*. We come to these again and again in several contexts.



One of the most important observations in Vedic times was of the extreme heat when sun was rising in the north-east corner followed by rains; this got fixed as the start of the *varṣa-ṛtu*. Even before the season names were introduced, the southern *ayana* of sun was known as *āgneya* (fiery/hot) starting with sun rising in the *maghā nakṣatra* and the return

journey towards north as *saumya* (calm/cool) when sun reached the *śraviṣṭhā* group. This is explicitly stated in MAU, which is an anchor point after the Pole Star observation of (2830-±200) BCE.

Before we analyse the above text further, it is useful to have a table of the *nakṣatras* and their modern equivalents with the help of which calculations can be carried out for dating past observations. This table taken from the *Mahāsalilam* book has 28 nakṣatras, including *abhijit*. The astrograph helps in identifying the nakṣatra in the sky. While some are identifiable even now without much difficulty, there can be significant differences in the number of stars, names and shapes between this list and later texts such as the *Sūryasiddhānta* and the *Bṛhatsamhitā*. The reasons for this change are due to dropping of *abhijit*, concept of equal nakṣatra sectors, equinoctial precession (*ayana-chalanam*) and break in observational tradition.

#	Nakṣatra	Star Count					Constituent Stars, IAU Names	Astrograph
		VGJ	PT	AVP	SKA	SCP		
1	Kṛttikā	6	6	6	6	6	Tau (17,19,20,23, 27, η)	Knife/Cleaver
2	Rohiṇī	5	5	1	5	5	Tau (α, γ, δ1, ε, θ2)	Śakāṭa (Cart)
3	Mṛgaśira	3	3	3	3	3	Ori (α, γ, λ)	Deer's Head
4	Ārdrā	1	1	1	1	1	Gem (γ)	Bāhuḥ ⁺ (Arm) Red Dot*
5	Punarvasu	2	2	2	2	5	Gem (α, β)	Balance*
6	Puṣya	1	1	1	3	3	Cnc (δ)	Śarāva (Pot-lid)*
7	Āśleṣā	6	6	6	1	6	Hya (δ, ε, ζ, η, ρ, σ)	Sārpa (Snake-head) Flag*
8	Maghā	6	6	6	5	7	Leo (α, γ1, ε, ζ, η, μ)	Koṣṭhāgāra Prākāra*
9	P. Phalgunī	2	2	2	2	2	Leo (δ, θ)	Half-chair
10	U. Phalgunī	2	2	2	2	2	Leo (93, β)	Half-chair
11	Hasta	5	5	5	5	5	Crv (α, β, γ, δ, ε)	Hasta (Hand)
12	Citrā	1	1	1	1	1	Vir (α)	Flower*
13	Svāti	1	1	1	1	1	Boo (α)	Kīlaka (Wedge)*
14	Viśākha	2	2	2	2	5	Lib (α1, α2)	Divider/Branch; Rope*
15	Anūrādhā	4	4	4	4	5	Sco (β1, δ, π, ω1)	Necklace*
16	Jyesthā	3	3	1	3	3	Sco (α, ε, σ/τ)	Elephant Tusk*
17	Mūla	6	2	7	7	1	Sco (ζ2, θ, ι1, κ, λ, ν)	Root/Split-end Scorpion-tail*
18	P. Aśādhā	4	4	4	4	4	Sgr (γ, δ, ε, λ)	Gajavikrama (Elephant-step)*
19	U. Aśādhā	4	4	4	4	4	Sgr (ζ, σ, τ, φ)	Simhaniśadya (Lion-seat) *
20	Abhijit	3	3	1	3	3	Aql (α, β, γ)	Gośīrṣāvali (Cow's head) *
21	Śravaṇa	3	3	3	3	3	Del (α, β, γ2/δ)	Ear
22	Śraviṣṭhā	4	5	5	4	5	Aqr (α, β, ε, γ)	Śakuni-pañjara (Bird cage) *

23	Śatabhiṣak	1	1	1	1	100	Aqr (λ)	Puṣpopacāra (Floral-decor) *
24	P. Proṣṭapada	2	2	2	2	2	Peg (α, β)	Cow's Foot
25	U. Proṣṭapada	2	2	2	2	2	Peg(γ) And(α)	Cow's Foot
26	Revatī	1	1	1	1	32	Psc ($\epsilon/\alpha/\zeta$)	Boat*
27	Aśvayuk	3	2	1	2	3	Ari (α, β, γ)	Horse-neck
28	Bharaṇī	3	3	3	3	3	Ari (35,39,41)	Casket

Here five BCE texts are listed. VGJ=Vṛddhagārgīya Jyotiṣa, PT=Parāśara Tantra, AVP= Atharvaveda Pariśiṣṭa, SCP=Sūrya-chandra Prajñapti, SKA=Sārdūla Karṇāvadāna. * astrograph as per SCP.

Maghādi Epoch

In the Vedic MAU the *dakṣiṇāyana* of sun is said to be from *maghādi* to *śraviṣṭhārdha*, that is from the beginning of *maghā* sector till $\frac{1}{2}$ -*śraviṣṭhā*, spanning six months amounting to one hundred and eighty-three (183) days, counted in terms of sunrises.

सूर्यो योनिर्वै कालस्य तस्य एतद्रूपम्। यन्निमेषादि कालात्संभृतं द्वादशात्मकं वत्सरम्। एतस्याग्नेयमर्धमर्धं वारुणम्।

मघाद्यं श्रविष्ठाद्यग्नेयं क्रमेणोत्क्रमेण सार्पाद्यं श्रविष्ठाद्यन्तं सौम्यम्। तत्र एकैकमात्मनो नवांशकसचारकविधम्॥ MAU (6.14)

This method of tracking sun, calls for a fixed starting point on the celestial circle identifiable with a visible star at sunrise. The *Nakṣatra Sūkta* attributed to the authorship of Ṛṣi Garga in the Atharvaveda⁶⁰, where also *maghā* is associated with the *ayana*, probably meaning the summer solstice.

Nakṣatra maghā made up of six stars identified as the group ($\alpha, \epsilon, \zeta, \eta, \gamma, \mu$ -Leo) is well described and remembered by the Vedic tradition. The ecliptic star α -Leo (Regulus) is the brightest among the group. The six stars together make an astrograph that looks like an enclosure, *koṣṭhāgāra*, which is used in literature as a synonym for the *maghā nakṣatra*. At Kurukṣetra (30° N), in the *maghādi* era, sun at the summer standstill would have been rising at nearly the same azimuth ($62^\circ \pm 0.5^\circ$) for about fourteen days, with progressively different stars of the *maghā* group becoming visible before sunrise, giving the feeling that sun stays and starts the southern travel from the beginning of *maghā* sector (*maghādyam*) as stated in MAU to proceed till the middle of *śraviṣṭhā* in six months and to return. In MAU apart from the sector dividers (*ādi, ardha, anta*), there are references to discrete time units starting with the *nimeṣa* (eye wink) and the *twelve* (stellar divisions) each with *navāmśa* (nine-quarter) parts. This amounts to dividing the year (*vatsara*) into twelve parts, each with nine divisions for sun to move through $2\frac{1}{4}$ *nakṣatra* in a solar month. The *Nidāna Sūtra* of the Sāmaveda specifically says that sun moves through the year spending 13 (5/9) days with each *nakṣatra*⁶¹.

The implication is that the year was tracked in terms of observed lateral shift of sun (*ayana*) by noting sunrise across the horizon from summer solstice to winter solstice and back. The *ṛtu, ayana* and *saṁvatsara* length mentioned in number of days could have been counted only

⁶⁰ पुनर्वसू सूनुता चारुपुष्यो भानुराश्लेषा अयनं मघा मे ॥ (AVS 19.7.2b)

⁶¹ स एष आदित्यसंवत्सरो नाक्षत्रः। आदित्यः खलु शश्वदेतावद्विरहोभिर्नक्षत्राणि समवैति। त्रयोदशाहं त्रयोदशाहमेकैकं नक्षत्रमुपतिष्ठति। अहस्तृतीयं च नवधा कृतयोरहोरात्रयोर्द्वे द्वे कले चेति संवत्सराः। ताश्चत्वारिंशच्चतुः पञ्चाशतंकलाः। तेषणववर्गाः सषट्त्रिंशतः।। (Nidāna Sūtra 5.12)

in terms of sun rises. It follows, the seasonal and solstice *nakṣatra* should have been the morning stars of the corresponding asterism seen rising while sun was still well below the horizon. A theoretical picture of such a zodiac can be constructed, as shown in Figure 1.2, by marking twenty-seven equal sectors, in the order of the *nakṣatra* names on the outer ring, treating the summer solstice day as the first point of the *maghā* sector. The winter solstice naturally falls at the centre of the *śraviṣṭhā* sector as stated in MAU. The day numbers can also be marked such that each of the six seasons is sixty-one days long, spanning $4\frac{1}{2}$ -*nakṣatra* sectors as per the texts PT, VGJ and AYJ.

Although MAU mentions *navāṁśa* that is $\frac{1}{4}$ -*nakṣatra* as a sky part amounting to 3- $3\frac{1}{2}$ days, no application of this is evident in the available Vedic texts till we come to the *Brahmāṇḍa Purāṇa* (BP). This Purāṇa defines the equinoxes (*viṣuvat*) correctly in terms of day and night being of equal duration of fifteen *muhūrtas*. Further BP provides the equinoctial full moon stars corresponding to spring equinox at $\frac{1}{4}$ -*kṛttikā* and autumn equinox at $\frac{3}{4}$ -*viśākhā* exactly opposite each other as they should be.

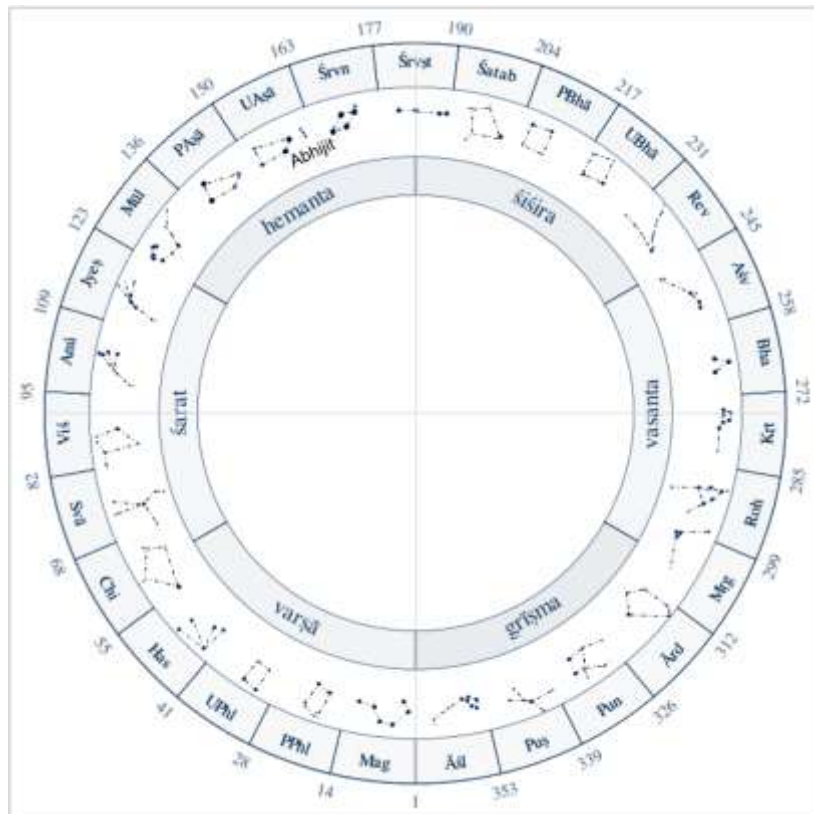


Figure 1.2. Illustrative sketch of the equal sector *nakṣatra* zodiac of the *maghādi* epoch, c 1800 BCE. Summer solstice coincides with the first point of the *maghā* sector reckoned as day-1 the beginning of the *varṣa* *ṛtu* nearly matching with the rise of the star ε-Leo. The sectors contain the respective visible stars as per the *nakṣatra* name or in the form of a known shape, made up of one or more stars shown as bold points. The dotted lines show the astrograph of the *nakṣatra* in relief not to scale. *Śravaṇa* the sector and the *nakṣatra* resembling an Ear fits in with the stars of the Delphinus constellation. *Śraviṣṭhā* first point matches with the rise of star ε-Aqr.

In Figure 1.2, the spring and autumn equinoxes automatically get aligned at the middle of the *vasanta* and *śarata* seasons corresponding to $\frac{1}{4}$ -*kṛttikā* and $\frac{3}{4}$ -*viśākhā* sectors as mentioned in BP:

कृत्तिकानां यदा सूर्यः प्रथमांशगतो भवेत् ।विशाखानां तथा ज्ञेयश्चतुर्थांशेनिशाकरः ॥
विशाखायां यदा सूर्यः चरतेऽशं तृतीयकम् ।तदा चन्द्रं विजानीयात्कृत्तिकाशिरसि स्थितम् ॥
विषुवन्तं तदा विद्यादेवमाहुर्महर्षयः ।सूर्येण विषुवं विद्यात् कालं सोमेन लक्षयेत् ॥
समा रात्रिरहश्चैव यदा तद्विषुवद्भवेत् ।तदा दानानि देयानि पितृभ्यो विषुवत्यपि ॥ (BP. Ch. 21 v.146-149)

In Figure 1.3, the continuously changing positions of the visible *kṛttikā* and *viśākhā* stars, due to precession, are shown along with equinoctial full moon possibilities. These two asterisms are remembered by unbroken tradition and recognized by their astrographs to this day. The results presented in Figure 1.3 indicate that the conditions of the *maghādi* solstice as per MAU and of the full moon equinoxes at $\frac{1}{4}$ -*kṛttikā* and $\frac{3}{4}$ -*viśākhā* were simultaneously satisfied during (1980-1610) BCE. This interval is shaded in the figure. Thus, the central date of *c* 1800 BCE can be recognized as the *maghādi* epoch of sky observations of the post Vedic astronomers.

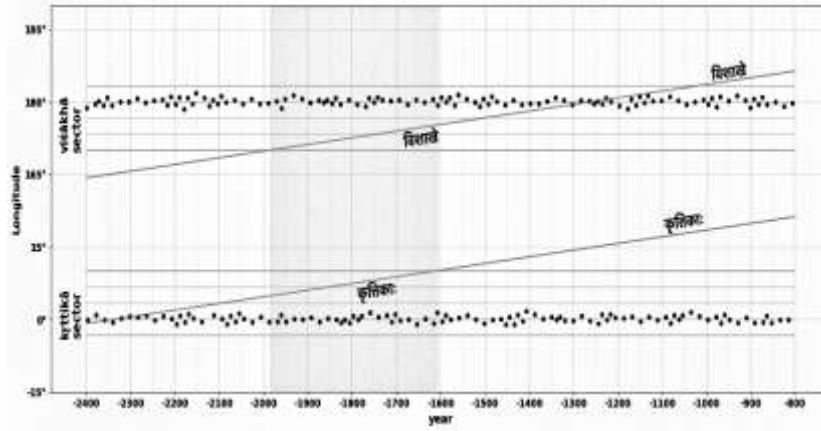


Figure 1.3. Full moon points around 180° longitude when sun was at 0° longitude (*vasanta*/spring equinox) are marked in the *viśākhā* sector. Full moon points around 0° longitude when sun was at 180° longitude (*śarat*/autumn equinox) are marked in the *kṛttikā* sector. The two straight lines show the variation in longitude of the stars *kṛttikā* (η -Tau) and *viśākhā* (α 1-Lib) due to precession of the equinoxes.

For more details, read the enclosed paper: “Equinoctial full moon of the *Brahmāṇḍa Purāṇa* and the *nakṣatra* solar zodiac starting from summer solstice”. *Indian Journal of History of Science*, 2023. **Encl.1**



Equinoctial full moon of the *Brahmāṇḍa Purāṇa* and the *nakṣatra* solar zodiac starting from summer solstice

R. N. Iyengar¹ · Sunder Chakravarty¹

Received: 26 June 2023 / Accepted: 22 September 2023
© Indian National Science Academy 2023

Abstract

The first theoretical system of tracking sun in the tropical annual cycle is cryptically mentioned in the *Maitrāyaṇīya Āraṇyaka Upaniṣat* (MAU) of the *Kṛṣṇa Yajurveda*, as the southern sojourn of sun starting at the summer solstice. This is called *maghādyam*, the first point of the *maghā nakṣatra*, identified most likely with the early morning visibility of ε-Leo, near the azimuth of the sunrise point on the horizon as observed at Kurukshetra. Twenty seven equal *nakṣatra* sectors named in the traditional sequential order cover one tropical circuit of sun of 366 days with the winter solstice falling exactly at the middle of the *śraviṣṭhā* sector. Even though MAU mentions each *nakṣatra* to be made up of four quarters, no practical application of this $\frac{1}{4}$ -*nakṣatra* sky part amounting to 3°20' in longitude is seen in Vedic texts till we come to the *Brahmāṇḍa Purāṇa*, a text closer to the Vedas. This *Purāṇa* states, observed equinoctial full moon positions corresponding to spring equinox at $\frac{1}{4}$ -*kṛttikā* and autumn equinox at $\frac{3}{4}$ -*viśākha* exactly 180° apart as they should be. This statement is analysed in this paper by computer simulation of full moon time series for the years – 2400 to – 800 to show that the *Purāṇa* data would be realistically valid for the period 1980 BCE to 1610 BCE. It is further demonstrated that the *Purāṇa* has followed the *maghādi* system of solar *nakṣatra* system stated in the MAU. The central epoch *circa* 1800 BCE of this *maghādi* equal *nakṣatra* solar zodiac got modified, due to precession effects, to the *śraviṣṭhādi* scheme of Parāśara, Vṛddha Garga and Lagadha dateable to *circa* 1300 BCE.

Keywords *Brahmāṇḍa Purāṇa* · *Maghādi* solar zodiac · Equinoctial full moon · Epoch 1800 BCE · Precession effects

Abbreviations

AE	Autumn Equinox
BP	<i>Brahmāṇḍa Purāṇa</i>
FM	Full Moon
MAU	<i>Maitrāyaṇīya Āraṇyaka Upaniṣat</i>
PT	<i>Parāśara Tantra</i>
RV	<i>Ṛgveda</i>
SE	Spring Equinox
SS	Summer Solstice
TB	<i>Taittirīya Brāhmaṇa</i>
VGJ	<i>Vṛddhagārgīya Jyotiṣa</i>
WS	Winter Solstice

1 Introduction

Solar phenomena of the two solstices have been of deep mystical and cultural importance in India since the Vedic times. The astronomical significance of the days when sun is at the extreme north and south declination, in the annual cycle, would have been directly observed and experienced in terms of the differing length of the day light. The Vedic sacrificial year started with or near the winter solstice day and the *śisīra ṛtu* (winter) with several texts indicating that the tropical year was taken to be 366 *ahorātra* (day-night), counted in terms of sun rises. In this reckoning, the mid-year was close to the summer solstice day that divided the year into two equal parts of six months each. The central day of the yearlong *gavāmayana* sacrifice, when sun rise was observed far north of due East, was called *viṣuvat*, a day of special significance in Vedic rituals. This was also the day when formally the *varṣa ṛtu* (rainy season) started. The meaning of the word *viṣuva* indicates a point in time that divides the year in half. This point is figuratively

✉ R. N. Iyengar
RN.Iyengar@jainuniversity.ac.in

¹ Centre for Ancient History and Culture, Jain University, Bangalore 560078, India

explained in the *Taittirīya Brāhmaṇa* (TB) by comparing the *viṣuva* day to the east–west running central roof beam of a sacrificial hall that divides the hall symmetrically into north–south wings of equal measure.¹ But this was not the only technical meaning of the word *viṣuva*, which in its etymological sense meant equality and symmetry with respect to a middle point. Thus, the *Purāṇas* define *viṣuva* as when the *ahorātra* (day–night) gets divided into day and night of equal length. This is the equinoctial day that occurs twice in a year. The practitioners of yearlong rites such as the *gavāmayana* would have noticed such days, but explicit reference to the two equinoctial days is not found in the available Vedic texts, unlike weather related narratives of the two solstice days.

Another significant feature of sky observation was about the background stars along the ecliptic, called *nakṣatra*. Special professionals known as *nakṣatradarśa* were the ancient Indian sky watchers. *Nakṣatra* (asterisms) were used not only for specifying moon's position in the monthly cycle, but also for sun in the tropical year. A clear reference to solar *nakṣatra* appears in the *Maitrāyānīya Āraṇyaka* (aka *Maitrī Upaniṣat*; MAU), which declares *Time* to have manifested coeval with sun. This text divides the tropical year into two solar transits (*ayana*) starting from the summer solstice to the winter solstice and back. This would be valid for any year, but the text indirectly refers to an epoch, when the southern sojourn of sun (*āgneyam*) was from the beginning of *nakṣatra maghā* (*maghādyaṃ*) to half-of-*śraviṣṭhā* (*śraviṣṭhārdham*). The *saumya* transit (northern) is indicated to be between the start of *āśleṣā* (*sārpadyam*) and middle-*śraviṣṭhā* but in reverse order (*utkrameṇa*). When reckoned in the direct order this northern transit was from half-*śraviṣṭhā* to end of *āśleṣā*.² This scheme is the earliest Vedic solar zodiac that not only divides the year into two equal halves but also mentions names of the starting, ending and half-of-*nakṣatra* divisions, in terms of eponymous stars that should have been visible in the sectors. Further, MAU refers to discrete time starting from the *nimeṣa* (eye wink) and the *twelve* (stellar divisions) each with *navāṃśa* (nine-quarter) parts. This amounts to dividing the year (*vatsara*) into twelve parts, each with nine divisions for sun to move through $2\frac{1}{4}$ *nakṣatra* in a solar month. In modern terminology, this makes the smallest angular measure indicated by MAU to be $3^{\circ}20'$ which is an indicator of possible error of

about three to four days in the observation of the solstice day, and *nakṣatra* sector boundaries.

The partition of the sun's path or the ecliptic into twenty-seven equal *nakṣatra* sectors and ordering them in terms of day counts is an interesting practical approach. But use of the same nomenclature for the visible asterisms and also for the *nakṣatra* stretches, can be confusing in identifying the starting point of the first *nakṣatra*. This *-ādi* scheme works well when the beginning of the division is identifiable with a star named and familiarized from the past becomes visible before sun rise. In this model of sun spending 366 days equally distributed over 27 *nakṣatra* divisions, days are counted as integral number of *ahorātra* or day-night (day for convenience) from the summer/winter solstice day. Once the *nakṣatra* part of sun on the solstice day can be estimated or observed, the remaining equal *nakṣatra* divisions can be marked in terms of number of days. Moon plays no role in this scheme as far as the divisions are concerned. But it is known that *pūrṇimā* (full moon), *aṣṭami* (half-moon) and *darśa* (new moon) have had important role in Vedic rites and practices. Although, unambiguous luni-solar observations are not found in the available Vedic texts, it is interesting to come across reference to Full Moon (FM) coordinates in terms of *nakṣatra* parts on equinoctial days, in the *Brahmāṇḍa Purāṇa* (BP) and a few other *Purāṇas* with minor variations.

In this paper, the *Brahmāṇḍa Purāṇa* statements are investigated first to demonstrate that this data is compatible with observations spread over a period of four centuries, the latest being 1700–1600 BCE. This is followed by a discussion of this result to demonstrate the *maghādi* scheme of MAU and BP as the original version of the formal Vedic solar zodiac that changed into the *śraviṣṭhādi* scheme circa 1400–1300 BCE due to the precession of the equinoxes. This represents an interesting period of pre-*siddhāntic* Hindu astral sciences that is important for the history of Indian astronomy before Common Era.

2 *Brahmāṇḍa Purāṇa* (BP)

Among the traditionally recognised eighteen *Purāṇas*, the *Brahmāṇḍa*, *Vāyu*, *Matsya*, *Viṣṇu*, *Liṅga Purāṇa* texts carry interesting astronomical and cosmological models inherited from their Vedic past. For example, all the above *Purāṇas* refer to the Vedic legend of *somapāna* by gods as the daily decrease in the brightness of moon in the dark fortnights (Iyengar, 2016). The Meru-Dhruva centric model for the periodic motion of sun, moon and other celestial bodies is also available in the above texts with variant readings, additions and omissions. Even though some of the statements may sound fanciful, there is a discernible layer of observation and effort to explain the same in terms of prevalent physical models. The first part of BP, in chapters 21 to 24 totalling 520

¹ विषुवान् दिवाकीर्त्यम् । यथा शालायै पक्षसी । एवं संवत्सरस्य पक्षसी । यद्येते न गृहेरन् । विषुची संवत्सरस्य पक्षसी व्यवसंसेयाताम् । आतिमारुह्युः । यद्येते गृह्यन्ते । यथा शालायै पक्षसी मध्यमं वंशमभिसमायच्छति ॥ TB (1.2.3).

² सूर्यो योनिर्वै कालस्य तस्य एतद्रूपम् । यन्निमेषादि कालात्संभृतं द्वादशात्मकं वत्सरम् । एतस्याग्नेयमर्धमर्धं वारुणम् । मघाद्यं श्रविष्ठार्धमाग्नेयं क्रमेणोत्क्रमेण सार्पाद्यं श्रविष्ठार्धान्तं सौम्यम् । तत्र एकैकमात्मनो नवांशकसचारकविधम् ॥ MAU (6.14).



verses presents this Purāṇic astronomy that must have been formulated before the Common Era. The intention here is not to critically assess or discuss the ancient Purāṇic cosmography and the geocentric geometric models used to explain the apparent movement of sun and other celestials. Readers interested in the interpretation and limitations of such models are referred to Thompson (2007) and Das (2018). Our primary focus here is to analyze the stated observation of equinoctial full moon in fractional *nakṣatra* sectors and trace them to the *maghādi* epoch as stated in MAU.

The 21st Chapter of BP titled *āditya-vyūha-kīrtanam* in 176 verses gives an account of the southern and northern *ayana* (lateral motion) of sun with description of seasons, in a colourful poetic style. There are a few statements here and there that cannot be easily understood due to lack of context in the currently available publications. Equally well, there are statements that are realistic, valid and hence of interest in understanding the growth of natural sciences in India. Among these are the six seasons with names inherited from past, but curiously enough *viṣuvat* day being in the center of the spring and autumn seasons unlike in the Vedic texts. Reference to *viṣuvat* as equinox event appears twice in this chapter of BP. After mentioning that the day light varies with the *ayana*, the text mentions a day that is of fifteen *muhūrta* duration. On such a day, it is said not only the day and night are equal, but moon acquires its digits equally in day and night.³ The five-year cycle of sun is stated to be made of 1830 sun rises. The solar year is said to be made of two *ayanas* and six seasons each of 61 days. After a few verses sun is said to attain uniform or medium speed at the middle of spring and autumn. Once again moon is referred, but quite clearly to be associated with *viśākhā* and *kṛttikā* asterisms. The text and translation follows:

शरद्वसन्तयोर्मध्ये मध्यमां गतिमास्थितः ।
 अतस्तुल्यमहोरात्रं करोति तिमिरापहः ॥
 हरिताश्च हयादिव्याः तस्य युक्ता महारथे ।
 अनुलिप्ता इवाभान्ति पद्मरक्तैर्गभस्तिभिः ॥
 मेषान्ते च तुलान्ते च भास्करोदयतः स्मृताः ।
 मुहूर्त्ता दश पञ्चैव अहोरात्रिश्च तावती ॥
 कृत्तिकानां यदा सूर्यः प्रथमांशगतो भवेत् ।
 विशाखानां तथा ज्ञेयश्चतुर्थांशे निशाकरः ॥
 विशाखायां यदा सूर्यः चरतेऽंशं तृतीयकम् ।
 तदा चन्द्रं विजानीयात् कृत्तिकाशिरसि स्थितम् ॥
 विषुवं तं विजानीयादेवमाहुर्महर्षयः ।
 सूर्येण विषुवं विद्यात् कालं सोमेन लक्षयेत् ॥
 समा रात्रिरहश्चैव यदा तद्विषुवद्भवेत् ।
 तदा दानानि देयानि पितृभ्यो विषुवेषुच ॥ (Ch. 21 v.143–149).

³ शरद्वसन्तयोर्मध्ये मध्यमां गतिमास्थितः । अहोरात्रे कलाश्चैव समं सोमः समश्नुते ॥ (Ch. 21.124).

Here and elsewhere the *Brahmāṇḍa Purāṇa* (ed. KV Sharma) Krishna Das Academy, Varanasi is followed.

*śaradvasantayormadhye madhyamām gatimāsthitaḥ ।
 atastulyamahorātram karoti timirāpahaḥ ॥
 haritāśca hayādivyāḥ tasya yukta mahārathē ।
 anuliptā ivābhānti padmaraktairgabhastibhiḥ ॥
 meṣānte ca tulānte ca bhāskarodayataḥ smṛtāḥ ।
 muhūrttā daśa pañcaiva ahorātriśca tāvatī ॥
 kṛttikānām yadā sūryaḥ prathamāṃśagato bhavet ।
 viśākhānām tathā jñeyaścaturthāṃśe niśākaraḥ ॥
 viśākhāyām yadā sūrya carateṃ'saṃ tṛtīyakam ।
 tadā candram vijānīyāt kṛttikāśirasi sthitam ॥
 viṣuvam taṃ vijānīyādevamāhurmaharṣayaḥ ।
 sūryeṇa viṣuvam vidyāt kālam somena lakṣayet ॥
 samā rātrirahaścaiva yadā tadviṣuvadbhavet ।
 tadā dānāni deyāni pitṛbhyo viṣuveṣuca ॥*

Sun being in normal (medium) speed at the middle of *śarata* (autumn) and *vasanta* (spring) makes the day and night to be equal. The yellowish divine horses of his chariot shine as if painted by lotus-red coloured rays. At the end of *meṣa* and *tulā* (*rāśi*/months) from sunrise, the day is fifteen *muhūrta* long; so is the night. When the sun is in the first *amśa* (quarter) of *kṛttikā*, it has to be understood that the moon is in the fourth *amśa* of *viśākhā*. When the sun moves in the third *amśa* (quarter) of *viśākhā*, then moon has to be known to be at the head (beginning) of *kṛttikā*. This has to be understood as the equinox day; so it has been said by the sages. From the sun one should know the *viṣuva* (day) and the time observed from the moon. When the *viṣuvat* happens, day and night are of the same duration. Then charities are to be offered for (pleasing) the manes.

The *purāṇa* bringing up the equinox definition twice within about twenty verses raises the doubt that the text might have been edited for some purpose. The mention of solar *rāśi* (months) named *meṣa* and *tulā*, that were not popular before Common Era adds to this doubt. While this verse might have been added later, it seems to have been done with a purpose to assert that the day and night should be of fifteen *muhūrta* at the equinoxes. The next verse does not sound modern as it is about sun and moon in *nakṣatra* parts and not in the *rāśi* (sign) of later texts. Since the equinox is asserted to be at the middle of the *vasanta* and the *śarad* seasons, the words *meṣa* and *tulā*, whether they refer to solar months or *rāśi* names (signs) are of no consequence to the present study. The observation of the equinoctial full moon near the two unambiguously recognizable stars and within their eponymous sectors is amenable for archaeo-astronomical analysis.

3 Equinoctial full moon

The BP text quoted above clearly takes equinoctial sun to be at the quarter point of the *kṛttikā* sector when moon would be at the third-quarter of the *viśākhā* division. The asterism



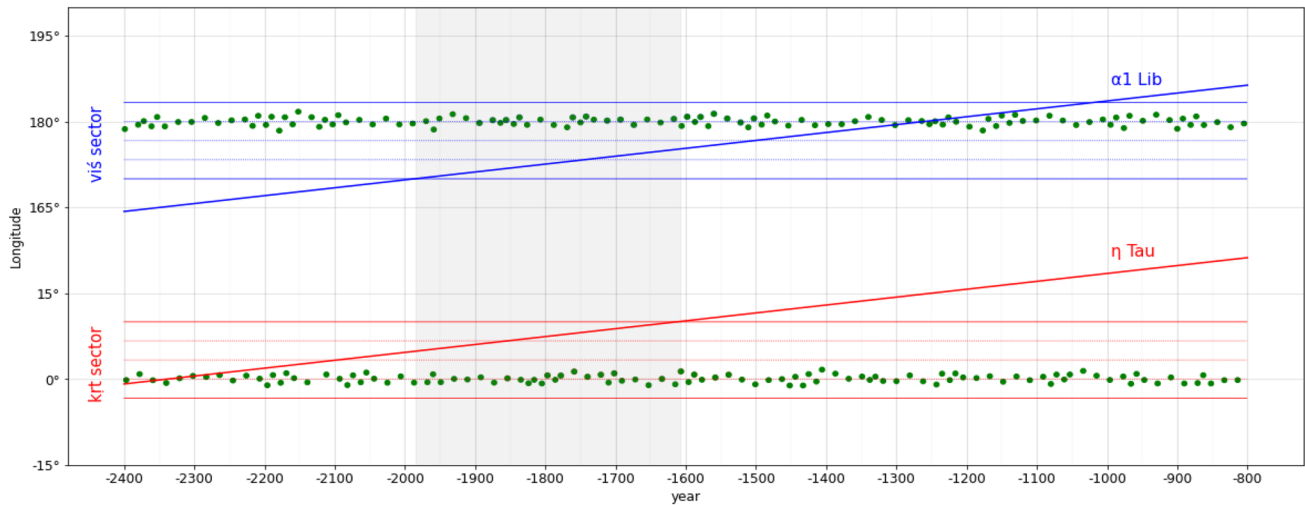


Fig. 1 Full moon points around 180° longitude with sun at 0° longitude (*vasanta*/spring equinox) are marked in the *visākhā* sector. Full moon points around 0° longitude with sun at 180° longitude (*śarat*/autumn equinox) are marked in the *kṛttikā* sector. Red and blue lines show the variation in longitude of the stars *kṛttikā* (η -Tau) and *visākhā* ($\alpha 1$ -Lib) due to precession of the equinoxes

kṛttikā is made of six stars that are compactly clustered and hence can be represented for practical purposes by η -Tauri. Similarly, *visākhā* with two close stars can be treated as $\alpha 1$ -Librae. These two prominent visible stars are separated in longitude by 165° . However, in the equal *nakṣatra* model, when the ecliptic is divided into twenty-seven equal parts with names ascribed as per the standard sequential order of the twenty-seven asterisms, the $\frac{1}{4}$ -*kṛttikā* and $\frac{3}{4}$ -*visākhā* points are always exactly 180° apart. Since BP text mentions moon to be at $\frac{3}{4}$ -*visākhā* when sun is at $\frac{1}{4}$ -*kṛttikā*, this event can be surmised to be the observation of the spring equinox FM rising or setting closer to sun set or sun rise, respectively. Subsequently, after about six months when sun is in the third part of *visākhā*, moon is said to be at the head or the first part of *kṛttikā*. This is not as sharp a statement as the first one but is realistic enough to be a naked eye observation of an autumnal FM observed near the visible star *kṛttikā*. It may be noted that *kārtika-pūrṇimā* and *vaiśākha-pūrṇimā* are important even now in the Hindu religious and socio-cultural calendar but have no special relation to the equinoxes. This fact underscores the chronological importance of the BP observations, when the solar equal *nakṣatra* zodiac was invoked to mention the position of full moons, visibly associated with the two important stars.

The possibility of the equinoctial FM in the indicated *nakṣatra* sectors can be found out by computer simulation of a time series of full moons. This exercise has been carried out for the years -2400 to -800 using the Astropy library algorithms.⁴ The FM data thus obtained is sieved to select only those that are on the equinoctial days when sun is at

0° or 180° longitude with an error of two degrees on either side. Since the accuracy of the BP text is of the order of $\frac{1}{4}$ -*nakṣatra*, the above error limit is found necessary to pick up equinoctial FM with observational error of about three days. This results in about 220 such FM, hovering around 0° and 180° longitude. In Fig. 1, these simulated results are shown for further discussion. The BP text is clear that the spring equinox should correspond to $\frac{1}{4}$ -*kṛttikā* and on the other side it should be $\frac{3}{4}$ -*visākhā*. This partition helps us to mark the particular epochal *nakṣatra* sector of *kṛttikā* as ($-3^\circ 20'$, 10°) and of *visākhā* as (170° , $183^\circ 20'$) in longitude.

Observation of FM near the stars *kṛttikā* or *visākhā* in a year is not at all rare. But FM on or close to the equinoctial day is not that frequent. The simulated results show that there will be about fifteen such events per century. Thus, the rationale behind the BP text can be taken as observation of a few equinoctial FM near the two visible stars in their designated sectors. In Fig. 1, the locus of these stars *kṛttikā* (η -Tau) and *visākhā* ($\alpha 1$ -Lib) is indicated by red and blue lines, incorporating the effect of precession of the equinoxes. The *nakṣatra* sector concept was an ancient Indian artifice for keeping track of the passage of time when the named star was visible to naked eye and could be associated for a few days with a solar or lunar event of interest. In Fig. 1, it is seen that star *visākhā* enters its assigned sector by 1980 BCE whereas star *kṛttikā* leaves its eponymous *nakṣatra* sector by 1610 BCE. Hence, the BP statement could have been possible anywhere in this wide window of nearly four hundred years, shown shaded in the above figure. However as pointed out before, the spring equinox statement is more specific than the other one. Thus, one may argue that FM observations nearer to star *visākhā* should be treated as more reliable. With this rider, 1700–1600 BCE will be a

⁴ Astropy Collaboration et al. (2022), Astropy Paper III (v5.0), A&A, 658, A5 <https://arxiv.org/abs/2206.14220>.



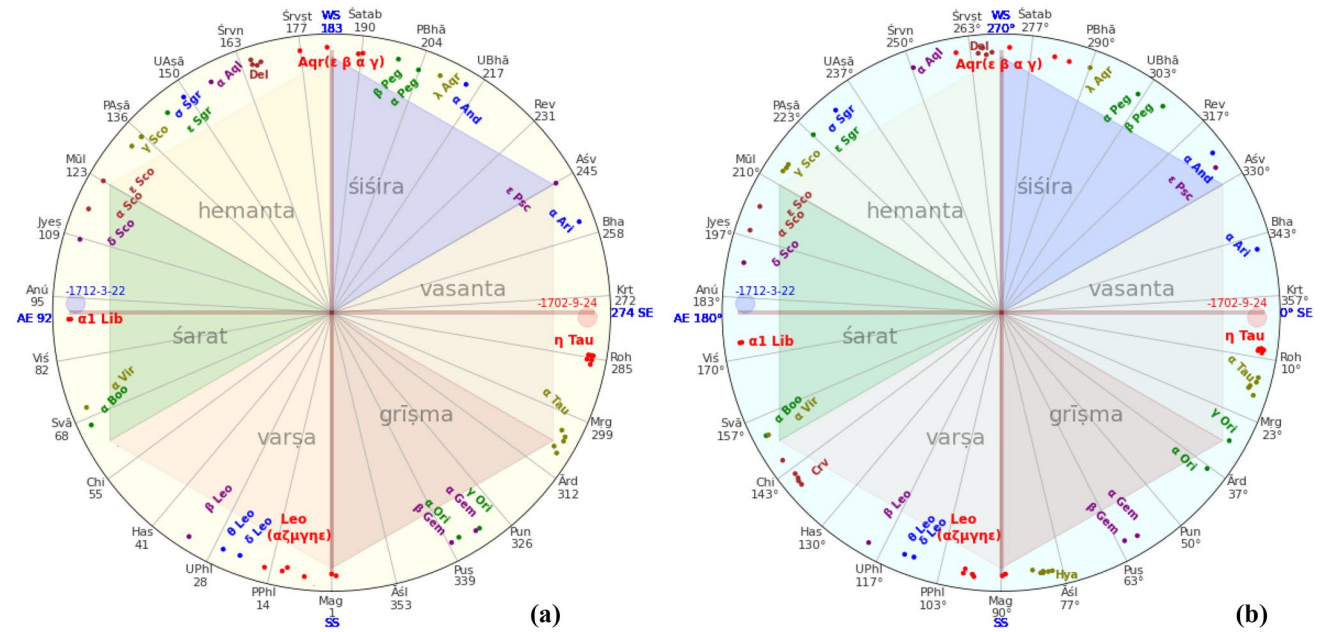


Fig. 2 a, b Dial plot of the 27 *nakṣatra* sectors, each 13(5/9) days long, super posed on the invariant N-S axis defining the beginning of the *śiśira* *ṛtu* (WS) and the *varṣa* *ṛtu* (SS) as in the Vedic MAU. The E-W axis bisects the centre of the *vasanta* (SE) and *śarat* *ṛtu* (AE) domains as in the *Brahmāṇḍa Purāṇa*. a The number of days counted from the summer solstice day to the beginning of each *nakṣatra* sector is marked clockwise in the left figure. As an example, sector visibility of select stars is shown for the year -1700. b The ecliptic is divided into 27 equal parts named as per the *nakṣatra* sequence, in terms of longitudes from the spring equinox point to show the spread of some stars along the ecliptic. Two sample equinoctial FM are shown with their dates as in the civil calendar. The dates JD: 1095845.56 (-1712-3-22) and JD:1099683.53 (-1702-9-24) correspond with (-1712-4-6) and (-1702-10-9) respectively in the stellarium software

conservative estimate for the chronological footprint in BP of a bygone era of astronomical observations. The *Purāṇa* text is silent about other *nakṣatra* sectors and the solstices while mentioning about the FM. But it can be demonstrated that *kṛttikā*-¼ being the equinoctial day is same as the winter solstice being at *śraviṣṭhā*-½ as in the Vedic MAU.

4 Maghādi scheme

The BP text from a critical study of its content can be understood to have acquired its present scriptural form in the early centuries of CE. But as pointed out above (Sect. 2) the *Purāṇa* describes ancient astronomical models and observations. The above description of equinoxes, FM and *nakṣatra* sectors demonstrate cultivation of astronomy in India prior to the astronomical works of Parāśara, Vṛddhagarga and the calendar formulae of Lagadha. Quite consistently, the *Purāṇa* statement fits in with the Vedic *maghādi* scheme stated cryptically in MAU. This becomes clear in the dial plot of Fig. 2, which shows both the *Purāṇa* equinox line (SE–AE) and the Vedic solstice line (WS–SS) together. The corresponding invariant domains of the six seasons are also shown in the background. In this system the equinox line bisects the *vasanta* and *śarat* seasons as defined in BP. These two axes are

superposed on the twenty-seven equal *nakṣatra* sectors marked clockwise starting from the *grīṣma-varṣa* vertex taken to be the first point of the *maghā* sector. It is easily seen that the *kṛttikā*-¼ and *viśākhā*-¾ equinoctial days of the BP are separated by exactly 6¾ *nakṣatra* sectors from *maghādi*, the first point of the *maghā* sector, as required for the compatibility between the astronomical statements in the two texts. In Fig. 2a the leading edges of the *nakṣatra* sectors are marked in number of days counted to the nearest integer from the origin. The 183rd day from *maghādi* gets marked at the middle of the *śraviṣṭhā* sector as the winter solstice day and the formal beginning of *śiśira* *ṛtu*. Figure 2b has the same information as Fig. 2a, except the origin is at 0° longitude starting from the spring equinox point and the summer solstice corresponds to 90° longitude. The two figures depicting the equinoxes and solstices of BP and MAU, in terms of *nakṣatra* sectors and as longitudes are fully consistent. Thus one can surmise that the *maghādi* system, beyond reasonable doubt, must have been in vogue by 1800 BCE and followed further for a century or two.

The hitherto unsuspected temporal overlap between the two independent Sanskrit texts MAU and BP, brought out here for the first time, is a pointer to the existence of an ancient convention to follow the position of sun, in terms of *nakṣatra* sectors, starting from a fixed summer solstice point on the horizon. This inference brings up in its wake the question of



the cultural influence of *maghā nakṣatra* on the Vedic society and how the naked eye visibility of the stars of this asterism might have been taken to indicate the beginning of *varṣa ṛtu*.

5 Stars of *Maghā Nakṣatra*

Summer solstice or the rise of sun at the same north eastern point of the horizon for a few days in the yearly cycle would have been naturally observed and felt as a weather condition in terms of the daylight hours getting longer and longer and the intense heat giving way to rains. The fixed point of sun rise could have been remembered as a mountain peak or marked as a physical object pointing towards a star visible before sunrise, intuitively considered close to sun. Search for this in the ancient Vedic literature leads to the asterism *maghā* as the most probable candidate. MAU clearly refers to the start of the southern sojourn of sun as *maghādyam* which means the beginning of the *maghā* sector understood in terms of a star of the group. In the *nakṣatra-sūkta* of the *Atharva Veda*, *ayanam*, the lateral motion of sun is associated with the asterism *maghā*.⁵ In the ancient *nakṣatra* rites of the *Yajurveda*, offerings to this constellation are enjoined on six bowls⁶ harmonising with the number of recognized stars.

Starting from the *Rgveda* (RV) the asterism *maghā* (*aghā*) is always cited in plural, hinting that to be a sky part, made up of more than one star. In this connection the laudation of Indra as *Maghavān* stands out conspicuously in RV. In its ritualistic context the word *maghā* is usually interpreted as wealth/ riches, but in the context of Indra's actions in the sky, *maghā* in all probability refers to an asterism of that name. Even though the Vedas are popularly said to be for and about performing sacrifices, the natural meaning behind the mystical hymns indicate Indra to be essentially an abstract entity or force having close affinity with sun, seasons, rhythms and time. The Vedic ritual, philosophical and other exegetical traditions in India were always aware of this. For example, Yāska (c 1000 BCE?) points out the act of Indra drinking thirty lakes of Soma juice as in RV (8.77.4) to be an allegorical reference to moon's digits being absorbed for fifteen days and fifteen nights in the dark fortnight. Sāyaṅcārya (14th cent CE) in his commentary, besides explaining the ritualistic practices associated with this hymn paraphrases Yāska; *as per the authority of Nirukta Indra represents time*.⁷

Consistent with this interpretation, following the *Nirukta* of Yāska, killing of Vṛtra by Indra is understood by many primarily, as an allegory for releasing the waters from the dark clouds. One of the most important attribute of Indra

Maghavān is his power to induce rains at the right time by reducing heat, near about the summer solstice day. In RV extolling the extreme northern position of sun as Indra's highest station and Indra said to be causing sun to climb up the peak for longer visibility indicate events connected with the summer solstice.^{8, 9} Even though the appellation 'Maghavān' for Indra appearing in more than two hundred places in RV need not mean *maghā* to be an asterism in every context, there is clear reference in the tenth *maṇḍala* about Maghavān hitting Vṛtra by the *maghās*.¹⁰ This can be interpreted as an indicator of the onset of rains when sun was in the *maghā* asterism. Sengupta (1947) pointed this out correctly but argued that this must be taken as the heliacal rise of α -Leonis in Kurukṣetra (30°N) around 4000 BCE. This does not stand to reason, since α -Leonis (Regulus) the brightest among the six stars of this asterism, was conjunct with sun as the summer solstice star around 2350 BCE. Without going into the intricacies of Vedic chronology, it is still reasonable to note that the broad picture of stationary sun rise at the summer solstice; the diffuse felt-weather border between the *grīṣma* and *varṣa* seasons with links to the *maghā* asterism has existed from the period of the *Rgveda*. This tradition of cultural astronomy may be inferred to have provided inspiration for the theoreticians among the star gazers (*nakṣatradarśa*) around 1800 BCE, to formalize a scheme for sun's yearly transit among the visible *nakṣatra* sectors. Further delineating the evolution of this through the *gavāmayana*, and different *atirātra*- and *ahargaṇa-yāga* rites as preserved in the voluminous *Brāhmaṇa* and *Śrauta* texts is beyond the scope of the present work. For our purpose it is sufficient to note that the *Nidānasūtra*, an ancillary *Brāhmaṇa* text (*anubrāhmaṇam*) of the *Sāmaveda*, explains an already existing definition of a year of 366 days as sun dwelling for 13(5/9) days in each of the *nakṣatras*.¹¹

Asterism *maghā* is well described and remembered by the Vedic, Jaina and other traditions as a group of six or seven stars anchored to the bright ecliptic star α -Leo (Regulus); the remaining five or six being above this star, together looking like the sketch of an enclosure (*koṣṭhāgāra*).¹² Visible

⁸ इन्द्रो दीर्घाय चक्षस आ सूर्यं रोहयद्वि वि गोभिः अद्रिमैरयत् ॥ (RV 1.7.3).

⁹ The chanters hymn thee, they who say the word of praise magnify thee. The priests have raised thee up on high, O Satakratu, like a pole. As up he climbed from ridge to ridge and looked upon the toilsome task, Indra observes this wish of his, and the Rain hastens with his troop. (RV 1. 10. 1–2. Translation by R. V. Griffith).

¹⁰ इन्द्रो मघैः मघवान् वृत्रहा अभुवत् ॥ (RV 10.23.2).

¹¹ स एष आदित्यसंवत्सरो नाक्षत्रः। आदित्यः खलु शश्वदेतावद्विरहोभिर्नक्षत्राणि समवैति। त्रयोदशाहं त्रयोदशाहमेकैकं नक्षत्रमुपतिष्ठति। अहस्तृतीयं च नवधा कृतयोरहोरात्रयोर्द्वे द्वे कले चेति संवत्सराः। ताश्चत्वारिंशच्चतुःपञ्चाशतं कलाः। ते षण्णववर्गाःसषट्ष्टिंशतः॥ (*Nidānasūtra* 5.12).

¹² The *Sūrya-candraprajñapti* of the Jaina tradition counts seven stars in *maghā* asterism looking like *prākāra*.

⁵ पुनर्वसू सूनुता चारुपुष्यो भानुराश्लेषा अयनं मघा मे ॥ (*Atharva Veda Samhitā*; 19.7.2b).

⁶ मघाभ्यः पुरोडाशं षट्कपालम् ॥ Tai. Br. (3.1.4).

⁷ नैरुक्तप्रसिद्ध्या तु कालाभिमानो इन्द्रः ॥ (*Sāyaṇa Bhāṣya* RV 8.77.4).



nakṣatra maghā made up of six stars can be identified as the group (α , ε , ζ , η , γ , μ Leo).

6 *Maghādi* epoch

The *Vṛddhagārgīya Jyotiṣa* (VGJ) includes a section called *Mahāsālilām*, in archaic prose, in the form of a set of questions followed by answers. One of the questions is about which star, day, month, season should be considered as the first one for counting. This must have been an important doubt, as it is even now, since any point can be considered as the origin on a circle and hence for practical purposes a convention has to be agreed upon. This is answered in a string of statements covering both the short and the long cyclic measures. For our limited purpose here, it is noted that *kṛttikā* is said to be the first one for work (rites and rituals); *śraviṣṭhā* (is the first) for keeping count of the eastern rise point (*lagna*); and *maghā* (is the first) among solar asterisms.¹³

Apart from the previous analysis of the *Purāṇa* and Vedic texts, the statement *maghā sauryānām*, in VGJ is evidence for the formal *maghādi* system of solar *nakṣatra* zodiac to have been in vogue around 1800 BCE with the four cardinal sectors having visible stars of the same name. The remaining sectors might have contained known stars or they might have remained namesake *nakṣatra* with corresponding stars rising/setting in the adjacent sectors. For purposes of illustration, year – 1700 is chosen to show the visibility of a few asterisms, identified in terms of their modern names. In Fig. 2a the earliest visibility of the selected stars in the morning or evening twilight, keeping sun 8° or 6° below the horizon, is marked using the stellarium software. The results shown are in terms of approximate number of days from the first point of the *maghā* sector. The well recognized stars α 1-Lib and η -Tau (Pleiades) are seen to be confined to their eponymous sectors for the corresponding equinoctial FM to be known after these visible stars as *vaiśākhī* and *kārtikī*.

In Fig. 2b the year – 1700 is divided into twenty-seven parts in terms of longitudes but marked with the same *nakṣatra* names. This is shown to bring out the differences in characterizing solar *nakṣatras* in terms of their sector visibility days as against their longitudes. The longitudes of the six stars (α , ε , ζ , η , γ , μ Leo) stay in the interval (90°–103°20′) not only in the above year but till about 1400 BCE. The specific star reckoned as *maghādi*, the visibility of which seems to have indicated the first day is estimated to be ε -Leo. The stellarium software, for the year – 1700

(1701 BCE) shows this star to be visible early in the morning at Kurukshetra, a few days after the actual summer solstice on 9th July. All the six stars of *maghā*, the last one being Regulus, would have been progressively visible by 27th July early in the morning, near about the same azimuth as the point of sun rise. During this period of nearly twenty days, the azimuth of the point of sun rise is almost stationary at $62^\circ \pm 0.5^\circ$. However, a few days before 9th July the bright stars γ , α and even ε -Leo would have been visible in the west, just after sun set, giving an opportunity for the *nakṣatradarśa* astronomers to bracket the onset of sun's southern sojourn (*dakṣiṇāyana*) and the start of the rainy season (*maghādi varṣa ṛtu*) with an error of about three days. It may be noted here that if year – 1800 were to be selected as an example the fit in the cardinal sectors for the named stars would be better.

That the rainy season should have been taken as the start of the civil calendar year in the remote past when sun was in *maghā nakṣatra* need not be surprising. The subcontinent has remained always heavily dependent on seasonal rainfall. Two of the Sanskrit words *varṣaḥ* (rainfall) and *abdaḥ* (water giver) used popularly to mean *Year* in Indian languages even now, primarily referred to the start of the rainy season in ancient times.

7 *Śraviṣṭhā Nakṣatra*

It has been pointed out that the *maghā* asterism with its connection to summer solstice has had a long memory before the formulation of the *maghādi* scheme. On similar lines, the ancients would have recognized the cold weather and the short days nearly six months later, when sun rise happened at nearly the same point towards the south eastern corner of the horizon. The statement about sun being in a particular *nakṣatra* sector at the solstices is due to the observation of sun rise at the same azimuth but with new stars appearing close to the point of sun rise. Thus, it is reasonable to expect *śraviṣṭhā* to be configured with several stars, visible sequentially over a period of ten days or more, in the proximity of sun. stars of the Aquarius constellation answer to this picture. In Fig. 2a the *śraviṣṭhā* sector in the year – 1700 starts on the 176th day, when star ε -Aqr would have risen clearly. Four stars of the Aquarius constellation get assigned to this sector, the bright star β -Aqr being visible in the evening nearer the 183rd day. Yajurveda texts refer to this asterism in plural as *śraviṣṭhāḥ*. The Atharvaveda in the famous *rātrisūkta* (Night hymn) poetically describes the rising of *śraviṣṭhāḥ* in the night¹⁴ which seems to be an observation in the evenings around the summer solstice when the stars

¹³ तेषां च सर्वेषां नक्षत्राणां कर्मसु कृत्तिकाः प्रथमम् आचक्षते। श्रविष्ठा तु संख्यया पूर्वलग्नानाम्। अनुराधं पश्चिमनिघ्नानां। रोहिणी सर्वनक्षत्राणां। मघा सौर्याणां। भोग्यानां चार्यमा सर्वासां च षड्राशीतानाम् आदिः श्रविष्ठा ॥ (*Mahāsālilādhyāya*, VGJ).

¹⁴ अतिविश्वान्यरुहत् गंभीरो वर्षिष्ठमरुहन्त श्रविष्ठाः ॥ (AV 19.49.2a).



of the *maghā nakṣatra* were setting. *Śraviṣṭhā* asterism is invoked in TB as composed of four goddesses belonging to the *Year* and arriving from south.¹⁵ This can be taken as an indication of *śraviṣṭhā nakṣatra* being linked with the winter solstice.

In the *maghādi* epoch the well attested asterisms, *kṛttikā*, *maghā* and *viśākhā* identifiable with their modern nomenclatures get placed in their respective cardinal sectors both in terms of visibility days and longitudes. The stars of the Aquarius constellation fit in with the *śraviṣṭhā* sector for visibility, but in longitudes they start spilling over to the next sector. The stars of constellation Delphinus, that were visible already by the 164th day in the *śravaṇa* sector (Fig. 2 a) fall into the *śraviṣṭhā* sector (Fig. 2 b) in terms of longitudes.

8 Discussion

The year – 1700 chosen here is only an example to show primarily the positions of the visible cardinal stars vis-à-vis their sectors. It is obvious that these positions would have changed slowly due to precession. If we go forward towards the year – 1300, proximate visibility of *maghā* early in the morning, near the farthest northern point of sun rise on the horizon becomes vague if not totally lost. Perhaps due to this and other cultural reasons, the *Parāśara Tantra* (PT), the *Vṛddhagārgīya Jyotiṣa* (VGJ) and Lagadha's *Āra-Yājuṣa Jyotiṣa* have taken the stationary sunrise at the extreme southern azimuth as the year marker. These texts use the equal *nakṣatra* scheme when the first point of the *śraviṣṭhā* sector coincided with the winter solstice day, same as the beginning of *śiśira ṛtu*. The relation of this *śraviṣṭhādi* scheme with its predecessor can be understood in Fig. 2, by keeping the cardinal points and season boundaries invariant but rotating the outer dial of sector names clockwise such that the start of *śraviṣṭhā* sector coincides with the *hemanta-śiśira* vertex. This makes, the spring and the autumn equinoxes to correspond with $\frac{3}{4}$ -*bharaṇi* and $\frac{1}{4}$ -*viśākha* respectively. In this system summer solstice will correspond to $\frac{1}{2}$ -*āsleṣā*, whether or not the named star rises near the sunrise point around the summer solstice day. The precession of the equinoxes by 6°40' indicates passage of 480 years between the *maghādi* and the *śraviṣṭhādi* zodiac schemes. This will alter the visibility conditions and the longitudes of the concerned stars supposed to be related to the corresponding older sectors.

Both PT (Iyengar 2013) and VGJ state the six seasons of a year in terms of the transit of sun through specified $4\frac{1}{2}$ *nakṣatra* sectors, each of 61 days, starting from *śraviṣṭhādi*

or the first point of *śraviṣṭhā* sector. In the above texts visible *nakṣatras* are assembled with multiple stars such that eighty-three or eighty-four visible stars make up the 27 asterisms. PT and VGJ are more matter of fact and have modified past methods to match with their observations of the seasons. It is likely, star ϵ -Aqr would have served as the fiducial star of the *śraviṣṭhā* sector for some years even after the starting point of the solar year was shifted from the northern standstill sunrise to the southern standstill of sun; same as the winter solstice or the start of the northern travel of sun (*udagayanam/uttarāyanam*).

However, there are some issues with the identification of the first (*ādi*) star of the *śraviṣṭhā* sector that is important mainly for the calendar text of Lagadha. These have been discussed with alternate possibilities of taking β -Aqr or β -Del as the first star while analysing the *ādityacāra* chapter on sun's transit in VGJ to demonstrate that the stated observations of the seasonal stars, assigned to their respective sectors, would be valid with minimum error for the epoch of 1300 BCE (Iyengar & Chakravarty, 2021). This is in harmony with the *maghādi* solar *nakṣatra* scheme demonstrated to have been prevalent in India around 1800–1600 BCE. This result is of historical importance as this system predates by four to five centuries the much discussed *śraviṣṭhādi* later known as *dhaniṣṭhādi* scheme of Lagadha (Abhyankar, 1991; Gondhalekar, 2013; Sastry, 1984) usually propagated as the original Vedic calendar.

9 Conclusion

A tendency to describe sky observations allegorically along with a predisposition to associate numbers with visible objects and to count words and syllables is widely recognizable in Vedic texts. The solar standstills and seasons are characterised in poetical language in the *Rgveda* and contextually ritualised with the number twenty-one in the ancillary texts. Efforts at making the annual passage of sun, between the two extreme points on the eastern horizon, more structured using the visible stellar background takes one to the very genesis of matter-of-fact Indian astral sciences. The two asterisms *maghā* and *śraviṣṭhā* are addressed in plural, indicating a sequence of stars to be associated with sun at the northern standstill and the southern standstill point for about 15–20 days. It is probably the perceived slowness of sun that has lead later astronomers to the concept of sun dwelling in the above two asterisms made up of multiple stars. This is clearly reflected in the MAU where the solstices are linked to the *maghā* and the *śraviṣṭhā* group of stars, with a further measure assigned to them in terms of four quarters. Start of the *ayana* of sun from the first point of *maghā* to $\frac{1}{2}$ -*śraviṣṭhā* and back, implies a year of twenty-seven equal *nakṣatra*

¹⁵ चतस्रो देवीरजराः श्रविष्ठाः[...] संवत्सरीणममृतं स्वस्ति [...] दक्षिणतो अभियन्तु श्रविष्ठाः || (TB III.1.2.6–7).



sectors of 13 (5/9) days each. Each *nakṣatra* is considered to have four parts such that the complete stellar circle is made of 108 parts, foreshadowing the modern ecliptic longitude measure.

Since sun rise is nearly stationary at the solstices naked eye observation of the associated *nakṣatra* is possible early in the morning with a level of confidence, but such will not be the case at the equinoxes where sun moves fast. In this regard, considerable development is seen in chapter twenty-one of the *Brahmāṇḍa Purāṇa*, where equinoxes are defined in terms of day and night being equal to fifteen *muhūrtas*. Some type of instrument like an outflow water clock (*nāḍikā*) might have existed to measure time within a day. The statement about the equinoctial day as $\frac{1}{4}$ -*kr̥ttikā* and the FM on that day to be exactly opposite at $\frac{3}{4}$ -*viśākha*, shows considerable sophistication in combining observation and theory. Detailed computer simulation of past equinoctial FM (2400–800 BCE) as per modern astronomical theories shows that the period of the *Brahmāṇḍa Purāṇa* statements match with 1980–1610 BCE. That the *Purāṇa* follows the Vedic *maghādi* scheme is a sign of progress in astronomy centuries before the calendar text of Lagadha. Synchronization of the four important solar events in terms of *nakṣatra* and correct alignment of the equinoctial full moon represents a science cultivated in terms of both observation and theory. It may be mentioned in passing that Koch (2014) has analyzed the BP statements by a different method using the precession value known as *Lahiri-ayanāmsā* in present day Hindu calendar astronomy. As per this method it is found that the equinoctial FM of BP is dateable to 1885–1645 BCE. This result satisfactorily matches with the more detailed simulation undertaken in the present paper. The results presented in Figs. 1 and 2 demonstrate that the late Vedic text MAU and the *Brahmāṇḍa Purāṇa* taken together represent an important central period of Indian astronomy *circa* 1800 ± 100 BCE. The two texts match perfectly in their cardinal sectors pointing towards the origin of their science to the same source, which can be inferred to be the early Vedic astronomical tradition.

The investigation undertaken in this paper broadly shows that, in addition to the untapped wealth of manuscripts (Srinivas, 2019), Vedic texts and some of the *Purāṇas* more ancient than the *Viṣṇudharmottara* should be seriously treated as containing hidden source material for mapping the history of Indian astronomy and mathematics before the advent of *siddhānta* astronomy in the early centuries of the Common Era.

Acknowledgements The study reported here is supported by the Ministry of Education, Govt. of India, under the IKS Center Scheme Project: AICTE/IKS/CENTER-1/2021-22/02.

References

- Abhyankar, K. D. (1991). Mis-identification of some Indian *nakṣatras*. *Indian Journal of History of Science*, 26(1), 1–10.
- Das, P. (2018). *Bhāgavata Cosmology*. Tulsi Books, Mumbai.
- Gondalekhar, P. (2013). *The time keepers of the Vedas*. Manohar. [ISBN 978-81-7304-969-9].
- Iyengar, R. N. (2013). *Parāśara Tantra* (Ed. Trans & Notes). Jain University Press. [ISBN 978-81-9209-924-8].
- Iyengar, R. N. (2016). Astronomy in Vedic texts, (Book Chapter pp.107–169). *History of Indian Astronomy A Handbook*, (Ed. K.Ramsubramanian, A.Sule &M. Vahia), Publ. by IITB and TIFR, Mumbai.
- Iyengar, R. N., & Chakravarty, S. (2021). Transit of sun through the seasonal *nakṣatra* cycle in the *Vṛddha-Gārgya Jyotiṣa*. *Indian Journal of History of Science*, 56(2), 159–170.
- Koch, D. (2014). *Astronomical dating of the Mahābhārata war*. Erlenbach, Switzerland. (https://www.gilgamesh.ch/KochMahabharata6x9_V1.00.pdf)
- Sastry, T. S. K. (1984). *Vedāṅga Jyotiṣa* of Lagadha. *Indian Journal of History of Science*, 19(4), 1–74.
- Sengupta, P. C. (1947) *Ancient Indian Chronology*. Univ. of Calcutta.
- Srinivas, M. D. (2019). The untapped wealth of manuscripts on Indian astronomy and mathematics. *Indian Journal of History of Science*, 54(3), 243–268.
- Thompson R. L. (2007). *The Cosmology of the Bhāgavata Purāṇa* (Indian Edn.) Motilal Banarsidass, Delhi.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.



Lecture-9

Era of Vedāṅga Jyotiṣa

Introduction

It is said that Vedic people did not have a solar zodiac (that is tracking sun in the background of the stars) but depended only on nakṣatras as lunar mansions. This is far from the truth. We have seen that MAU states observation of sun rising at the summer solstice in the *maghā nakṣatra*. The number of sunrises from solstice to solstice was counted as 183 and year as 366 equally distributed among the 27 nakṣatras; each nakṣatra being further divided into four quarters. These were the sectors or sky parts in which the visible figure of the stars was contained. We have seen previously (Lecture-2) that the cosmic constant 15 was associated with Prajāpati as the visible moon so that both the *amāvāsyā* and full moon states were known as *pañcadaśī* that is, Fifteenth. Even though, watching the sky in the night may be pleasant, tracking the fast and changing moon is not easy.

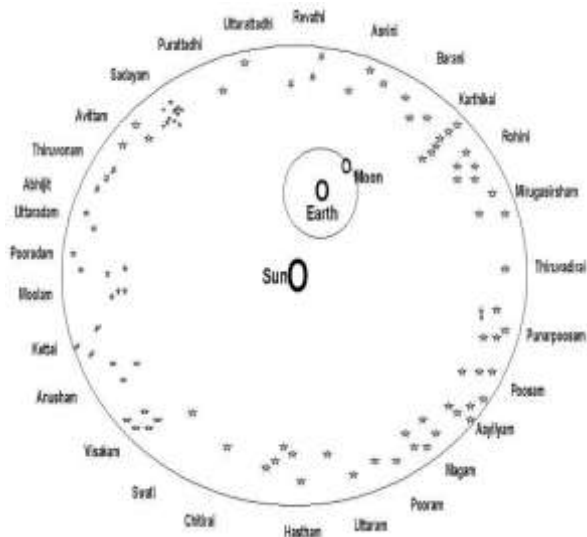
Lunar Cycle

Observation of moon can be done in two different ways in the night sky. The first is FM to FM and observe the changes in the shape (phases) of moon. The second is to note the *nakṣatra* background of moon.

Full Moon to Full Moon = 1 *māsa*; but how to reckon this? The natural answer is count the number of days; that is sunrise-sunrise or sunset-sunset. But there is a catch. On FM evening when FM rises in the east, sun may not exactly set. Some seasons sun is yet to set and at others sun has already set. If we count the days as integers we find it would be 29 or 30. If this is counted for two FM-FM cycles, the day count would be nearly 59; neither 58 nor 60. So we have to make a choice about the number count in a *māsa* as an integer. Over a period, this got accepted as one month (FM to FM or NM to NM) equal to 30 *tithi*. *In terms of days this will be nearly 29½ ahorātra. This is the synodic cycle in modern astronomy = 29.53059 days.*

In the second type of observation, we start to observe full moon very near a bright star say *chitra* (star *spica*). Moon will be seen near the same point in the sky (that is completing 360 degrees) after nearly 27 days, but not in full-moon form. This cycle is the nakṣatra cycle equal to $\sim 27\frac{1}{3}$ days (27.3216 modern value). The 'day' count had to be w.r.t sunrise only or the '*ahargana*' from a particular day. For naked eye observation, the fraction means daytime invisibility. Hence, we surmise that our ancients observed moon long enough (at least for 82-83 days) for moon coming close to *chitra* star in the night again. This seems to be the reason for ancient texts to take 83-86 stars for marking the 27 *nakṣatra* sectors. Since there are two cycles associated with FM it would be natural to wonder, whether FM occurs at the same starting star (*chitrā* in our case) again. Indeed, this happens at the beat period of the two cycles

$$(29.5 \times 27.3) / (29.5 - 27.3) = 805.35 / 2.2 = 366.06 \text{ days (nearly the N-S-N } ayana \text{ of sun)}$$



Note: This figure illustrates the difficulty in observing moon correctly in the star background. The star names in this figure are modern Tamil equivalents of Sanskrit names. The star numbers are also modern, not of the Vedic period.

There are two *ayanas* in a Year, for Sun. Similarly, there are two *pakshas* in a *Month* for Moon. There are contrasts too. For example, sun's lateral movement matches with seasons (*ṛtu*) felt by everyone. So Year can be divided depending on the seasons. In India by long observation seasons are decided as six in number. Hence in the vedāṅga period each season was taken to be of 61 days. If we take each *ṛtu* to be of 2 months a solar month will have 30½ days. We have seen that FM-FM month is only 29 ½ days. If 12 such months are counted as 'year', we get 354 days; 11-12 days short of sun's *N-S-N* year.

The FM-FM month was convenient for lay people since moon's shape and shine could be observed directly to make at least a guess of its size and the day *count* within the *śukla/kṛṣṇa pakṣa*. The nakṣatra background was not essential, but could be known for FM. If remembered this would have certainly added to the memory of the observation within a past month of the year and to estimate the days to the next FM. However, the limitation of the lunar year of 354 days was that the *ṛtu* lengths which depend entirely on sun, got disturbed. For agriculture and food supply the season of rainfall (*varsha ṛtu*) was the key, even as it is now. To synchronize the moon and the sun cycle over a period of one solar year, 11 days had to be added to the presumptive lunar year of 12-FM's. This is the problem of intercalation. Instead of adding every year the 11/12 days, one can add 2 months of 60 days in five years. Another choice was to add one month after every 2½ years. This is the origin of the *adhikamāsa* in *chāndramāna* (lunar) reckoning. VGJ and Lagadha's *vedāṅga* calendar explain this principle, which was practised from more ancient times in some manner as evidenced in the Vedic texts.



An elegant alternative is to maintain the fidelity of the seasons is by following the sun's solstice/equinox points with the morning visible *nakṣatras*. This is the *souramāna*. Intercalation can be avoided, without sacrificing moon's importance for rituals and cultural activities. But there is a catch: the visible stars (*nakṣatra*) will drift over long time roughly at the rate of one-*nakṣatra* in 900-1000 years. Whether the reason for axial precession was known or not, the effect of this drift was felt around 1500 BCE, as evidenced by

the *maghādi* five-year system from summer solstice of MAU and Mahāsalilam changing to the *śraviṣṭhādi* five-year system from winter solstice as stated by Parāśara, Garga and Lagadha.

The relation between solstices, equinoxes and the ṛtus was very well understood also in terms of day light variations and shadow lengths. The day light varied from 18 muhūrta at summer solstice to 15 at the two equinoxes but was 12 muhūrta at the winter solstice. Even the Purāṇas declared that the viṣuva day (equinox) occurs at the middle of the *vasanta* and *śarad* seasons. Further, on such viṣuva-day, the length of day and night are equal to 15 muhūrtas. This called for measurement of time within a day (not just the count of sunrises).

In the Vedic context, the above six seasons were equated to 12 months in the Taittirīya Samhita (4.4.11)

madhu-mādhava-> vasanta ṛtu; śukra-śuchi-> grīṣma ṛtu; nabha-nabhasya-> varṣa ṛtu
iṣa-ūrja-> śarad ṛtu; saha-sahasya->hemanta ṛtu; tapa-tapasya -> śiśira ṛtu

These are defined qualitatively in terms of portents and natural signs in the Taittirīya Āraṇyaka. When words such as *kārtikī*, *vaiśākhī*, *chaitrī*, *āśādhī*, *māghī pūrṇimā* are mentioned in the Vedas it referred to full moon near the cited *nakṣatra* and not to any “month name”.

In the Vedāṅga period, month names came into vogue depending on the full moon nakṣatra. Since, A month is 30 tithi long and a *pakṣa* is only 15, one can have a month starting from FM to end on FM, or have FM at the centre of the month, such that the month starts and ends on *amāvāsya*. Both, *amānta* and *pūrṇimānta* months came into use. It appears both soura and chāndra followers used same month names.

Jyotiṣa as Vedāṅga

It is natural to expect, as with the case of the *Nirukta*, help from *Jyotiṣa* texts that are genuinely *vedāṅga*, to unravel hidden sky pictures of the Vedic hymns that are obscure. At present the short *Āra- Yājñuṣa-jyotiṣa* (AYJ) which is a combined calendar text in about fifty verses, attributed to Lagadha is widely referred to as the unique *Vedāṅga Jyotiṣa*. This is an exaggeration except for chronological help in discriminating AYJ from later astral works appearing in the Common Era (CE) that are designated as *samhitā*, *siddhānta*, *horā* texts. The likely time of the above codified calendar of Lagadha has been determined to be in the period 1200-1400 BCE (Sastri and Sarma 1984). Due to such antiquity, one can take AYJ to reflect the *śraviṣṭhādi* (*nakṣatra*) calendar starting from the winter solstice day prevalent among the Vedic people in the above period. If the antiquity of a versified calendar scheme is any criterion for qualifying a text as *vedāṅga*, the works of Parāśara and Vṛddhagarga/Garga on natural sciences still available in parts, in a form similar to the Vedic *Brāhmaṇa* texts in prose, have far stronger claims to be recognized as repositories of the original *Vedāṅga Jyotiṣa*, not just limited to the calendar, but extending to a vast array of topics such as eclipses, comets, planets, atmospheric anomalies and Vedic astrology.

The prose text *Parāśara Tantra* (PT), known to us through quotations from later authors describes the position of sun with the nakṣatras in terms of a six-season solar zodiac. As per this, *śiśira ṛtu* started with sun at the beginning of *nakṣatra śraviṣṭhā*, and sun transiting 4½ nakṣatra space in a season of sixty-one days, completing the tropical yearly cycle of twenty-seven nakṣatra space in six such seasons amounting to 366 days. The asterisms associated with sun and visible to the naked eye near the beginning and end of each season are named. Ballālasena (12th cent.) quotes the ancient text and remarks that this sun’s transit was valid during the time of Parāśara. This time period can be shown to be 1350-1130 BCE without

assuming *śraviṣṭhā* to be same as the asterism named in later literature as *dhaniṣṭhā*, and in modern times generally identified with star β-Delphini.

[*Parāśara Tantra* (Reconstructed text, with translation and notes) by R.N. Iyengar, Jain University Press, 2013.]
We shall discuss this later.

Vṛddhagārgīya Jyotiṣa (VGJ)

Whereas for *Parāśara* we have to be satisfied with quotations by later writers, fortunately for *Vṛddhagarga* (VG) and his followers, several manuscripts known as *Vṛddhagarga Samhitā* (VGS) and *Garga Samhita* (GS) are available. But one faces a difficulty in knowing which among the texts listed in the manuscript libraries under the name *Vṛddha-Garga/-Gārgi/-Gargīya/-Gārgya* with and without the prefix *vṛddha/brhad* are on ancient astronomy and which are about *hora*, medieval astrology, Purāṇa or other topics.

[Please follow the *Mahāsalilam* book]

Interestingly, VGS manuscripts have a few chapters in prose as contrasted with other parts of the text in versified format. This anomaly hints at contributions belonging to different periods combined and preserved in the manuscripts. We find that the 24th *aṅga* titled *Mahāsalilam*, that is wholly in archaic prose similar to the Vedic *Brāhmaṇa* style, is the most ancient part of VGJ.

Contents of VGJ

The names of the sections as extracted from the manuscripts, that may not exactly match with the stated list of contents in the *aṅgasamuddeśa* chapter are as follows.

Aṅga (24): *Karmaguṇa, Candramārga, Nakṣatrendubha, Rāhucarita, Brhaspaticāra, Śukracāra, Ketumālā, Śanaīscaracāra, Aṅgārakacāra, Budhacāra, Ādityacāra, Agastyacāra, Antaracakra, Mrgacakra, Śvacakra, Vātacakra, Vāstuvidyā, Aṅgavidyā, Vāyasavidyā, Svātīyoga, Āśādhayoga, Rohiṇīyoga, Janapadavyūha, Mahāsalila.*

Upāṅgā (38): *Grahakośa, Grahasamāgama, Grahaprādakṣiṇya, Grahavikrīḍita, Grahasīṅgātaka, Grahapurāṇa, Grahapāka, Yātrālakṣaṇa, Agnivarṇa, Senāvyyūha, Mayūracitraka, Bhuvanapuṣkara, Balyupahāra, Śāntikalpa, Rāṣṭrotpātalakṣaṇa, Tulākośa, Yugapurāṇa, Sarvabhūtaruta, Vastraccheda, Brhaspatipurāṇa, Indradhwaja, Ajalakṣaṇa, Kūrmalakṣaṇa, Strīlakṣaṇa, Gajalakṣaṇa, Golakṣaṇa, Bhārgavasamsthāna, Garbhasamsthā, Dakārgala, Nirghāta, Bhūmikampa, Pariveṣa, Ulkālakṣaṇa, Pariveṣacakra, Ṛtusvabhāva, Sandhyālakṣaṇa, Ulkālakṣaṇa, Nakṣatrapuruṣakośa.*

Three chronology footprints

The three sections *Ādityacāra*, *Mahāsalila* and *Ṛtusvabhāva* describe observation of sun in specific seasons with the visible *nakṣatras*. These statements can be analysed accounting for precession to find when such observations were possible. Sun's transit among the 27 *nakṣatra* is the *Ādityacāra* in 135 verses, as narrated by Garga to Nārada, largely devoted to qualitative description of sun's orb, shape, colour, weather changes, characteristics of seasons and portents for good and deficient rainfall. There are six verses, one each for the six seasons stating the position of sun among the *nakṣatra* starting from the beginning of the *śiśira-ṛtu*, which is winter.

श्रविष्ठादीनि चत्वारि पौष्णार्धञ्च दिवाकरः।वर्धयन् सरसस्तिक्तं मासौ तपति शैशिरे ॥
 रोहिण्यन्तानि विचरन् पौष्णार्धाद्याच्च भानुमान्।मासौ तपति वासन्तौ कषायं वर्धयन् रसम् ॥
 सार्पाधन्तानि विचरन् सौम्याद्यानि तु भानुमान्।ग्रैष्मिकौ तपते मासौ कटुकं वर्धयन् रसम् ॥
 सावित्रान्तानि विचरन् सार्पाध्यानि भास्करः।वार्षिकौ तपते मासौ रसमल्लं विवर्धयन् ॥
 चित्रादीन्यथ चत्वारि ज्येष्ठार्धञ्च दिवाकरः।शारदौ लवणाख्यं च तपत्याप्याययन् रसम् ॥
 ज्येष्ठार्धादीनि चत्वारि वैष्णवान्तानि भास्करः।हेमन्ते तपते मासौ मधुरं वर्धयन् रसम् ॥

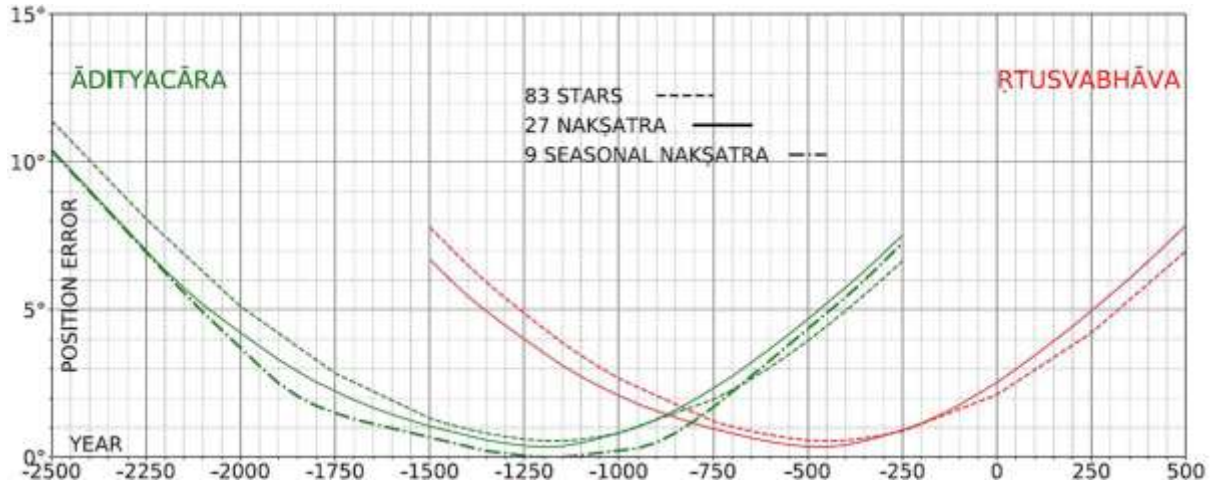
This is same as the six-season solar zodiac of the *Parāśara Tantra* (PT)

तथा च स्वकालिकमृतुकममाह पराशरः। तस्य श्रविष्ठाद्यात् पौष्णार्धचरतः शिशिरः। वसंतः पौष्णार्धात्रोहिण्यन्तम्। सौम्याद्यात्सार्पाध्ग्रैष्मिः।
 प्रावृद्धार्पाध्न्हस्तान्तं। चित्राद्यात् इन्द्रार्धं शरत्।हेमन्तो ज्येष्ठार्धात् वैष्णवान्तं। इति ॥ (*Adbhutasāgara; Sūryādbhūtāvarta*).

This has been shown to be observationally valid for 1350-1130 BCE.

Both PT and VGJ reckon the twenty-seven *nakṣatras* in terms of eighty-three individual stars, assembled such that the *nakṣatra* sectors are of equal measure in terms of number of days. Sun’s transit starting from *śraviṣṭhā nakṣatra* till *half revatī* is the *śiśira-ṛtu*; from *half-revatī* to end of *rohiṇī* is the *vasanta-ṛtu*. Sun’s course from the beginning of *mṛgāśiras* till *half-āśleṣā* is the *grīṣma-ṛtu*; from *half-āśleṣā* till end of *hasta* is the *varṣa-ṛtu*. Sun’s travel from the beginning of *citrā* till *half-jyeṣṭhā* is the *śarad-ṛtu*; from *half-jyeṣṭhā* ending with *śravaṇa* is the *hemanta-ṛtu*.

Here, as in the *Parāśara Tantra*, the seasons are linked to the position of sun with respect to stars visible in the background to common people and farmers. This is in contrast to later *siddhānta* astronomers defining seasons in terms of the twelve signs or *rāśi*.



Yearly variation of the *nakṣatra* location error in the seasonal solar zodiac of VGJ. The curves on the left side (...83 stars; --- 27 proxy stars; -.-.- 9 seasonal *nakṣatra*) refer to the *Ādityacāra* data of the 11th Section of VGJ. Errors for the nine seasonal *nakṣatra* boundaries remain zero during 1210–1150 BCE. The right-side curves refer to the twelve-month solar *nakṣatra* data available in the 59th Section of VGJ, titled *Rtusvabhāva*.

[Read enclosed paper: R.N. Iyengar and S. Chakravarty “Transit of Sun through the Seasonal Nakṣatra Cycle in the Vṛddha-Gārgīya Jyotiṣa”, *Indian Journal of History of Science*, 56, 2021, pp. 159–170.]

This points in the direction of the observational astronomical information in the early sections (*aṅga-2* to *aṅga-12*) of VGJ to be somewhat in parallel but later than the *Parāśara Tantra*. The *Rtusvabhāva* date of *c* 500 BCE is due to the newer Gārgīya/Gārgya month notations, and observations in continuation of the ancient VG School. This BCE date, for the 59th section, almost towards the end of VGJ as available to us now in the manuscripts (Mss.1 to 11), is still

nearly thousand years before the type of horoscope astral culture depicted in the *Garga/Gārgya-saṁhitā* (Mss. 14,15,16) came into vogue.



The *Mahāsalilam* section edited and published should be more ancient than 1500 BCE. The asterisms *kṛttikā*, *rohiṇī*, *maghā*, *śraviṣṭhā* and *anurādhā* are mentioned by name as being the first, for some special counting. Among these five asterisms, *maghā* and *śraviṣṭhā* are observational anchors, specified for *ayana* and *pūrvalagna*, during its own epoch.

Maghā, specifically declared as the first *ayana nakṣatra* takes MS closer to the *Nakṣatra Sūkta* attributed to the authorship of Ṛṣi Garga in the Atharvaveda, where also *maghā* is associated with the *ayana*.

This is the information contained in (MS.102) which says *maghā*, during its time, was the base or beginning (*ādih*) for counting the *ayana* that is, the lateral movement cycles of sun and moon (*maghā sauryāṇām saumyānām ayananakṣatrāṇām ādih*)

Since, *Mahāsalila* is explicit about the primacy of *maghā* for counting the *ayana* in terms of sunrises, we surmise that this was the *maghādi* calendar anchored to the summer standstill correlated with the stars of the *maghā* nakṣatra. This consistently points to a date of at least 1600 BCE for the calendar part (MS.102-106) appearing towards the end of the *Mahāsalilam* text. This still precedes by several centuries the *śraviṣṭhādi* system (*c* 1300 BCE) of solar transit described in the Parāśara Tantra, VGJ (*aṅga*-11) and the AYJ calendar of Lagadha.



Transit of sun through the seasonal *nakṣatra* cycle in the *Vṛddha-Gārgīya Jyotiṣa*

R. N. Iyengar¹ · Sunder Chakravarty¹

Received: 29 April 2021 / Accepted: 30 July 2021 / Published online: 24 January 2022
© Indian National Science Academy 2022

Abstract

Vṛddha-Gārgīya-Jyotiṣa (VGJ) is an important text of Indian astral sciences before the astronomy texts of the Common Era. Only a few of the chapters of this text have been edited and published so far. The present paper reports an important study of two sections of this text which describe the transit of Sun along the 27 asterisms (*nakṣatra*) during the six seasons beginning with winter. The first section called *Ādityacāra* describes each season to be covered by Sun travelling 4½ asterisms starting from *śraviṣṭhā nakṣatra* at the beginning of *śiśira ṛtu* reckoned as the winter solstice day. The seasons are stated in terms of Sun transiting the beginning, middle and end of nine asterisms some of which are made of more than one star. The second section of the text known as *Rtusvabhāva* starts with the *vasanta ṛtu* and names twelve asterisms through which Sun transits in the 12 months of the tropical year. It is shown that the solar transit information in the *Ādityacāra* and the *Rtusvabhāva* chapters of *VGJ* can be dated, for minimum observational error, to *c* 1300 BCE and *c* 500 BCE respectively.

Keywords Ancient India · Astral sciences · *Pre-siddhāntic* astronomy · Seasonal asterisms · *Vedāṅga Jyotiṣa*

1 Introduction

Vṛddha-gārgīya Jyotiṣa (VGJ) is an ancient encyclopedic text, originating several centuries before the more popular *saṃhitā* text, the *Bṛhatsaṃhitā (BS)* of Varāhamihira (sixth century CE). Several manuscripts attributed to Garga, Vṛddha-garga, Gārgya, Gārgīya and other variant names are available to differing levels of accuracy and readability. Such manuscripts are yet to be edited and published in readable form to properly understand and appreciate the contribution of the Vṛddha-garga or Garga School of Indic astronomy before the proliferation of *Siddhānta* texts of mathematical astronomy from around the beginning of the Common Era (CE).

Existence of the school of Vṛddha-Garga (VG) and/or Garga has been known for a long time. Dikshit (1896) and Sudhākara Dvivedi (1908) drew the attention of modern scholars to the text of Garga quoted by Somākara (7th century?) in his commentary on the calendar text of Lagadha in support of sun being with *śraviṣṭhā nakṣatra* on the

winter solstice day. This observation of *śraviṣṭhā* (later known as *dhaniṣṭhā*) epoch of winter solstice seems to have been transmitted over centuries as a memorized standard. Varāhamihira in *BS* writes that as per ancient treatises the winter solstice occurred once upon a time with sun in *dhaniṣṭhā* asterism.¹ Varāhamihira refers to both Parāśara and Vṛddha-garga by name in several places, but not specifically to their winter solstice data. Bhaṭṭotpala (9th–10th century) the commentator of *BS* quotes extensively from Vṛddha-Garga and Garga, but attributes the above *dhaniṣṭhā* observation to Parāśara, further adding that it must have been an *utpāta* or an unprecedented anomaly.² He quotes from the prose text of *Parāśaratantra (PT)* to the effect that the transit of sun started from *śraviṣṭhā* at the beginning of the winter season, taken as the winter solstice day, to pass through the six seasons at the rate of 4½ *nakṣatra* (asterisms) per season. It is interesting to note that *VGJ* the text under study in the present paper, contains the same seasonal transit in versified form in one place, but towards the end of

✉ R. N. Iyengar
RN.Iyengar@jainuniversity.ac.in

¹ Centre for Ancient History and Culture, Jain University, Bangalore 560078, India

¹ आश्लेषार्धाद्दक्षिणमुत्तरायणं रवेर्धनिष्ठाद्यम् । नूनं कदाचिदासीद्येनोक्तं पूर्वशास्त्रेषु ॥*BS* (3.1).

² तत्र रवेः आदित्यस्य आश्लेषार्द्धात् सार्पान्त्यपादद्वयाद्दक्षिणमयनं तथा धनिष्ठाद्यं वासवप्रारम्भमुत्तरमयनं नूनं निश्चितं कदाचित् उत्पातवशात् आसीत् अभूत् । येन पूर्वशास्त्रेषु पाराशरादिषु उक्तं कथितम् । नूनमनुमाने वा ॥ (Commentary of Bhaṭṭotpala on the above verse).

the compilation describes a different transit for each month of the solar year. *VGJ* states matter-of-fact invisibility day numbers for planets and realistic periods for eclipses and description of a sequence of comet appearances with details of rise and transit in the background of the stars. The present study is limited to a brief review of sun's transit as given in two sections of *VGJ* named *Ādityacāra* and *Ṛtusvabhāva*. Analysis of this information helps one in estimating the historical origin of the School of Vṛddha-Garga, known as Vṛddha-gārgīya or just the Gārgīya tradition, before the Common Era (BCE).

2 Manuscripts of *VGJ*

The manuscripts of *VGJ* referred to by some as *Gārgīya-jyotiṣa*, are heavily layered with the most ancient and the relatively later parts mixed up. Since the available manuscripts are reproductions of previous versions, scribal errors are quite large in some copies. Additionally, some of the chapters in whole or in part seem to be added by the followers of the tradition of *VG* in the early centuries of the Common Era. Notwithstanding such difficulties a timeline of development of observational astronomy can be deciphered in *VGJ*. Pingree (1971) lists more than ten versions of *VGJ*, popularly known as *Vṛddha-garga-saṁhitā*, available in the manuscript libraries in India and abroad. Previously Mankad (1951), Mitchener (1986), Geslani *et al* (2017), Mak (2019), Iyengar *et al* (2019) have reviewed these manuscripts from differing perspectives and in varying details. At present only certain select chapters extracted from the manuscripts have been edited and published. Broadly, it is known that the astral sciences part of *VGJ* contains ideas and theories of ancient Vedic thinkers, generally followed by later astronomers. Thus, the importance of *VGJ* for tracing history of science in general and of Hindu astral sciences in particular can never be over emphasized.

3 *Ādityacāra*: sun's transit

The astral science tradition expounded in *VGJ* is organized in 24 *aṅga* (section) and 40 *upāṅga* (sub-section), each such section having one or more *adhyaḥya* (chapter). Sun's transit among the 27 *nakṣatra* circle forms the 11th section with a single chapter. There are 135 verses in this chapter, as narrated by Garga to Nārada, largely devoted to qualitative description of sun's orb, shape, colour, weather changes, characteristics of seasons and portents for good and deficient rainfall. Among these are six verses, one each for the six seasons that state the position of sun among the *nakṣatra* starting from the beginning of the *śiśira-ṛtu*, which is winter. This implies that the Vedic Year started on the winter

solstice day with the sun starting to move north, from its extreme southern declination. Each season is stated to cover $4\frac{1}{2}$ *nakṣatra* stretches starting from *śraviṣṭhā*. One could easily see that this is same as the seasonal solar zodiac stated in the *Parāśara Tantra (PT)*. The difference between the two is only in the style and not in the content. Parāśara's statement is in prose known to us through quotations by later authors (Iyengar, 2013). *VGJ* gives the same information in versified form. The six verses are as follows:

श्रविष्ठादीनि चत्वारि पौष्णार्धञ्च दिवाकरः ।
वर्धयन् सरसस्तिक्तं मासौ तपति शैशिरे ॥
रोहिण्यन्तानि विचरन् पौष्णार्धाद्याच्च भानुमान् ।
मासौ तपति वासन्तौ कषायं वर्धयन् रसम् ॥
सार्पार्धान्तानि विचरन् सौम्याद्यानि तु भानुमान् ।
ग्रैष्मिकौ तपते मासौ कटुकं वर्धयन् रसम् ॥
सावित्रान्तानि विचरन् सार्पार्धाद्यानि भास्करः ।
वार्षिकौ तपते मासौ रसममूं विवर्धयन् ॥
चित्रादीन्यथ चत्वारि ज्येष्ठार्धञ्च दिवाकरः ।
शारदौ लवणाख्यं च तपत्याप्याययन् रसम् ॥
ज्येष्ठार्धादीनि चत्वारि वैष्णवान्तानि भास्करः ।
हेमन्ते तपते मासौ मधुरं वर्धयन् रसम् ॥

(*Ādityacāra*; v. 47, 48, 52, 53, 54, 55)³

The text is more detailed about the environmental features and changes that occur in the seasons but the sun's positions are stated crisply with only the starting and ending parts of the respective *nakṣatra*. In the above six verses the astronomical content is limited to the first half of each verse. The second half states the name of the season of 2-month duration. The month names are not mentioned. The gist of the text is as follows.

Sun's transit starting from *śraviṣṭhā nakṣatra* till *half-revatī* is the *śiśira-ṛtu*; from *half-revatī* to end of *rohiṇī* is the *vasanta-ṛtu*. Sun's course from the beginning of *mṛgaśiras* till *half-āśleṣā* is the *grīṣma-ṛtu*; from *half-āśleṣā* till end of *hasta* is the *varṣa-ṛtu*. Sun's travel from the beginning of *citrā* till *half-jyeṣṭhā* is the *śarad-ṛtu*; from *half-jyeṣṭhā* ending with *śravaṇa* is the *hemanta-ṛtu*.

Here, as in the *Parāśara Tantra*, the seasons are linked to the position of sun with respect to stars visible in the background. This is in contrast to later *siddhānta* astronomers defining seasons in terms of the twelve signs or *rāśi*.

In *VGJ* the winter starts with sun in the asterism *śraviṣṭhā* denoted as *dhanīṣṭhā* in later texts. Each of the seasons is 61 days long, equal to one-sixth of the year of 366 days. The three seasons of *śiśira*, *grīṣma* and *śarat* start with sun

³ The numbering of the verses here and later follows the sequential order in the manuscript no.Th.319 of the National Library of India, Kolkata. The text presented has been edited for correctness and readability by comparing it with six other manuscripts.



respectively in *śraviṣṭhā*, *saumya* (*mṛgaśiras*) and *citrā*, to extend up to the middle/half of *pauṣṇa* (*revatī*), *sārpa* (*āśleṣā*), and *jyeṣṭhā* respectively. The subsequent seasons *vasanta*, *varṣa*, and *hemanta* are stated to continue from the same half-points of the above three asterisms, but are said to end with sun in *rohiṇī*, *hasta* and *śravaṇa* respectively.

Vedic astronomers had long recognized that seasons follow the sun and had qualitatively characterized them in terms of annual periodicity of felt weather, sky features, environmental conditions and social behaviour.⁴ Observation of the early morning rise of auspicious *nakṣatra* for performance of house hold rites as enjoined in the *Taittirīya Brāhmaṇa* (*TB*)⁵ and the recognition of *maghā*, *śraviṣṭhā* and *sārpa* as the background *nakṣatra* for defining the southern and northern transit of sun in the *Maitrāyaṇīya Āraṇyaka Upaniṣat* (*MAU*) are the easily traceable beginnings of the formation of the Vedic solar zodiac.⁶ *MAU* says that the fiery southern transit of sun is in direct order from beginning of *maghā* till *śraviṣṭhārdha* and the milder northern transit is in the *reverse order* from beginning of *sārpa* to *śraviṣṭhārdha*. Taken in the direct order the mid-*śraviṣṭhā* (*śraviṣṭhārdha*) boundary is common to both the transits. But curiously, the beginning of the southern and the end point of the northern sojourn of sun which should be temporally identical are stated in terms of two spatially distinct but consecutive asterisms. The mention of the beginning and ending *nakṣatra* exhibits a peculiarity that is common to *MAU*, *PT* and *VGJ*. To find the position of sun in a *nakṣatra* with several constituent stars by observation is a difficult task. By observing the star that is just above the horizon before sunrise and similarly noting the same star that is just visible in the west after sun set, one can form an idea about sun's station in a *nakṣatra*. The ending and starting of the seasons are in reality seamless, but here expressed in terms of two different asterisms. We can only speculate that this may be an attempt to relate the end and start of a *ṛtu* with the set and rise of consecutive boundary stars. These texts are the very early specimens of observational astronomy and formation of the Indic solar zodiac, developed over the already existing lunar zodiac. The statements in *VGJ* are verbal expressions for technically equating the temporal extent of 183 days in one *ayana* and 61 days in one *ṛtu* on earth, counted in terms of sun rises, to the visible spatial transit of sun in the sky as a matter-of- fact observation.

Rohiṇī asterism is made of five stars, looking like the Vedic Soma-cart with a triangular plank. The bright star α Tau (Aldebaran) is located at the western end of this figure.

⁴ *Taittirīya Āraṇyaka* (I.3,4,5).

⁵ *Taittirīya Brāhmaṇa* (I.5.2).

⁶ [...]एतस्याग्नेयमर्धमर्धं वारुणम् | मघाद्यं श्रविष्ठाधर्माग्नेयं क्रमेणोत्क्रमेण सापार्द्यं श्रविष्ठाधर्मान्तं सौम्यम् || *MAU* (6.14).

The distance between this and the next *nakṣatra* namely, *mṛgaśiras* with three (or five) stars, usually recognized by the middle star λ Ori is about 14° . If the end of spring, when Sun is at 30° longitude, were to be recognized by the early morning rise of *rohiṇī*, it might take another 10–15 days for parts of *mṛgasiras* to be seen in the morning. Thus, when *PT* and *VGJ* declare *vasanta* (spring) ends in *rohiṇī* and *grīṣma* (summer) begins with *mṛgasiras*, a diffuse boundary is implicitly recognized between the above two asterisms. Since *śiśira-ṛtu* by convention started on the day of the winter solstice, sun would have been with the asterism *śraviṣṭhā* (*dhaniṣṭhā* in later texts) theoretically at 270° longitude. Based on this, all the 27 *nakṣatra* sectors, each taken to be $13^\circ 20'$ wide, can be figured out and named in their traditional order which has remained unchanged since the Vedic past. The textual statements on the seasons can be taken to be meaningful if the relative positions of the 27 *nakṣatra* sequence remain internally consistent. However, since the *VGJ* text uses phrases such as *rohiṇyanta* and *saumyādi*, without equating the two in space, this internal consistency condition of the 27 *nakṣatra* that are made up of more than eighty stars can be verified only in a statistical sense using a suitable error criterion. Even if the consistency condition gets satisfied, the *VGJ* verses can be taken to be observationally realistic if the named nine asterisms remained coevally visible on yearly basis at or near the season boundaries for a few years in the past. If such a period can be found, it would be a historical bench mark in the practice of astronomy in ancient India.

4 Nakṣatra identification

There is considerable literature on the identification of the 27–28 *nakṣatra*, the names of which along with interesting astral lore have come down to us from antiquity. A standard reference for the names of traditional stars and their possible identification with the help of *siddhānta* texts of the Common Era is the Report of the Calendar Reform Committee (Saha & Lahiri, 1955). Some of the *nakṣatra* are star groups and consequently several works exist on the relation between the bright stars with which moon comes in conjunction (*yogatārā*) of the ancient asterisms, their given longitudes in the astronomical texts of the Common Era and attempts at backward projection of such results to the ancient period. There is difficulty in correctly identifying the *nirayana nakṣatra* zodiac of *c* 285 CE, in terms of the Vedic asterisms, which if successful would have helped in knowing the ancient system of Parāśara and Vṛddha-Garga more accurately (Dikshit, 1969; Sen & Shukla, 2000). The sequential order of the *nakṣatra* names starting with *ṛttikā* has remained unchanged, except for the elision of *abhijit* from the original list of 28 asterisms and postulation of average



travel time of nearly 13½ days for sun in each *nakṣatra*. As a corollary the stellar circle got divided into 27 equal divisions of 13° 20' with each *nakṣatra* assigned to its corresponding sector.

Some of the famous *nakṣatras* such as *kṛttikā*, *rohiṇi*, *maghā*, *hasta*, *citrā*, *svāti*, *viśākhe*, *jyēṣṭhā* are identifiable reasonably well in terms of their modern names due to the number of member stars, their geometry and shape as stated in *PT* and other ancient texts. However, the same cannot be said about others such as *aśvayuk* (*aśvini*), *bharaṇi*, *uttarāśādhā*, and *revatī*. The sequential organization of the *nakṣatra* system, though stable by itself, might have suffered disturbances in the assigned eponymous older divisions, due to effect of precession. This introduces uncertainty particularly in the identification of *uttarāśādhā*, *śravaṇa* and *śraviṣṭhā* asterisms near the eliminated *abhijit nakṣatra*, with possibility of positional errors propagating further.

In effect, identification of the winter solstice *nakṣatra* of Lagadha's Vedic calendar (Sastriy, 1984) with the star α - or β -*delphini* and consequent dating of his work to c 1300 BCE is not as straight forward as it is generally presumed. Abhyankar (1991) pointed out this problem and also suggested corrections to the identification of some traditional stars, which will be discussed later. Previously while analysing the seasonal zodiac of Parāśara, the above difficulty of fixing the origin of the circle of seasons, was circumvented by considering only the well-known six *nakṣatras* namely, *kṛttikā*, *rohiṇī*, *maghā*, *citrā*, *viśākhe* and *jyēṣṭhā* represented by their constituent bright stars further identified in terms of their modern names, for verifying whether their positions as understood from the yet unidentified *śraviṣṭhā* at 270° remain internally compatible. Even though this does not address the textual star statements directly, visibility of the above six stars within their sectors in a year, constrain the possible epoch of *PT* and subsequently of *VGJ* to a narrow band of 1350–1130 BCE (Iyengar, 2014). For this period, it is natural to take the winter solstice star to have been in the Delphinus constellation as demonstrated by Gondalekhar (2013). Now, it remains to verify whether the star boundaries given in our text are consistent with β Del as a proxy for the *śraviṣṭhā nakṣatra* of the seasonal zodiac of *VGJ*.

Here, we face a new difficulty. Both *PT* and *VGJ* characterize the seasons by the *ādi* (beginning), *ardha* (half/middle) and *anta* (end) of the asterisms which have to be some type of limits associated with particular seasons and visible asterisms. Since the *nakṣatras* are groups made of one to six stars of varying geometrical forms, the boundaries are not at all obvious. We can only surmise that there must have been naked eye spatial markers visualized on the sky by means of an imaginary figure or astrograph made by the particular *nakṣatra* and nearby stars. In any case, for further analysis, it is useful to collect available data on the *nakṣatras* from *VGJ* and a few other ancient texts fixed in the centuries

before the beginning of the Common Era. Apart from *PT*, the *Atharvaveda-pariśiṣṭa* (*AVP*), the *Śardūlakarṇāvadāna* (*SKA*) and the *Sūrya-candra-prajñapti* (*SCP*) discuss ancient astral topics including the star list. The three texts *PT*, *VGJ* and *AVP* are in the Vedic tradition; *SKA* and *SCP* are from the Bauddha and Jaina tradition respectively. Information available in the above texts on the number of stars, their objectivised shape and nearest possible modern star names is presented in Table 1. The visual figure of the asterism or astrograph is collected as stated in the texts, given therein as an aid for identification of the *nakṣatra*. In some cases, the Vedic name and its synonym indicates the shape, like the name *hasta* refers to the Corvus constellation looking like a hand or *palm* with five (fingers) constituent stars. *Āśleṣā* called *sārpa* resembles a snake-head. However, *SCP* sees here the shape of a *dhvaja* or a flag, which is equally possible.

The *Nakṣatropasarga* (occultation and affliction of asterisms) chapter of the *Parāśara Tantra* gives the relative directions of the stars in a *nakṣatra*. This helps in understanding how *rohiṇī* with five stars is figured as *śakaṭa* (cart) and *maghā* with six stars is mapped as *koṣṭhāgāra* (enclosure/room). *SKA* and *SCP* also give the star count and the shape of all the 28 *nakṣatras* of their list which is broadly same as in the Vedic tradition with a few exceptions. Some of the picturesque names given to the *nakṣatra* shapes are indicative of the astrograph of such asterisms. For example, in *SCP* the shape of *jyēṣṭhā* with stars α Sco, σ Sco, ϵ Sco, is named *gajadanta* or elephant tusk which is apt for the bent profile of this asterism. When a *nakṣatra* has only one member, *SKA* and *SCP* denote the figure as *tilaka*, *bindu* or flower. The astrographs listed in the table are as per the Vedic, *PT* and *VGJ* texts wherever available, otherwise they are taken from *SCP* (marked by a star) which is in some places different from the shapes meant by the Vedic tradition.

It is to be noted that the primary objective of the present study is not identification of the ancient asterisms, but finding the period when the *nakṣatra* of *VGJ* were visibly stationed in their seasonal positions. This in turn depends on how closely we are able to equate the 27 *nakṣatra* of *VGJ* with corresponding star names in current astronomical tables. As a first step the constituent stars of the asterisms with their star catalogue names can be sourced from the works of past authors. These are shown in Table 1, with a few significant differences. The total number of stars making up the twenty-seven *nakṣatra* as per *VGJ* is eighty-three; a system inherited from antecedent sources for tracking the moon.⁷ In fact, *VGJ* assigns unequal time for moon to transit

⁷ Saha and Lahiri (1955) list 79 constituent stars to represent the 27 asterisms omitting *abhijit*. These largely overlap with the 83 stars of *VGJ* listed in Table 1. Notable differences are in the number of constituent stars making up asterisms 18 to 22. The single star *ādra* is



Table 1 *Nakṣatra* list with star count, shape, catalogue names, proxy star and *yogatāra*

No	<i>Nakṣatra</i>	Star Count					Astrograph	Constituent Stars	Proxy Star (Authors)	<i>Yogatāra</i> (Abhyankar)
		VGJ	PT	AVP	SKA	SCP				
1	<i>Kṛttikā</i>	6	6	6	6	6	Knife/Cleaver	(17,19,20,23,27,η) Tau	η Tau	η Tau
2	<i>Rohiṇī</i>	5	5	1	5	5	Cart	(α,γ,δ1,ε,θ2) Tau	α Tau	α Tau
3	<i>Mṛgāśīra</i>	3	3	3	3	3	Deer's Head	(α,γ,λ) Ori	λ Ori	λ Ori
4	<i>Ārdrā</i>	1	1	1	1	1	<i>Bāhu</i> (Arm)	(γ) Gem	γ Gem	γ Gem
5	<i>Punarvasu</i>	2	2	2	2	5	Balance	(α,β) Gem	β Gem	β Gem
6	<i>Puṣya</i>	1	1	1	3	3	<i>Śārāva</i> (Pot-lid)	(δ) Cnc	δ Cnc	δ Cnc
7	<i>Āśleṣā</i>	6	6	6	1	6	Snake Head Flag*	(δ,ε,ζ,η,ρ,σ) Hya	ζ Hya	ζ Hya
8	<i>Maghā</i>	6	6	6	5	7	Enclosure	(α,γ1,ε,ζ,η,μ) Leo	ζ Leo	α Leo
9	<i>P Phalgunī</i>	2	2	2	2	2	Half-chair	(δ,θ) Leo	δ Leo	δ Leo
10	<i>U Phalgunī</i>	2	2	2	2	2	Half-chair	(93,β) Leo	β Leo	β Leo
11	<i>Hasta</i>	5	5	5	5	5	Hand	(α,β,γ,δ,ε) Crv	δ Crv	γ Crv
12	<i>Citrā</i>	1	1	1	1	1	Flower	(α) Vir	α Vir	α Vir
13	<i>Svātī</i>	1	1	1	1	1	Wedge	(α) Boo	α Boo	α Boo
14	<i>Viśākhā</i>	2	2	2	2	5	Divider, Rope*	(α1,α2) Lib	α2 Lib	α Lib
15	<i>Anūrādhā</i>	4	4	4	4	5	Necklace	(β1,δ,π,ω1) Sco	δ Sco	δ Sco
16	<i>Jyeṣṭhā</i>	3	3	1	3	3	Elephant Tusk	(α,ε,σ) Sco	ε Sco	α Sco
17	<i>Mūla</i>	6	2	7	7	1	Root Scorpion Tail*	(ζ2,θ,ι1,κ,λ,ν) Sco	κ Sco	λ Sco
18	<i>P Aṣādhā</i>	4	4	4	4	4	<i>Gajavikramā*</i> (Elephant Step)	(γ,δ,ε,λ) Sgr	λ Sgr	δ Sgr
19	<i>U Aṣādhā</i>	4	4	4	4	4	<i>Simhaniṣadya*</i> (Lion seat)	(ζ,σ,τ,φ) Sgr	τ Sgr	σ Sgr
**	<i>Abhijit</i>	–	3	1	3	3	<i>Gośtrīśāvalī*</i>	–	–	α Aql
20	<i>Śravaṇa</i>	3	3	3	3	3	Ear Barley seed*	(α,β,γ) Aql	α Aql	β Del
21	<i>Śraviṣṭhā</i> (<i>Dhaniṣṭhā</i>)	4	5	5	4	5	<i>Śakuni-pañjara*</i> (Bird cage)	(α,β,γ2,δ) Del	β Del	β Aqr
22	<i>Śatabhiṣak</i>	1	1	1	1	100	<i>Puṣpopacāra*</i> (Flower Boquet)	(λ) Aqr	λ Aqr	α PsA
23	<i>P Proṣṭhapadā</i>	2	2	2	2	2	Cow's Foot	(α,β) Peg	α Peg	α Peg
24	<i>U Proṣṭhapadā</i>	2	2	2	2	2	Cow's Foot	(γ,λ) Peg	λ Peg	λ Peg
25	<i>Revatī</i>	1	1	1	1	32	Canoe*	(ε,α,ζ) Psc	ε Psc	ζ Psc
26	<i>Aśvayuk</i>	3	2	1	2	3	Horse-neck	(α,β,γ) Ari	β Ari	β Ari
27	<i>Bharanī</i>	3	3	3	3	3	<i>Bhaga</i> (Perineum)	(35,39,41) Ari	41 Ari	41 Ari

the *nakṣatra* stretches. But in describing the six season solar transit, each season is equalized in time and space to be of 4½ *nakṣatra* span. We may infer that for lunar transit of a shorter period, unequal dwell time was more realistic, whereas when sun arrived nearly to the same *nakṣatra* at the solstices, equal division was a natural choice for demarcating the two *ayana* and the six seasons. Such a view is quite explicit in the Sāmavedic *Nidāna Sūtra* which takes sun to spend equal time of 13 and (5/9) days in each of the

27 asterisms.⁸ The year is 366 days long as in our text and hence expectation of the stated season boundary to be in the specified *nakṣatra* division of 13° 20' arc is logical. However due to the extended shape of some asterisms with two to six stars, the member stars may creep into neighbouring sectors. In the literature, including astronomical *siddhānta* texts, the difficulty of multiple stars is handled by defining a junction star (*yogatāra*) usually the brightest member in

Footnote 7 (continued)

taken as α Ori by Saha and Lahiri, whereas VGJ points towards γ Gem.

⁸ स एष आदित्यसंवत्सरो नाक्षत्रः। आदित्यः खलु शश्वदेतावद्भिरहोभिर्नक्षत्राणि समवैति। त्रयोदशाहं त्रयोदशाहमेकैकं नक्षत्रमुपतिष्ठति। अहस्तृतीयं च नवधा कृतयोरहोरात्रयोर्द्वे द्वे कले चेति संवत्सराः। ताश्चत्वारिंशच्चतुःपञ्चाशत् कलाः। ते षण्णववर्गाः सषट्द्विंशतिशतः॥ (*Nidāna Sūtra* V.12).



the asterism. But, when mid-points of the *nakṣatra* form the seasonal limits, it will be convenient to have a representative proxy star that can be followed over time. Accordingly, a few comments on the selection of the proxy stars, particularly those mentioned by *VGJ* as seasonal boundaries, would be appropriate.

The first two *nakṣatra* namely, *kr̥ttikā* and *rohiṇī* have stood the test of time since their Vedic antiquity and are identifiable easily. The *nakṣatra mṛgaśīras* (*saumyam*) with three (or five) stars is in the Orion constellation. The astrograph as deer's head gets well defined with the α , λ , γ stars of Orion, the first and the third being brighter than the second, but λ Ori forming a vertex joining the other two. The vertex star λ Ori with two nearby dim stars is sometimes called *invakā*. The Yajurvedic *Maitrāyaṇīya Saṃhitā* (*MS*) gives the name *invakā* (*invagam*) for what others call *mṛgaśīras* and states the regent deities as *maruts* and not as *soma*. *VGJ* in the *nakṣatra-karma-guṇa* chapter describes *mṛgaśīras* as *trīṭāraṃ adhikā saumyam*. Even though the text is not very clear, this may mean one with three surplus stars. The famous lexicon *Amarakośa* characterizes *mṛgaśīras* as that asterism at the head of which *invakā* are stationed.⁹ Kṣīraswāmin the commentator of the above lexicon is clear not only about the Vedic name and the deities, but also says *invakā* or *mṛgaśīras* is made of five stars.¹⁰ Hence λ Ori near about the centre of the figure, as the proxy star for *mṛgaśīras* is reasonable. Abhyankar (1991) arrived at the same conclusion through different arguments. This discussion on the ancient asterism *mṛgaśīras* indicates that the identification of the next asterism *ārdra* with α Ori (Betelgeuse) in the more ancient periods is not tenable. In the *MS* we read *bāhuḥ nakṣatram rudro devatā* in the place of *ārdra*. This means, the single star *ārdra* was located on the arm-like part of a constellation next to Orion, which is Gemini. Hence we have taken this to be the bright star γ Gem, which is same as the revised identification of *ārdra* by Abhyankar following different arguments. In the case of interpreting the half-limit *sārpārdha*, *jyeṣṭhārdha*, and *pauṣṇārdha* in the absence of any other clarifications available, we have to select a star near the central part of the asterism figure as the proxy. The representation of the first and the second above with ζ Hya and ϵ Sco is straightforward since the astrograph with multiple stars is stated in the texts. The selection of ϵ Psc needs some explanation. *Revatī* is called *pauṣṇam* since *Pūṣan* is the deity of this asterism. All the ancient texts mention only one star for this *nakṣatra*. But, the spatial extent of Pisces constellation, figured as a fish, is large and texts like *SCP*

and *BS* mention 32 stars forming the figure of a canoe. Even though this location for *revatī* is an inherited tradition, there is a tenuous link for the fish astrograph in the Vedic texts. In the *Taittirīya Saṃhitā* the Vedic deity of *revatī* namely, *Pūṣan* the leader of animals is characterized as toothless and hence flour balls are prescribed as food offering in rituals.¹¹ This seemingly harmonizes with the celestial figure of toothless *Pūṣan* to be like fish. In the past literature *revatī* has been identified variously as α Psc, ζ Psc and other stars. Since, there is no mention of separation of stars in terms of angular or other distances in *VGJ*, we take *pauṣṇārdha* as the visible star ϵ Psc in the middle region of the Pisces constellation.

For sake of comparison, the *27-yogatārā* identified by Abhyankar for the *vedāṅga* period is listed in the last column of Table 1.

5 Error analysis

The analysis we have to carry out is to check how closely a given *nakṣatra* is located in its predetermined interval corresponding to the *VGJ* seasonal stars. As a first step in this direction the ecliptic longitudes of each of the eighty-three stars constituting the twenty-seven *nakṣatras* are found for a long period with the help of the Stellarium software. Some stars will satisfy the internal location condition for some years, while many others may not do so over long time periods. To capture this information an error function *E* is defined as follows. Let, the desired interval of the *i*th asterism be (J_i to J_{i+1}) and its longitude in a given year *y* be L_i ($i = 1, 2, \dots, 27$). The error of location will be zero, if a *nakṣatra* with single star, is found to be in its division; otherwise the lesser of the absolute difference between L_i and the two boundary values J_i and J_{i+1} is the error E_i . That is,

$$E_i = 0 \text{ if } (J_i < L_i < J_{i+1}) \text{ else } E_i \\ = \min [\text{abs}(L_i - J_i), \text{abs}(L_i - J_{i+1})]$$

For a *nakṣatra* with multiple stars there will be more than one sample error value which will be smoothened over the constituent stars to get the mean location error E_i ($i = 1, 2, \dots, 27$) in any year. The location error E_y in a given year *y* is the average of E_i over all the 27 *nakṣatra*. This quantity is plotted (green broken line) in Fig. 1 for the period of (2500–250) BCE at intervals of 50 years. It is seen that the error curve is smooth and reaches its minimum around 1250 BCE. The mean positional error of consistency for any *nakṣatra* is about 1° during (1500–1000) BCE which is

⁹ मृगशीर्षं मृगशिरस्तस्मिन्नेवाग्रहायणी । इन्वकास्तच्छिरोदेशे तारका निवसन्ति याः ॥ (vyomavarga 23).

¹⁰ मार्गशीर्षादारभ्य संवत्सरप्रवृत्तेः [...] इन्वका इति पञ्चताराः, इन्वन्ति प्रीणन्तीन्वकाः, मरुतो देवता इन्वका नक्षत्रमिति श्रुतेः ॥

¹¹ पूषा प्राश्यदतोऽरुणत् तस्मात् पूषा प्रपिष्टभागोऽदन्तको हि [...] ॥ (TS II.6.8.5).



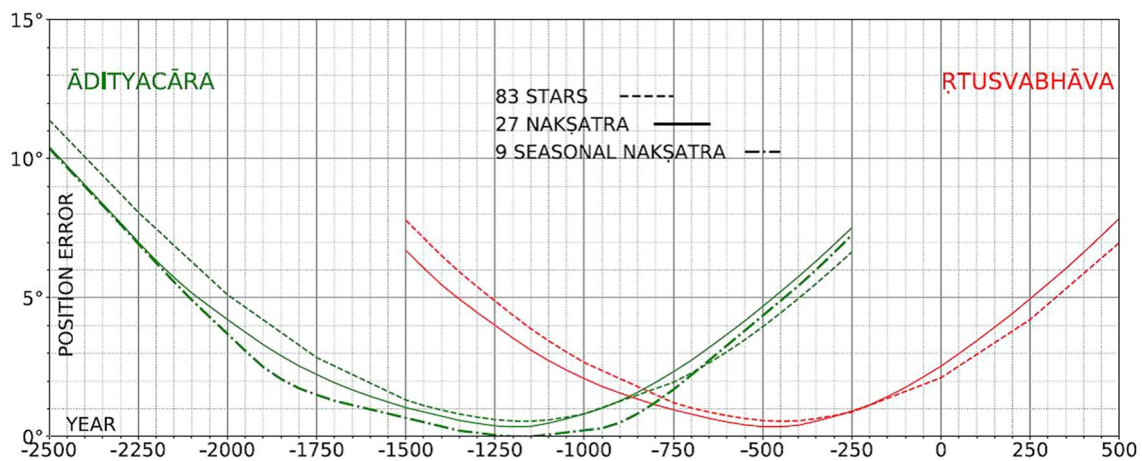


Fig. 1 Yearly variation of the *nakṣatra* location error E_y in the seasonal solar zodiac of *VGJ*. The green curves (.....83 stars; — 27 proxy stars; -.-.- 9 seasonal *nakṣatra*) refer to the *Ādityacāra* data of the 11th Section of *VGJ*. The 83 constituent and the 27 proxy stars are as per Table 1. Errors for the nine seasonal *nakṣatra* boundaries remain zero during 1210–1150 BCE. The red curves refer to the 12 month solar *nakṣatra* data available in the 59th section titled *Ṛtusvabhāva*

acceptable for the ancient epoch, considering that the correspondence shown in Table 1 is not perfect. One more result of consistency is shown in Fig. 1 (green full line) by considering only the 27 proxy stars. This result is not very different from the previous one, indicating the sufficiency of considering the proxy stars for further verification of the visibility condition for the nine seasonal boundary stars of *VGJ*. The internal consistency with minimum error exhibited by the 27 proxy and 83 constituent stars, when the winter solstice was in *śraviṣṭhā*, identified with β Del, upholds that the six equal division tropical zodiac was formalized in middle 2nd millennium BCE. This is still a broad picture, since seasonal dependence is inherent in the sequencing of the stars.

Several older Vedic texts mention the names of the six felt seasons and 12 months of the tropical year, implying that from the extreme southern declination day of sun the onset of the seasons was estimated in terms of multiples of 61 sun rises. The texts of Parāśara and Vṛddha-Garga exhibit more sophistication in that they connect the seasons with the position of sun with visible stars.

For declaring sun’s position among the *nakṣatra*, which should have been useful in predicting the onset of a season in advance, careful observation of the morning and evening stars nearer to sun should have taken place over a prolonged period. Existence or otherwise of such an effort can be verified by considering the nine named asterisms (2-*rohiṇī*, 3-*mṛgaśira*, 7-*āśleṣā*, 11-*hasta*, 12-*citrā*, 16-*jyēṣṭhā*, 20-*śravaṇa*, 21-*śraviṣṭhā*, 25-*revatī*) as border points through which the transition from season to season was said to be taking place. This amounts to verification of coeval yearly visibility of the above nine specific *nakṣatra* in their respective divisions. This can be done by finding the error E_y for these nine stars separately. This result is also

shown in Fig. 1 (green dot & dash line) where it is found that during 1210–1150 BCE the error of location of all the nine seasonal asterisms was precisely zero. There could be minor variations in the above result if small errors due to vague star boundaries are considered. Nevertheless, the core statement of *Ādityacāra* originating with the *śraviṣṭhādi* (*dhaniṣṭhādi*) scheme, cannot be more recent than 1150 BCE, from when the errors start steadily increasing.

At this stage one may question, due to the omission of *abhijit* from the original 28 Vedic *nakṣatra* system, whether our identification of the stars corresponding to *śravaṇānta* and *śraviṣṭhādi* for the start of the *śiśira* season needs a relook. How sensitive is our result for possible errors in identifying the Vedic *śraviṣṭhā* as β Del? Another question would be how sensitive are the results, if Abhyankar’s list is used for checking the positional error.

6 *Abhijit, Śravaṇa, Śraviṣṭhā/Dhaniṣṭhā*

Vedic texts use the nomenclature *śraviṣṭhā* for the 21st *nakṣatra* and this is followed by *VGJ* in 13 out of 15 places. *Atharva Pariṣiṣṭa* knows only the name *śraviṣṭhā* which is cited 19 times. *Atharvaveda Samhitā* refers to *śraviṣṭhā* in the *Nakṣatrasūkta* and in the *Rātrisūkta*.¹² The nomenclature *dhaniṣṭhā* is found once in the *Bodhāyana Śrauta Sūtra* text. The Buddhist SKA, knows only *dhaniṣṭhā* mentioned 22 times. These are perhaps the BCE texts to use the name *dhaniṣṭhā* in the place of the older *śraviṣṭhā*. The *Mahābhārata* in one place uses the nomenclature

¹² *Atharva Veda Samhitā* (19.20 & 19.49.2).



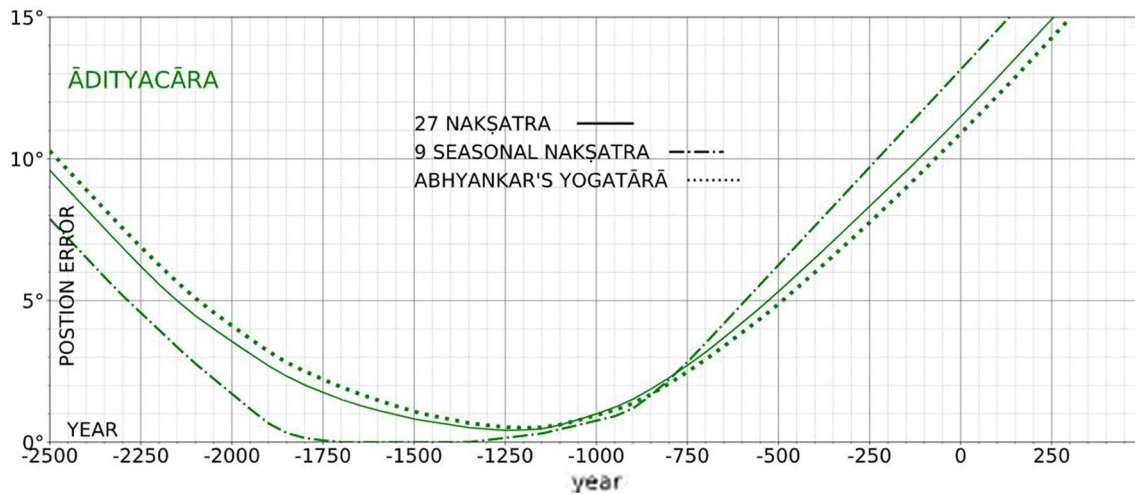


Fig. 2 Error sensitivity for possible identification of Vedic star *śraviṣṭhā* as β Aquari and *śravaṇa* as β Delphini. The readjusted 27 proxy stars and the *yogatāras* of Abhyankar lead to almost the same result of c 1250 BCE for the error minimum. Errors for the nine seasonal *nakṣatra* boundaries remain zero during 1700–1350 BCE

śraviṣṭhā,¹³ otherwise *dhaniṣṭhā* appears in four instances. The epic has the famous legend of *abhijit* going away to do penance when Time was made to begin with *dhaniṣṭhā* by Brahma.¹⁴ This makes a case for arguing that, at some time in the past the winter solstice was occurring with sun in a *nakṣatra* part called *śraviṣṭhārdha* (*MAU*) and still later it fell back to the beginning parts called *śraviṣṭhādi* (*PT*, *VGJ*). With passage of time, winter solstice was observed to be shifting towards *abhijit*. This changed winter solstice *nakṣatra* was called *dhaniṣṭhā* sounding similar to *śraviṣṭhā* and for equalizing the length of each season to 61 days covering $4\frac{1}{2}$ *nakṣatra*, *abhijit* was eliminated. This must have affected visual identification of three nearby asterisms since the name of the *nakṣatra* and the order could not be violated. Abhyankar's (1991) line of argument on misidentification by later authors of these three Vedic *nakṣatras* is different, but the conclusions are same. He worked on this issue to demonstrate that there is good ground to show that the ancient *abhijit*, with cow-horn as the astrograph in SCP and a small sky sector allocated between *U. āṣāḍha* and *śravaṇa*, was what is now called Aquila. *Śravaṇa* with the astrograph resembling an *Ear* was in Vedic times the constellation Delphinus, but due to the elision of *abhijit*, *śravaṇa* got identified with the constellation Aquila with three stars. This argument leads one to infer that in the older 28-*nakṣatra* list, *śraviṣṭhā nakṣatra* with five constituent stars should have been in the Aquarius constellation. After the solar

equal *nakṣatra* system came into vogue, *śraviṣṭhā* with a new name *dhaniṣṭhā* became the winter solstice *nakṣatra* visualized as α , or β Del. This line of argument postulates a transition period between the 28-*nakṣatra* cycle year and the 27-*nakṣatra* tropical year divided equally into six seasons. In such a transition period, *abhijit* was ignored when *śisira ṛtu* started with sun in Aquarius and *śraviṣṭhā* approximately identifiable as β Aqr and *śravaṇa* as β Del. The reality or otherwise of this transition period can be verified by the same methods as discussed above.

The error E_y for the 27 asterisms and also for the nine seasonal stars with the above two readjustments is shown in Fig. 2. On the same figure the error variation of Abhyankar's 27-*yogatāra* list is superposed. It is observed that the overall error for the 27 asterisms, taken either as the proxy stars or as the *yogatāra* of Table 1, reaches its minimum still around 1250 BCE. But the interesting fact is that all the stated nine *nakṣatra* season boundaries would have remained visible in their respective longitudinal divisions within a year for a long period of 1700–1350 BCE. This indicates that the prose *PT* textual tradition of Parāśara which knew *abhijit* with three stars and also the *śraviṣṭhādi* scheme of $4\frac{1}{2}$ *nakṣatra* per season must be more ancient than 1350 BCE. This helps us to surmise that the six-part zodiac stated in the *Parāśaratantra* starting with the *śisira-ṛtu* originated first in terms of day numbers counted from the winter solstice day. Thus, errors notwithstanding, the theoretical six division tropical zodiac was fully developed and in use by the Vedic schools of astronomy already by 1500 BCE. This stability got disturbed around 1300 BCE and observed to be so, when two new asterism identities but with old names, as discussed previously were introduced most likely by Vṛddha-Garga or his followers.

¹³ अहः पूर्वं ततो रात्रिर्मासाः शुक्लादयः स्मृताः । श्रविष्ठादीनि ऋक्षाणि ऋतवः शिशिरादयः ॥ *MB Aśvamedhika parvan* (44.2).

¹⁴ धनिष्ठादिस्तदा कालो ब्रह्मणा परिनिर्मितः । रोहिण्याद्योऽभवत्पूर्वमेवं सङ्ख्या समाभवत् ॥ *MB Vana parvan* (219.10).



Once again the seasons remained true with the original *nakṣatra* nomenclature during a short span of 1210–1150 BCE. But this order could not remain unchanged and had to be reorganized. How this was done is not clear. But *VGJ* which is like a compendium of the *Vṛddha-Garga* tradition takes us further in time by a few centuries to the monthly transit of sun through twelve *nakṣatra* in the *Ṛtusvabhāva* section.

7 Continuity of observations

The *Ādityacāra* chapter with 135 verses, as it is available now, can only be quoting the above seasonal transit of sun (v. 47, 48, 52–55) from some ancient text or tradition followed by the *VG* School. This follows easily, once we recognise that a later verse¹⁵ (v. 125) in the same chapter mentions “sun turning north without reaching the *śraviṣṭhā* asterism and not reaching *āśleṣā* on return is cause of fear”. This is clearly an observation of the effect of precession with passage of time and taken as a bad omen due to change of the *śraviṣṭhā* epoch. Such an observation seems to have happened towards the beginning of the 1st millennium BCE. This follows from the 59th section (*upāṅga*) of *VGJ* known as *Ṛtusvabhāvaḥ*. This section has six chapters, one each for the six seasons starting with the *vasanta*. All the chapters are a mix of prose and poetry. Interestingly in each chapter the *nakṣatra* through which sun transits in the 2 months of the season is stated along with the name of the month. Thus, here for the first time in Hindu astronomy we come across the 12-month solar zodiac, not in terms of the *Rāśi* signs (*meṣa*, *vr̥ṣabha* etc.), but in terms of the names of months starting with the Vedic month *madhu* equated in civil calendar reckoning with *caitra*. The chapters have varying number of verses totalling seventy-five, increased further with archaic prose sections that describe the seasons qualitatively in terms of weather, flora, fauna and social behaviour. Here only the text of interest containing information on sun’s transit is presented followed by a gist for further analysis.

वसन्तघर्मो जलदागमश्च विद्याच्छरद्भैमतशैशिरौ च ।
ऋतून् पृथग्लक्षणतः प्रवक्ष्ये संवत्सरं ये परिवर्तयन्ति ॥
तेषामुद्गदक्षिणतश्च गच्छेद्यावान् विवस्वान् प्रचिनोति तावान् ।
तांस्तान् प्रवक्ष्यामि तथैव सर्वान्यथा च वै
लौकिकवैदिकानि ॥
यद्रेवती ऋक्षमुपैति भानुश्चैत्रः स मासो मधुसंज्ञकश्च ।
वैशाखमासोऽपि च माधवश्च तदा हि भानुर्भरणीगतः
स्यात् ॥

¹⁵ यदा निवृत्तेदप्राप्तः श्रविष्ठासुत्तरायणे । आश्लेषां वा यदाऽप्राप्तस्तत्र विद्यान्महद्भयम् ॥ (v.125).

एतैर्वसन्तः समयैर्विदध्याद्वौ द्वौ च पक्षौ भवतीह मासः ।
(*VGJ Āṅga* 59; Ch.1)

I shall explain individually the character of the seasons; *vasanta*, *gr̥ṣma*, *varṣa*, *śarat*, *hemanta*, *śiśira* that cyclically change the year. Also, I will explain, as sun goes from north and from south, his access to the civil and the Vedic months. When sun attains *revati* asterism, that month is *caitra* also known as *madhu*. *Vaiśākha* is also the *mādhava* month. Then sun would have reached *bharani*. By this *vasanta ṛtu* is recognized and each month is made of two fortnights.

शुचिशुक्रौ मृगशिरो गच्छत्कुर्यात्तु भानुमान् ।
तथा पुनर्वसू चैव ज्यैष्ठाषाढौ तु तौ स्मृतौ ॥
एतौ मासौ विजानीयाद्वैष्णिकौ कालवित्तमः ।
(*VGJ Āṅga* 59; Ch.2)

Sun in *mrgaśiras* is the month *śuci* known also as *jyēṣṭha*. Sun in *punarvasū* is the *śukra* month same as *āṣāḍha*. These two months are to be known as the *gr̥ṣma ṛtu*.

नभस्तु कुर्त्यादुपसर्प्यमाणो रविर्मघाश्रावणजातसञ्ज्ञा ।
तत् प्रोष्ठदं च तथा नभस्यं गत्वा विदध्याद्भगदैवतर्क्षम् ॥
एतौ तु वार्षिकौ मासौ विद्यात्कालविशारदः ।
(*VGJ Āṅga* 59; Ch.3)

When sun approaches *maghā*, the month is *nabhaḥ* known as *śrāvaṇa*. Next, having gone to *pūrvaphalguni* sun makes the *nabhasya* month same as *bhādrapada*. These two are the rainy months (*vārṣikau māsau*).

इषमाश्वयुजं विद्याद्भानुश्चित्रागतस्तदा ।
कार्तिकं जनयत्यूर्जमैन्द्राग्र्यं प्राप्यरश्मिवान् ॥
(*VGJ Āṅga* 59; Ch.4)

Month *iṣu* equivalently *āśvayuja* is when sun has reached the *citrā* asterism. Sun generates *kārtika* month also known as *ūrja* having reached the *viśākhe* asterism.

ऐन्द्रं समासाद्य तथोष्णरश्मिः स मार्गशीर्षं सहसं करोति ।
अद्भैवते त्वेव गतः सहस्यं पौषं विदध्यात् प्रचिनोति
मासम् ॥
(*VGJ Āṅga* 59; Ch.5)

Sun in *jyēṣṭhā nakṣatra* makes the *mārgaśira* month same as *sahas*. When sun goes to *pūrvāṣāḍha*, it is the month of *pauṣa* or *sahasya*.

गतश्रविष्ठासमयं तु माघस्तपोविधत्ते भगवान् विवस्वान् ।
सफाल्गुनं चापि तथा तपस्यं पूर्वा गतप्रोष्ठपदां करोति ॥
ऋतुं तु विद्याच्छिशिरं विचार्य तस्यैव भावावयवं च
सम्यक् ।
(*VGJ Āṅga* 59; Ch.6)



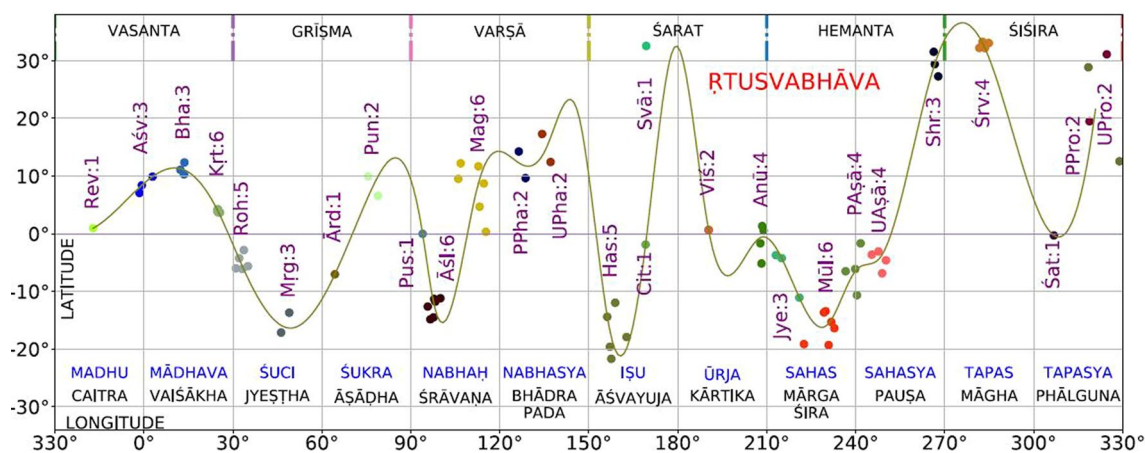


Fig. 3 Twelve month (*madhu-tapasya*) or (*caitra-phālguna*) Sun's transit in 500 BCE as per the *R̥tusvabhāva* (59th *āṅga*) of *VGJ*

The month of *māgha* or *tapas* is when the time for *śraviṣṭhā* is past. Sun makes the month *phālguna* or *tapasya* having attained the *pūrvābhādrā nakṣatra*. This should be understood as the *śīsira ṛtu* with its parts and features.

The above solar transit is different from the previous one, not only in the star positions but more so in the way it is organized and stated. The description is still about the seasons, but here it begins with the *vasanta* (spring) and not the *śīsira* (winter). The older *ādityacāra* was only about the seasons with no mention of the months. Here the stress is on the months for which their Vedic and *laukika* (civil/popular) names are given. Seasons are mentioned only in terms of the months and not as per any *nakṣatra* boundaries. For each month starting from *madhu/caitra*, the prominent *nakṣatra* through which sun passes is mentioned. This way there are 12 months and correspondingly twelve *nakṣatra*, each spanning 30° in longitude. The equinox is here reckoned in the middle of the *vasanta ṛtu*, and the starting of the *mādhava/vaiśākha* month, with sun passing through the asterism *bharaṇi*. The implication is that this month started on the equinox day. The text does not name *aśvini* after *revatī*, through which sun had to transit before arriving at *bharaṇi*. Similarly, *kṛttikā*, *rohiṇī* are not mentioned before sun is said to be in the *mrgaśiras nakṣatra* in the month *jyeṣṭhā*. The text is in line with the older tradition of reckoning the winter solstice as the start of the *śīsira ṛtu*. But, in the month of *māgha*, asterism *śraviṣṭhā* is mentioned not as with sun, but *having past its time*. The text just narrates the stars that were visible in the months that are named and counted starting from the vernal equinox or nearby full moon or new moon. This seems to be the origin of the solar calendar of twelve months, without any need for intercalation.

We can get an idea of the period in which the above 12-month solar zodiac was organized by finding the location

error for the twenty-seven asterisms starting with the first named *bharaṇi* sector stretching from zero to 13° 20' longitude as done previously. The result is shown in Fig. 1 (red lines) side by side with the results of the earlier seasonal zodiac. Clearly in the *VGJ* text there are two different observations of sun's position among the *nakṣatra*, separated by 700 to 800 years. One can further find an interval in which the twelve stated asterisms would have been visible in a given year in the specified months. This turns out to be (620–160) BCE. Since the text is silent on the visibility of adjacent *nakṣatra* in the named months, the above interval cannot be further refined. However, beyond reasonable doubt, we can say that the observational data available in the *R̥tusvabhāva* section of *VGJ* belongs to the epoch of 600–500 BCE. As a demonstration of this, for the year 500 BCE the ecliptic coordinates of the eighty-three stars making up the twenty-seven *nakṣatra* are plotted in Fig. 3. The points are joined smoothly for better visualization with markings for the seasons and the months. It can be verified that all the twelve *nakṣatra* named in the *VGJ* text would have been visible sometime in the specified months.

8 Discussion

In popular parlance *nakṣatras* are taken as twenty-seven stars with which moon comes in contact. However, since Vedic antiquity several *nakṣatras* are composed of multiple stars. All the five ancient texts shown in Table 1 state the number of stars for each of the *nakṣatra*, obviously due to some special importance attached to that number. We guess by hindsight, that multiple stars might have helped the ancient observers to follow the wavy path of moon, by recognizing some of the *nakṣatra* to have more than one star, for clarity in visual perception and memory. This was before *amśa* (1/4) and *ardha* (1/2) *nakṣatra* parts as in *MAU* came into



vogue among particular groups of sky observers. *VGJ* in its chapters on the transit of moon postulates the conjunction of moon with a *nakṣatra* as being of three types; leading, following and at same level. It also states three groups of *nakṣatra* with which moon spends 15, 30 or 45 *muhūrta* of time in its sidereal month cycle of about 27 1/3 days. Such an observational model directly leads to vague spatial domains and unequal longitudinal intervals for the visible asterisms. Investigation of the unequal *nakṣatra* system is beyond the scope of the present paper, but it suffices to point out that the sequence of 28 *nakṣatra* with augmented star counts as background points for observing and remembering moon's spatial position should have existed from very ancient times. Gradually associating *nakṣatra* with sun arose once the seasons were differentiated, named and recognized as six in a year. The *nakṣatrasūkta* of the *Atharvaveda* (19.7) hints that one of the two north–south–north transit of sun happened in the asterism *maghā*.¹⁶ This must have been the southern sojourn (*dakṣiṇāyana*) of sun when some stars of the *maghā* asterism such as α , η -Leo were at around 90° longitude. The *Yajurvedic MAU* specifically differentiates the felt weather for sun's north to south transit from *maghā* to *half-śraviṣṭhā* for 6 months as *hot* and the 6 month return from south to north as *mild*. Starting with such formulations in the Vedas proper, astronomy emerged as an ancillary to the Vedas by the middle of the second millennium BCE, to be aptly called *Vedāṅga Jyotiṣa*.

Three textual traditions of *Jyotiṣa* attributed to Parāśara, Vṛddha-Garga and Lagadha, have come down to us from this period. Among these three, the first called the *Parāśaratantra* (*PT*) being largely in prose stands in stark contrast with the other two. This is the first text to give the six seasonal solar zodiac; conditions for the rise and set of the southern star Agastya (Canopus); visibility day numbers for Venus, Mercury, Jupiter, and Saturn. This is also the first text to list twenty-six comets with names, their transit among the stars and arrival intervals in years. The second text denoted here as *VGJ* contains archaic prose parts and also long versified chapters on varied topics added at later dates. The text seems to have had an original nucleus in the 24th section named the *Mahāsalilam* over which later layers have been deposited in differing order. It is plausible that *PT* and *VGJ* originated as independent traditions, but over time *VGJ* seems to have inherited the astral content of the *Ādityacāra*, some parts of *Rāhucāra* and large parts of *Ketucāra* from *PT*. *VGJ* is more detailed about moon, the sidereal and synodic months and the unequal time spent by moon with the asterisms. Both the texts present matter-of-fact sky observations. *VGJ* is more detailed, repetitive

and with texts of several other authors interpolated by the manuscript copyists. While *PT* is purely observational, *VGJ* recommends combination of observation and computation in the context of moon's conjunction with the stars.¹⁷ *VGJ* has long chapters devoted to each of the five planets, with quantitative information on visibility and retrograde movement of Mars, which is absent in *PT*. Lagadha's work on finding the position of sun and moon in the 5-year cycle is short and terse but more sophisticated than the other two being entirely computational. The common factor of all the three is their Vedic origin, absence of week days and *Rāśi* (Sign) notation and starting of the yearly cycle at the winter solstice point, even if the determination of this were to be approximate. If we take the general view that sky observations precede computational approaches, the chronological order of the three *Vedāṅga Jyotiṣa* tradition has to be first *PT*, next *VGJ*, followed by the *Ārca-yājuṣa-jyotiṣa* of Lagadha. All the three have Vedic precedents as well as later interpolations, but interestingly in *VGJ* we get a verifiable temporal separation of eight centuries (c1300 to 500 BCE) between two chapters on the transit of sun through the *nakṣatra* circle.

9 Conclusion

The *nakṣatra* system for tracking moon in the background of stars has been in vogue since very ancient times. As interest in understanding the relation between seasons and the position of sun grew, identifying some special *nakṣatra* for heralding important seasons came into practice. Naked eye observation of rise of sun in the extreme south position of the horizon was the starting of the *śisīra ṛtu*, harmonized as the winter solstice day. Probably in the early days when observation of sun's position with a *nakṣatra* was not yet practiced, the onset of the seasons was counted in number of days starting from the vague winter solstice day. With evidence for observing early morning Vedic *nakṣatra* before sunrise as in the *Taittirīya Brāhmaṇa* and the northern and southern sojourn of sun correlated with visible *nakṣatras* as in *MAU*, we can say that a primitive solar zodiac was theoretically conceptualized in the core Vedic period with two *ayana*, three *cāturmāsya* and six *ṛtu* (seasons). This background work got empirically formalized in *PT* and *VGJ* by observing the seasonal boundary *nakṣatras* in the early morning sky, by which the onset of the seasons could be forecast. Such seasonal *nakṣatra* information available in *VGJ*, in two different sections, is analyzed in the present study. Sun's transit through the six seasons mentioned in terms of nine *nakṣatra* names forms part of the earlier

¹⁶ पुनर्वसू सूनुता चारु पुष्यो भानुराश्लेषा अयनं मघा मे ॥ (*Atharva Veda Samhitā* 19.7.2b).

¹⁷ नहि सर्वत्र गणितं नहि सर्वत्र दर्शनम् । दर्शनं गणितं चैव युगपद्योगसाधकम् ॥ (*VGJ; Āṅga 2; Candramārga*, v.6).



Ādityacāra section. This can be shown to belong to *c* 1300 BCE. The *Ṛtusvabhāva* section wherein prominent twelve *nakṣatras* through which sun transits in the 12 months of the year are stated can be dated to *c* 500 BCE. This by itself should be of interest in following how the original Vṛddha-Garga school has contributed to the development of astral literature in India before the Common Era.

Acknowledgements The study of the *VGJ* manuscripts was supported by ICHR through a project during 2016–2018. Help received from Vinay Iyer, Anand Viswanathan and H. S. Sudarshan in reading and comparing the manuscripts is thankfully acknowledged.

References

- Abhyankar, K. D. (1991). Misidentification of some Indian *nakṣatras*. *Indian Journal of History of Science*, 26(1), 1–10.
- Dikshit, S. B. (1969, 1981). *Bharatiya Jyotish Sastra (in Marathi) Poona* (1896), Vol. 1. (English trans.: Vaidya, R.V.). Government of India Press.
- Dwivedi, S. (1908). *Yājñusa Jyotiṣa edited with the Commentary of Somākara Śeṣa (Sanskrit)*, Medical Hall Press, Benares.
- Geslani, M., Mak, B., Yano, M., & Zysk, K. G. (2017). Garga and early astral science in India. *History of Science in South Asia*, 5(1), 151–191.
- Gondalekhar, P. (2013). *The time keepers of the Vedas*. Manohar. [ISBN 978-81-7304-969-9].
- Iyengar, R. N. (2013). *Parāśara Tantra* (Ed. trans & Notes). Jain University Press. [ISBN 978-81-9209-924-8].
- Iyengar, R. N. (2014). Parāśara's six season solar zodiac and heliacal visibility of star Agastya in 1350–1130 BCE. *Indian Journal of History of Science*, 49(3), 223–238.
- Iyengar, R. N., Sudarshan, H. S., & Viswanathan, A. (2019). *Vṛddhagārgya Jyotiṣa (Part1)*. *Tattvadīpaḥ, Journal of Academy of Sanskrit Research, Melkote*, 25(1), 60–81.
- Mak, B. (2019). Vedic astral lore and planetary science in the *Gārgyājyotiṣa*. *History of Science in South Asia*, 7, 52–71.
- Mankad, D. R. (1951). *Puranik chronology*. Gangajala Prakashan.
- Mitchiner, J. E. (1986). *Yuga Purāna*. The Asiatic Society.
- Pingree, D. (1971). *Census of the exact sciences in Sanskrit* (Vol. 1–4). American Philosophical Society.
- Saha, M. N., & Lahiri. (1955). *Report of the calendar reform committee*. Council for Scientific and Industrial Research.
- Sastry T. S. K. (1984). *Vedānga Jyotiṣa of Lagadha*. *Indian Journal of History of Science*, 19(4), 1–74.
- Sen, S. N., & Shukla, K. S. (Eds.). (2000). *History of astronomy in India* (2nd ed.). Indian National Science Academy.



Mahāsalilam

L 10-11

Manuscript collection of VGS, recognition of importance of 24th Aṅga, Vedic concepts, explanations, Maghādi epoch, primary Vedāṅga Jyotiṣa. Agni-Soma of MS, Theory of Anomaly. Importance of the VGJ school.

Refer to the book Mahāsalilam.

Parāśara Tantra

L-12

Reconstruction, Structure, contents, Date, Time definitions, Solar zodiac, Star Agastya. Nāḍi Nakṣatra Astrology of Parāśara. Natural Sciences in PT and VGJ. Astronomy/Science heritage of Parāśara and Vṛddhagarga.

Refer to the book Parāśara Tantra.

Time Measurement

L-13

Muhūrta, Nāḍikā, Ghaṭikā, Jalayantra, Akṣara, Vedic Prātaranuvāka, Siddhānta Calibration with 60 *Gurvakṣara* in the *Līlākhelā* meter.

Refer to enclosed IJHS publication

Akṣara the Basic Unit of Time Measure in Ancient India

R. N. Iyengar^{a*}, H. S. Sudarshan^b, Anand Viswanathan^b

^aDistinguished Professor, ^bResearch Associate,
Centre for Ancient History and Culture, Jain University, Bangalore.

(Received 15 August 2020)

Abstract

In this paper after a brief review of ancient Indian time units, the ingenious method of Indian astronomers for calibrating the small time unit of *vighaṭikā* (24 seconds) phonetically by the recitation of a Sanskrit verse in the *līlākhelā* meter with sixty *gurvakṣaras*, is experimentally verified by sixty independent sample recitations. This is followed by exploring the concept of congruence of *akṣara* count and time periods such as the month and the year in Vedic texts. This leads to the symbolic equivalence of the *br̥hatī* meter of 36 syllables to the Year and several other numerical synchronies between phenomenal time and *akṣara*. The 1000 *br̥hatī* verses of the *prātarānuvāka* nocturnal performance in the *atirātra* ritual is the traceable most ancient origin and inspiration for gauging and estimating lapse of time by recognizing audible syllable as a time measure. To verify this, apart from text based theoretical estimates, real time information from a famous *śrauta* expert on his *prātarānuvāka* performance is presented. It is further demonstrated empirically that the rate of 3600 *gurvakṣara* per *ghaṭikā* of *siddhānta* astronomy is closely correlated with the speed of present day traditional chanting of the *Ṛgveda*, the fidelity of which has remained stable over millennia.

Key words: *Br̥hatī-chandas*, *Gurvakṣara*, *Līlākhelā*, Oral calibration, *Prātarānuvāka*, Time unit, Vedic recitation, *Vighaṭikā*, Water-clock.

1 Introduction

A large number of time measures with a variety of nomenclature and conversion values are mentioned in ancient Indian texts. In a recent publication Hayashi (2017) has presented a detailed review of time units in ancient and medieval India. He has discussed almost all important texts numbering sixty. There are some extremely small measures such as *aṇu* and *truṭī* as well as some very large time measures such as *yuga*, and *kalpa*. It would be clear that for practical purposes *muhūrta*, *nāḍikā* (*ghaṭikā*), *ahorātra*, *pakṣa*, *tithi*, *māsa*, *ayana*, *rtu*,

varṣa with their simple multiples should have been in vogue. The smallest measures *samaya*, *truṭī*, *paramāṇu* must have been proposed by philosophers and mathematicians to imaginatively indicate that Time is continuous with no gaps in between.

Texts describing instruments for measurement of time within an *ahorātra* provide evidences to two types of devices; the gnomon (*śāṅku*) and the water clock (*jalayantra*). A detailed description of such devices found in Sanskrit texts with relevant historical background and available photographs has been presented by Sarma (1994, 2001) (Figure 1). Several of his investigations on the water clock and time determination in medieval India with insightful discussions are available in his monograph *The*

Archaic and the Exotic (2008). Further recently Sarma (2018) has presented a detailed exposition on how the Jaina text *Jyotiṣkaraṇḍakam* by Pādalipta Sūri (c 100 CE) describes time measurement using the water clock and the steelyard.

2 Jalayantra

Two major types of water clocks, with some minor variants, were popular in ancient India. The *nālikāyantra*, perhaps the more ancient device, consisted of a tall jar or a pot with an outflow orifice at the bottom. The device when filled up with water at sunrise (*prātaḥ*) would get emptied at the next sunrise representing 60 *nāḍikā*. Assuming that on the equinoctial day, sun at midday (*madhyāhna*) and sunset (*sāyam*) were observed, two more time markings could have been done on the device. Measuring finer intervals in such a device would be complex since the relation between time elapsed from sunrise to the water level is not necessarily linear. For example, if a cylindrical vessel of uniform cross section empties in one *ahorātra* of 60 *nāḍikā* (30 *muhūrta*), the time elapsed from sunrise to the point when the water is at mid-height will not be 15 but will be $(15/\sqrt{2})$ or between 10 and 11 *muhūrta*. However, by trial and error one may be able to mark two more graduations when sun is halfway between horizon and zenith and when sun is between midday and sunset.

The other device, namely the *ghaṭikāyantra* is the sinking-bowl type of water clock. This appears to have been popular among astronomers, administrators and priests who had to specify time periods within a day in advance to conduct the rituals during prescribed intervals. In the *ghaṭikāyantra*, the bowl would sink 60 times in one *ahorātra* or once in a *ghaṭikā* same as *nāḍikā* that is half *muhūrta*. The shape and dimensions of this bowl are mentioned in a few texts. This must have been arrived at by experimentation and continuous refinements. Based on available textual information, Kulkarni (1986) verified analytically, applying the laws of Mechanics, that the spherical pot mentioned in the *Arthaśāstra* when filled fully, would take nearly 24 minutes or one *ghaṭi* to discharge one *pala* of water.¹

¹सुवर्णमाषकाश्चत्वारश्वतुरङ्गलायामाः कुम्भच्छिद्रमाढकमम्भसो वा नालिका ॥ KAS (22.35).

Whichever device was in use, there must have been an independent way to calibrate the unit of *muhūrta* or of *ghaṭi* or some part thereof. Only after such verification the water clock could get marked for measuring and announcing time routinely for administrative purposes. This was well known to ancient Indian scientific thinkers who proposed several smaller natural markers of time; *akṣara* (syllable), *nimeṣa* (eye wink), *prāṇa* or *asu* (breath or pulse rate). It is easy to note that these parameters are dependent on the subject selected for observation and hence vary from person to person. Whichever fundamental unit one may prefer, the accuracy of dividing *ahorātra* into 30 or 60 equal parts would depend on the accuracy of equating a convenient longer time unit on the device to the equivalent number of *akṣara*, or *nimeṣa* or *prāṇa*. In the medieval texts several equalities for time units are available, sometimes with same name but with different equations. Fortunately, all authors belonging to widely differing time periods and regions, are in agreement that *ahorātra* should be taken as 30 *muhūrta* as in the Vedas, and reckon it as 60 *nāḍi(kā)* or *ghaṭi(kā)*. This must have helped standardization of time measure with *akṣara* as the fundamental unit all over India. Before we consider *akṣara* in detail, a brief reality check on the other units would be useful.

3 Nimeṣa, Asu, Prāṇa

Nimeṣa refers to the time taken for one eye-wink or blink. This word appears in the *Ṛgveda* and in several other Vedic texts. Notably the *Maitrāyaṇīya-āranyaka* (c 1800 BCE) which declares sun as the generatrix of Time (*sūryo yoniḥ kālasya*), mentions *nimeṣa* as a time unit, but does not quantify the term.² Blinking of eyes is a normal activity for all humans, but can be voluntary or involuntary. The rate of blink is sure to vary since continuous voluntary blinking fatigues the muscles. The natural clock with reference to which the experimental value had to be obtained was the position of the sun in the sky divided into two, three or four observably equal spatial intervals. The *Viṣṇupurāṇa* and the *Samarāṅgaṇa-sūtradhāra* of King Bhoja (1055 CE) report 1 *muhūrta* = 13500 *nimeṣa*. The famous astronomical text *Siddhānta-śiromaṇi* of 12th

²अथान्यत्राप्युक्तमन्नं वा अस्य सर्वस्य योनिः, कालश्चात्रस्य, सूर्यो योनिः कालस्य । तस्यैतद्रूपं यन्निमेषादिकालात् सम्भृतं द्वादशात्मकं वत्सरम् । एतस्याग्नेयमर्धम्, अर्धं वारुणम् । MAU (6.14).



Figure 1 (a) Copper bowl water clock sinking in half *ghaṭi* from Uva Province, Sri Lanka in the Pitt Rivers Museum of Ethnology, Oxford. (photo by S. R. Sarma); (b) Coconut shell water clock sinking in one *ghaṭi*. Government Museum, Chennai. (photo by S. Ramaratnam)

Source: Sarma S. R. *A Descriptive Catalogue of Indian Astronomical Instruments*, 2019, pp. 3821–26.

Reproduced with permission.

century also reports the same value. Quite interestingly all the above four texts state two smaller units of time *kāṣṭhā* and *kalā* before *muhūrta* in the same way as 1 *kāṣṭhā* = 15 *nimeṣa*; 1 *kalā* = 30 *kāṣṭhā* and 1 *muhūrta* = 30 *kalā*. Several other texts also refer to the *nimeṣa*, but this parameter must have been difficult to count in practice, particularly for fixing parts of a *muhūrta*. This limitation seems to have been circumvented by accepting *nimeṣa* to be equivalent to *laghvakṣara* time. The other basic unit *asu* is the breath rate and *prāṇa* the pulse rate. But the two words are often used with varying meanings in different contexts. The *Śatapatha-brāhmaṇa* (*ŚB* 12.3) divides *muhūrta* into four smaller units namely, *kṣipra*, *etarhi*, *idānīm* and *prāṇa* each being 15 times the next one in the same order.³ The pulse rate as per modern measurements is about 70 per minute. This gives approximately 3360 heart beats per *muhūrta*. This value is quite close to 3375 *idānīm* for one *muhūrta* of *ŚB*. It is to be noted that the same word *idānī* of the *Taittirīya Brāhmaṇa* (*TB*) and of the *ŚB* carry different values. Also, the *prāṇa* unit of *ŚB* in the present context is not the heart beat. On the other hand the rate of breathing of normal

humans is around 15 per minute. This leads to 720 *asu* (breaths) per *muhūrta* leading to 21600 breaths per *ahorātra*, which count is reported in several texts. Some texts such as the *Siddhānta-śekhara* (10th cent.) denote *asu* as *prāṇa* and report 21600 *prāṇa* for one *ahorātra*, as in the *Sūrya-siddhānta*. *Nimeṣa*, *asu* and/or *prāṇa* were not imaginary units, but were based on experiments. However, they were not robust for arriving at a scale that can be impersonally applied for measuring *ghaṭi* or *muhūrta* repetitively like a short rope or stick (*śulba/daṇḍa*) that was used repetitively in length measurements.

4 Akṣara

It can be easily gathered from the review of Hayashi (2017) or otherwise, that *muhūrta* was the older unit inherited from the Vedas but half-*muhūrta* or the *nāḍikā/ghaṭikā*, was perhaps more convenient for day to day work. A further interesting shift is in the recognition of *akṣara* as more practical than *nimeṣa/prāṇa*, although the two units are not independent of each other. The most ancient traceable text to mention *akṣara* or syllable as a unit of time is Lagadha's *Vedāṅga-jyotiṣa* (*LVI*). Both the Ṛgvedic and the Yajurvedic recensions (Sastriy and Sarma 1985) mention the length of *ahorātra* as 30 *muhūrta* equivalent to 60 *nāḍikā*, as in the works of Āryabhaṭa, Varāhamihira and others. However, the relation between the *akṣara* and the *nāḍikā* of *LVI* is different from the equation stated

³दश च वै सहस्राण्यष्टौ च शतानि संवत्सरस्य मुहूर्ताः। यावन्तो मुहूर्तास्तावन्ति पञ्चदशकृत्वः क्षिप्राणि। यावन्ति क्षिप्राणि तावन्ति पञ्चदशकृत्व एतर्हीणि। यावन्त्येतर्हीणि तावन्ति पञ्चदशकृत्व इदानीनि। यावन्तीदानीनि तावन्तः पञ्चदशकृत्वः प्राणाः। यावन्तः प्राणास्तावन्तोऽक्तनाः। यावन्तोऽक्तनास्तावन्तो निमेषाः। यावन्तो निमेषास्तावन्तो लोमगर्ताः। यावन्तो लोमगर्तास्तावन्ति स्वेदायनानि। यावन्ति स्वेदायनानि तावन्त एते स्तोका वर्षन्ति॥ *ŚB* (12.3.2.5).

by later astronomers. In the *LVJ* the two units are related as 1 *nāḍika* = 6231 *akṣara*, which is different from 1 *nāḍikā* = 3600 *gurvakṣara* of the *siddhānta* texts. Even though Sastry and Sarma (1985) mention that the *akṣara* of *LVJ* is equal to one *gurvakṣara* of two *mātrā* time duration there is no statement in the original text to that effect. Here it is to be noted that the word *akṣara* normally translated as 'syllable' carries different shades of meaning in technical subjects. In the present context it should be interpreted as the time taken to produce audible sound of one syllable of a particular type. Unless specified clearly, *akṣara* can be one of the four types; *hrasva* (short), *laghu* (light), *guru* (heavy), *dīrgha* (long). The time taken by a *hrasva* and a *laghu* and similarly by a *guru* and a *dīrgha* syllable need not be exactly equal. In Sanskrit prosody it is by definition the long and heavy syllables take twice the time relative to the short and light ones that are assigned one *mātrā* measure. The word *mātrā* (measure) is inherited from the antecedent oral tradition wherein the *Prātiśākhya* texts describe and fix the Vedas in minute details of *chandas*, *akṣara*, *svara*, and *mātrā*. In classical literature the *mātrā* is by definition not divisible, unlike in the Vedic tradition where *mātrā* is divided into at least four fractions. Without further digression, it suffices to point out that the *akṣara* of *LVJ* might be referring to a particular definition of Vedic *syllable* as a time unit which need not closely match with the syllabic time of classical Sanskrit prosody (Tripathi 2008).

There are also references to *laghvakṣara* (light or short syllable) as in the *Purāṇa*,⁴ which equate *nimeṣa* and *laghvakṣara* leading to 13500 short syllables per *muhūrta*. *Suśruta Samhitā* also equates *nimeṣa* and *laghvakṣara*, but present day texts lead to 9045 syllables per *muhūrta*.⁵ This seems to be based on the misreading of the word *trimśat* as *vimśat* in later day manuscripts which has formed the basis for present day printed versions. If we take the original reading as *trimśat*, (30 *kalā* per *muhūrta*) we get the same value of 13500 *laghvakṣara* per *muhūrta* as in other texts. There is also mention of *vikṛtākṣara* (distorted syllable) in the *Parāśara Tantra* (Iyengar 2013) as quoted by Bhaṭṭotpala that equates 16000 *vikṛtākṣara* to

⁴निमेषकालतुल्यं हि विद्याल्लघ्वक्षरं च यत् ॥ काष्ठा निमेषा दश पञ्च चैव त्रिंशच्च काष्ठा गणयेत्कलां तु। त्रिंशत्कलाश्चापि भवेन्मुहूर्तस्तैस्त्रिंशता राज्यहनी समे ते॥ *Brahmāṇḍa Purāṇa* (I. 29.5–6).

⁵तत्र लघ्वक्षरोच्चारणमात्रोऽक्षिनिमेषः, पञ्चदशाक्षिनिमेषाः काष्ठा, त्रिंशत्काष्ठाः कला, विंशतिकलो मुहूर्तः कलादशभागश्च, त्रिंशन्मुहूर्तमहोरात्रं, पञ्चदशाहोरात्राणि पक्षाः। स च द्विविधः शुक्लः कृष्णश्च। तौ मासः। *Suśruta Samhitā* (6.5).

one *muhūrta*.

5 Gurvakṣara Scale

Definition of time in terms of different *akṣara* type points to the wide spread practice of estimating elapsed time using oral recitation of some texts. This should not be surprising since the learning of the Vedas has remained an oral tradition to this day. But the time covered naturally depends on the internal structure of the syllabic compositions and the speed of oral reproduction. Indian astronomers in their search for accuracy in the use of the water clock must have experimented with different texts to finally arrive at the attractive result that 60 *gurvakṣara* sound-string would need one *vināḍī* or *vighaṭī*. Sixty of such *vināḍī* make up one *nāḍikā* or *ghaṭikā* equal to the time needed for the bowl type water clock to sink once. While the *Soma*-, *Brahma-siddhānta* (Dvivedi 1912) and the *Vṛddhavasīṣṭha-siddhānta* (Dvivedi 1917) know the above relation of 60 *gurvakṣara* being equal to one *vināḍī*, it is the *Pañcasiddhāntikā* (*PS*) that standardizes this for calibration of the water clock. Varāhamihira (c 530 CE) the author of this text gives in the 14th Chapter, a verse of 60 *gurvakṣara* that can be used as an objective audible scale for measuring longer time by simply repeating it the required number of times. The relevant text and the translation by Sastry and Sarma (1993) are as follows;

द्युनिशिविनिःसृततोयादिष्टच्छिद्रेण षष्टिभागो यः ।
सा नाडी (स्वमथो) वा श्वासाशीतिः शतं पुंसः ॥ ३१ ॥
कुम्भार्धाकारं ताम्रं पात्रं कार्यं मूले छिद्रं
स्वच्छे तोये कुण्डे न्यस्तं तस्मिन् पूर्णे नाडी स्यात् ।
मूलाल्पत्वाद्बोधो वा षष्टिर्योज्या चाह्ना रात्र्या वर्णाः
षष्टिर्वक्राः श्लोको यत्तत् षष्ट्या वा सा स्यात् ॥ ३२ ॥
(VM)

One-sixtieth of the time taken by water to flow out through a desired hole during a nychthemeron is defined as the duration of a *nāḍī*. Or it is the time of 180 breaths of a man. ॥31॥

Construct a copper vessel resembling one-half of a spherical pot and pierce a hole at its bottom. Put it in pure water in a basin. The time in which the vessel is filled up is the duration of a *nāḍī*. The hole at the bottom of the vessel should be so small that on account of its small

size, the vessel may sink into water exactly sixty times during nychthemeron. Or, it is the time in which one may recite 60 times a verse composed of 60 long syllables (as verse 32 itself is).

॥32॥

The above verse 32 (denoted as VM) has fifteen *gurvaksaras* in each foot in the meter *lilākhelā* (also called *kāmakrīḍā* or *sārāṅgikā*) belonging to the class of *atiśakvarī chandas*. Varāhamihira in *PS* reviews five older astronomical texts (*Paulīśa*, *Romaka*, *Vasiṣṭha*, *Sūrya* and *Paitāmaha siddhānta*) but in Chapter 14 there is no attribution to other authors for the above verse on the water clock. Before we verify the accuracy of VM, it is noted that there is another verse in the same meter in the commentary by Bhāskara-I (7th cent.) on the *kālakriyāpāda* of Āryabhaṭa (5th cent.). This verse with its correct version (B-I) as in the manuscript *ghaṭīyantra-ghaṭanā-vidhi* along with two more in the same meter has been unearthed by Sarma (2001).⁶ The verse given by Bhāskara for calibrating the *vināḍī* is:

मा कान्ते पक्षस्यान्ते पर्याकाशे देशे स्वाप्सीः
कान्तं वक्त्रं वृत्तं पूर्णं चन्द्रं मत्वा रात्रौ चेत् ।
शुक्लामः प्राटंश्चेत् राहुः क्रूरः प्राद्यात्
तस्माद्भ्रान्ते हर्म्यस्यान्ते शय्यैकान्ते कर्तव्या ॥(B-I)

In the previous section different *akṣara* types and their measures were mentioned. In the absence of a clear definition of the syllabic time it would be reasonable to say that about 13500–16000 short syllables per *muhūrta* was the prevalent understanding before the astronomers introduced their refinement. The above approximates to 7375 long/heavy syllables per *muhūrta* as per the conventional understanding that *laghu* and *guru* are for one and two *mātrā* duration respectively. This evidence of measuring *muhūrta* in terms of *akṣara* counting in the early *purāṇas* and other texts originating before the common era naturally points to Vedic oral tradition as the progenitor of the

⁶Sarma, S. R. (2018, p. 165). Two more verses in the same meter from the above manuscript follow:

मार्ताण्डस्तारानाथः क्षोणीसूनुः सनुश्चेन्दोः
वागीशो दैत्याचार्यः छायापुत्रो राहुः केतुः।
नक्षत्रैरश्विन्याद्यैस्तारायुक्तेश्चाभिः सर्वे
कुर्यासुः कल्याणं वो नित्यारोग्यं लक्ष्मीमायुः॥12॥
लोकक्षेमायासीन्मत्स्यः कूर्मः क्रोडः पुंसिंहो
यो ह्रस्वाकारो रामो रामः कृष्णो बुद्धः कल्की।
एवं नानारूपं नानाकारं नाना नामानं
योगिध्वयं देवं देवानां वन्देऽहं गोविन्दम्॥13॥

concept of *akṣara-kāla* or syllabic-time. This point will be further discussed and demonstrated to be so in the present study.

Astronomers before and after Āryabhaṭa being aware of the prevalent use of *akṣara* count as a time measuring artifice, standardized one *vināḍī* (*vighaṭī*) to the audible scale of 60 *gurvaksaras* embedded by verses in a particular meter known as *lilākhelā*, with 15 long/heavy syllables per quarter. The speed of recitation is said to be neither too fast nor too slow but in medium pace as pointed out by Bhāskara.⁷ This must have existed as a culturally inherited trait followed in the medieval schools aptly called *ghaṭikāsthāna*, where a *ghaṭīyantra* the sinking type water clock was also operated probably by the students. Existence of such a school with a time measuring device is well attested in the inscription dated 1058 CE at Nagai, in Gulbarga District. This record mentions about the school, the number of teachers and students and the donation made for the upkeep of the institution including payment for the *ghaṭikā-praharī*, whose work was to announce the passage of each *ghaṭikā* by beating a gong.⁸

6 An Experiment

An interesting question arising out of the above prescription is, how accurate are the verses for representing one *vighaṭikā* that is equal to 24 seconds in current parlance? To understand this issue we conducted an experiment with the help of 30 volunteers drawn from in and around Bangalore. The group included persons knowledgeable in Sanskrit as well as some who could not understand the language, but had the tradition of reciting Sanskrit texts in their families for religious and spiritual practices. The members were requested to recite audibly the verse (B-I) in private at medium pace, as is normal for them, and submit the audio tracks. After a lapse of several months the verse (VM) from the *Pañcasiddhāntikā* was tested in similar fashion by another group that included a few members

⁷गुर्वक्षरेषु मध्यमवृत्तिग्रहणम्। “ गुर्वक्षराणि षष्टिः” इत्यत्र मध्यमायां वृत्तौ षष्टिः गुर्वक्षराणि विनाडिकाकाल इति वक्तव्यम् । अन्यथा हि तिसृषु अपि वृत्तिषु अविशेषेण ग्रहणं प्राप्नोति । तद्यथा – द्रुतायां वृत्तौ षष्टिः गुर्वक्षराण्यल्पेन कालेन पठ्यन्ते, विलम्बितायां महता कालेन इति, मध्यमायां पुनर्न अल्पेन, न महता कालेन । तर्त्तर्हि मध्यमवृत्तिग्रहणं कर्तव्यम् । कथमनुच्यमानमवगम्यते, लोकप्रसिद्धेः। तद्यथा – लोके अनिर्दिष्टेषु कार्येषु मध्यमप्राप्तिः॥ Commentary of Bhāskara-I on the *Āryabhaṭīya*.

⁸The Inscriptions of Nagai, published in *Hyderabad Archaeological Series*, No. 8. Calcutta, 1928, p.16.

from the former group. The time taken for recitation was extracted from the sample audio tracks. The results obtained for both the verses are shown below in seconds.

Time samples for B-I: 23.28, 23.13, 22.23, 23.76, 22.4, 23.68, 25.2, 23.22, 24.15, 26.65, 23.42, 22.1, 24.72, 25.59, 24.47, 23.94, 25.91, 22.62, 25.04, 25.74, 23.06, 24.02, 23.31, 24.23, 23.19, 24.13, 24.15, 23.29, 24.31, 23.3.

Time samples for VM: 22.61, 21.45, 24.62, 23.81, 23.16, 25.51, 22.52, 21.98, 21.35, 23.55, 25.83, 24.86, 23.05, 23.12, 23.84, 23.48, 24.86, 23.07, 23.57, 25.04, 21.95, 25.18, 23.17, 23.5, 23.74, 24.24, 23.81, 24.29, 22.68, 23.76.

The average time in seconds taken for B-I is 23.94 with standard deviation of 1.1 seconds. The average time for the VM verse is 23.59 seconds, the standard deviation being 1.12 seconds. The sample variation in both the cases is about 5%. Verse B-I is easier to recite with lesser number of conjunct syllables and hence seems to be more accurate than VM.

7 Vedic Prelude

Vedic texts characterize *kāla* (Time) in a variety of ways. While some of these are abstract and philosophical, others are about *time* as related to the sun, the moon and the stars. The latter is the *mūrta-kāla* (concrete or phenomenal time) such as year, month, day, night etc. *Maitrāyaṇīya Āraṇyaka Upaniṣad* (MAU) extols *Time* as *Brahman*, with and without form.⁹ Time with form, that is nameable time divisions, starts with Sun. The *ahorātra* (day-night) based on counting sunrises is the most natural time unit, so much so the MAU declares sun to be the origin/generator of time.¹⁰ This and such other evidences indicate that with the help of the sun and the moon, longer periods such as *pakṣa*, *māsa*, *ṛtu*, *ayana*, *saṃvatsara* were conceptualized and used. It is no exaggeration to say that Vedic sacrifices, rites and rituals couched in legends of meters as deities show a deep sense of preoccupation with time measures, short and long, synchronized with numbers and syllables.

⁹द्वे वाव ब्रह्मणो रूपे कालश्चाकालश्च ॥ MAU (6.15).

¹⁰See footnote 2.

8 Prajāpati's Choice of 15 and 30

The concept of *māsa*, the time interval from full moon to full moon and from *amāvāsyā* to *amāvāsyā* is central to Vedic culture. It is easy to note that sunrise to sunrise is one *ahorātra* and hence this can be counted in integral numbers. But the *māsa* measure of sunset or sunrise as related with moon will not be a round number but will be between 29 and 30. The naming of both the *pūrṇamāsa* and the *amāvāsyā* as the Fifteenth that is *pañcadaśī* in the *Taittirīya Brāhmaṇa* (TB 1.5.10) is due to the idea of *pakṣa* synchronizing with the number 15. The *Śatapatha Brāhmaṇa* provides the heuristics for selecting the numbers 15 and 30 through a legend connected with *Prajāpati* one of his forms being the Year. After creation of the cosmos the joints of *Prajāpati* became slack at the meeting of day and night and at full moon and at *amāvāsyā*. His joints at the syzygy were fixed by conducting the *darśa-pūrṇamāsa* rites.¹¹ The text further works out by recursion how the 360 days and 360 nights, that make up the year of 720 (*ahas + rātri*), can be factored into integers starting from 2 and increasing by unity at every step up to 24.

The number 720 is divided by 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 16, 18, 20 to get 360, 240, 180, 144, 120, 90, 80, 72, 60, 48, 45, 40, 36. The text says, for each of these possibilities, *Prajāpati* could not envelop (*sa naiva vyāpnot*).¹² When divided by 7, 11, 13, 14, 17, 19, 21, 22, and 23 *Prajāpati* could not manifest himself (*na vyabhavat*).¹³ Then, He sat there in that 15 boxed figure. Since he settled in the Fifteen, there are 15 forms (for moon) in the waxing and 15 forms in the waning fortnight.¹⁴ Twenty-four is the number of *ardhamāsa* (half-months) in a year.¹⁵ In similar-

¹¹प्रजापतेर्ह वै प्रजाः ससृजानस्य पर्वाणि विसंखंसुः। स वै संवत्सर एव प्रजापतिः तस्यैतानि पर्वाण्यहोरात्रयोः सन्धी पौर्णमासी चामावास्या चर्तुमुखानि ॥ स विस्रस्तैः पर्वभिः न शशाक संहातुम्। तमेतैर्हविर्यज्ञैर्देवा अभिषज्यन्नग्निहोत्रेणैवाहोरात्रयोः सन्धी तत्पर्वाभिषज्यंस्तत्समदधुः पौर्णमासेन चैवामावास्येन च । पौर्णमासीं चामावास्यां च तत्पर्वाभिषज्यंस्तत्समदधुः। चातुर्मास्यैरेवर्तुमुखानि तत्पर्वाभिषज्यंस्तत्समदधुः ॥ ŚB (1.6.3).

¹²स द्वेधात्मानं व्यौहत् षष्टिश्च त्रीणि च शतान्यन्यतरस्येष्टका अभवन्नेवमन्यतरस्य स न व्याप्नोत्। त्रीनात्मनोऽकुरुत्। तिस्रस्तिस्त्रोऽशीतय एकैकस्येष्टका अभवन्त्स नैव व्याप्नोत्। [...] विशतिमात्मनोऽकुरुत् षड्विंशदिष्टकान्त्स नैव व्याप्नोत् ॥ ŚB (10.4.2; 2-14).

¹³न सप्तधा व्यभवत्। [...] नैकविंशतिधा व्यभवत् द्वाविंशतिधान त्रयोविंशतिधा ॥ ŚB (10.4.2; 8-16).

¹⁴चतुर्विंशतिमात्मनोऽकुरुत् त्रिंशदिष्टकान्त्सोऽत्रातिष्ठत पञ्चदशे व्यूहे तद्यत्पञ्चदशे व्यूहेऽतिष्ठत। तस्मात् पञ्चदशापूर्वमाणस्य रूपाणि पञ्चदशापक्षीयमाणस्य ॥ ŚB (10.4.2; 17).

¹⁵अथ यच्चतुर्विंशतिमात्मनोऽकुरुत्, तस्माच्चतुर्विंशत्यर्धमासः संवत्सरः । ŚB

ity with the *śukla*- and the *kṛṣṇa-pakṣa* (bright- and dark-fortnight) being presided over by the number 15, the day and the night in an *ahorātra* are equated with 15 *muhūrta* of time.

This choice of taking *ahorātra* as equal to 30 *muhūrta* must be more ancient than the Brāhmaṇa texts. The word *muhūrta* occurs twice (*RV* III.33.5 & III.53.8) in the *Ṛgveda*, but from the context of the hymns it is not clear whether the word stands for one-thirtieth of *ahorātra* or is used in the sense of vague time. However, there are three instances where the number 30 is invoked referring to *Uṣas* (twilight) or Sun specifically illuminating and crossing 30 divisions every day.¹⁶ In the first instance (*RV* I.123.8) it is 30 *yojana* which is generally taken as a distance measure. In the other two cases (*RV* VI. 59.6 & X. 189.3) the larger context of the *sūkta* (hymn) is about time as *aharahaḥ* (day by day) and hence Sāyaṇācārya's interpretation of 30 *dhāma* and 30 *pada* as equivalent to 30 *muhūrta* of time should be acceptable. This convention of taking parts of time and space to be numerically congruent is preserved in the *Parāśaratantra* where it is asserted *kāla-kṣetrayoḥ sāmīyam*.¹⁷ This principle is reflected in (*RV* V. 76.3) where the day is divided into five parts. Starting from sunrise these intervals are named *prātaḥ*, *saṅgava*, *madhyāhna*, *aparāhna* and *sāyam*. Each of these intervals dependent on the position (*kṣetra*) of sun in the sky are notionally three *muhūrta* long, as attested in the *Viṣṇu Purāna*.¹⁸ The *Taittirīya Brāhmaṇa* (*TB*) fine tunes this time division to introduce individual names for the 15 day and 15 night *muhūrta* for the dark and bright fortnights¹⁹ separately and also mentions that each such *muhūrta* (48 minutes) is made of 15 further parts called

(10.4.2; 18).

¹⁶अनवद्याःत्रिंशत्तं योजनान्येकैका क्रतुं परि यन्ति सद्यः। *RV* (I.123.8 b).

हित्वी शिरो जिह्वया वावद्दृष्टत्त्रिंशत्पदा न्यक्रमीत् । *RV* (VI. 59.6 b).

त्रिंशद्भ्राम विराजति वाक्पतङ्गाय धीयते। प्रति वस्तोरह द्युभिः॥ *RV* (X.189.3).

¹⁷Quoted by Bhaṭṭotpala in his commentary on the *Brhatsamhitā*. Ref: *Parāśaratantra* (Iyengar 2013).

¹⁸रेखाप्रभृत्यथादित्ये त्रिमुहूर्तगते रवौ।

प्रातः स्मृतस्ततः कालो भागश्चाहः स पञ्चमः ॥

तस्मात् प्रातस्तनात्कालात् त्रिमुहूर्तस्तु सङ्गवः।

मध्याह्नस्त्रिमुहूर्तस्तु तस्मात्कालात् सङ्गवात् ॥

तस्मान्माध्याह्निकात्कालात् अपराह्न इति स्मृतः।

त्रय एव मुहूर्तास्तु कालभागः स्मृतो बुधैः ॥

आपराह्णे व्यतीते तु कालः सायाह्न एव च।

दशपञ्च मुहूर्तं वै मुहूर्तास्त्रय एव च ॥ *VP* (2.8.61-64).

¹⁹चित्रः केतुः प्रभानाभान्तु सम्भान्। [...]

आभूर्वाभूः प्रभूः शम्भूर्भुवः। *TB* (3.10.1.1-3).

*muhūrta-of-muhūrta*²⁰ also called *prati-muhūrta*. If such a small division as the *pratimuhūrta* (3 minutes 12 seconds) were to be important, what artifice might have been used to estimate the *muhūrta* measure in Vedic times? While there is no direct answer for this question in the sacred texts, it can be verified that *akṣara* count had significant role in stating, estimating and keeping vigil through specific time intervals.

9 Akṣara Congruence

The two prominent meanings of the word *akṣara* are i) imperishable, ii) syllable. Without going further into etymology, nuances and definitions of the word, we note that there is a hoary tradition of preserving the counts of the chapters, subdivisions, hymns, verses, words and the syllables of Vedic texts (Vaidya 1930). In some of the sacrificial rites the sacred formulas ritualistically state the number of syllables a particular hymn or a set of hymns contain. These statements are like recognizing equivalence between the number of *akṣara* and some important character and distinctive property of the deity that is invoked through the laudatory hymn. A typical example is about statements that enunciate connections between *samvatsara* as *Prajāpati* and the number of *akṣara* in a hymn or the number of stanzas in a ritual. Here we cite only a few such cases to illustrate the germination and growth of the idea of linking phenomenal time measure with syllable counts. The *Taittirīya Saṃhitā* refers to 15 *Sāmidhenī* verses that together make up 360 syllables to obtain the year of 360 days.²¹ *Aitareya Brāhmaṇa* (3.41) synchronizes 360 hymns with the length of the year counted as 360 *ahorātra* in the *ukthyā* sacrifice.²²

This *ukthyā* sacrifice has fifteen *stotras* and fifteen *śastras*. These make, if taken together, one

²⁰इदानीं तदानीमेतर्हि क्षिप्रमजिरम् ।

आशुर्निमेषः फणो द्रवन्नतिद्रवन् ।

त्वरंस्त्वरमाण आशुराशीयाञ्जवः। *TB* (3.10.1.4).

इदानीं तदानीमिति । एष एव तत् ।

एषहोव ते मुहूर्तानां मुहूर्ताः ॥ *TB* (3.10.9.9).

²¹पञ्चदश सामिधेनीरन्वाह पञ्चदश वा अर्धमासस्य रात्रयः।

अर्धमासशः संवत्सर आप्यते तासां त्रीणि च शतानि

षष्टिश्चाक्षराणि तावतीः संवत्सरस्य रात्रयः।

अक्षरश एव संवत्सरमाप्नोति। *TS* (2.5.8).

²²This is the summary as per the Mysore Palace Edition of the *Ṛgveda*, MPRV, Vol. 31 pp. 858–62.

month of thirty days. By performing this sacrifice they commence the year as divided into months. This *ukthyā* sacrifice has 360 *stotriya* verses as many as the year has days. By performing this sacrifice, they commence the year as divided into days.

A special character stated for the year is the number 36 made of 12 full moons, 12 *aṣṭakā* (half-moon in the dark fortnight) and 12 new moons. This is said to be homologous to the *br̥hatī* meter that consists of 36 syllables.²³ Such concepts built around the number 36, 360, 3600, 36000 and the *br̥hatī* meter appear in several Vedic texts. The *Aitareya Āraṇyaka* represents 100 years each of 360 days, in terms of 1000 *br̥hatī* verses each of 36 *akṣara*.²⁴ Since the total number of days and the total number of syllables are both equal to 36,000, apparently here one day is matched with one syllable. But there are instances where the match is made differently; the constant component being *br̥hatī* the 36-*akṣara* and its simple multiples.

We have seen above how the numbers 15 and 30 were arrived at in *ŚB* (10.4). The text in similar fashion continues to state the number of *muhūrta* in a year as 10,800. Along with the year, seasons, months, fortnights, day and nights, *muhūrta* is also a form or limb of *Prajāpati*. In the construction of the sacred Vedic altar described in minute detail in the *ŚB*, the 10,800 *muhūrta* are represented by that many *lokampr̥ṇā* bricks which fill the small space in between the specially consecrated bricks which represent longer time elements. In addition to such a theoretical equivalence between *Prajāpati* as Time (year and its parts) and *Prajāpati* as Space (*mahāvedi* and other altars) one more equation in terms of the syllables of the three Vedas is stated. As per *ŚB* the *Ṛgveda* has 432,000 *akṣaras*; the *Yajurveda* and the *Sāmaveda* have 288,000 and 144,000 *akṣaras* respectively.²⁵ These together, adding to 864,000

syllables, too form the body of *Prajāpati*. This number is 80 times 10,800 the number of *muhūrta* in a year. Thus, an *akṣara* is smaller in its esoteric magnitude than the *muhūrta*. Following such an argument the text discerns congruence between one *muhūrta* and 80 Vedic syllables. This is not still an equation suggested or speculated for the real time *muhūrta*. *ŚB* mentions about *Prajāpati*'s 1000-year sacrifice and asks the performer to imagine scaling up all the parameters of the sacred altar by 1000. Here, the *muhūrta* and the corresponding syllable relation remain same at 80 *akṣara*. But the total *lokampr̥ṇā* space filling bricks become one crore eight lakh (1,08,00,000) hair pits, on the body of the self-similar *Great Prajāpati*, that are stated to be equal to the number of stars seen in the sky.²⁶ We need not digress on the doctrines and theories of the Vedic *Brāhmaṇa* texts. It suffices to point out that an underlying axiomatic relation between time and the Vedic chants forms the doctrinal basis for maintaining temporal sequencing and work flow discipline in the rituals carried out in real time.

Though *muhūrta* was given prominence as a division of the day, it was not the smallest such Vedic measure. *TB* defines *prati-muhūrta* that divides *ahorātra* into 450 parts. As per the *ŚB* legend about *Prajāpati* and the number 15, *muhūrta* was divided further by fifteens several times. In the 12th *kāṇḍa* of *ŚB* this division goes up to 50625 parts of *ahorātra*. The *Śāṅkhāyana Śrautasūtra* a later text is an exception to the above rule of sequential division into 15 parts. This text divides *muhūrta* into 10 *nimeṣa* which is further divided into 10 *dhvaṁsī*. The commonality among the different Vedic texts is in the *ahorātra* divided into 30 equal *muhūrta* parts and an effort to visualize close affinity among day, night, month and year with the number 36 of the *br̥hati* meter.

10 Real Time

Leaving aside ideological musings about very long and very small time periods, division of the *ahorātra* should have been a practical necessity in the conduct of the sac-

साम्नामेतावद्धैतयोर्वेदयोर्त्यज्रापतिसृष्टं तौ त्रिंशत्तमे व्यूहे पङ्क्तिष्वतिष्ठेताम् । तौ यत्रिंशत्तमे व्यूहेऽतिष्ठेतां तस्मात्त्रिंशन्मासस्य रात्रयः। अथ यत्पङ्क्तिषु तस्मात्पाङ्क्तः प्रजापतिस्ता अष्टाशतमेव शतानि पङ्क्तयोऽभवन्॥ *ŚB* (10.4.2.23-24).

²⁶तस्य तपस्तेपानस्य एभ्यो लोमगर्तेभ्य ऊर्ध्वानि ज्योतीष्यायंस्तद्यानि तानि ज्योतीष्येतानि तानि नक्षत्राणि। यावन्त्येतानि नक्षत्राणि तावन्तो लोमगर्ता, यावन्तो लोमगर्तास्तावन्तः सहस्रसंवत्सरस्य मुहूर्ताः॥ *ŚB* (10.4.4.2).

²³यद्वेव संवत्सरमभिसम्पद्यते तद्बृहतीमभिसम्पद्यते

बृहती हि संवत्सरो द्वादश पौर्णमास्यो द्वादशाष्टका
द्वादशमावास्यास्तत्षड्विंशत् षड्विंशदक्षरा बृहती..॥ *ŚB* (6.4.2.10).
द्वादशपौर्णमास्यः। द्वादशाष्टकाः। द्वादशमावास्याः।
एषा वाव सा देवाक्षरा बृहती ॥ *TB* (1.5.12.2).

²⁴तद्वा इदं बृहतीसहस्रं सम्पन्नं तस्य वा एतस्य बृहतीसहस्रस्य संपन्नस्य षड्विंशतमक्षराणां सहस्राणि भवन्ति तावन्ति शतसंवत्सरस्याह्नां सहस्राणि भवन्ति। *Aitareya Aranyaka* (2.2.4).

²⁵स ऋचो व्यौहृद्वादश बृहतीसहस्राण्येतावत्यो हर्षो याः प्रजापतिसृष्टाः तान्त्रिंशत्तमे व्यूहे पङ्क्तिष्वतिष्ठन्त ता यत्रिंशत्तमे व्यूहेऽतिष्ठन्त तस्मात्त्रिंशन्मासस्य रात्रयोऽथ यत्पङ्क्तिषु तस्मात्पाङ्क्तः प्रजापतिस्ता अष्टाशतं शतानि पङ्क्तयोऽभवन् ॥ अथेतरो वेदो व्यौहृत् द्वादशैव बृहतीसहस्राण्यष्टौ यजुषां चत्वारि

rifices that were of various durations, from one day to one year and even longer. We have already seen that *RV* (V.76.3) attests five divisions of the day. These five divisions are elaborated qualitatively further in *TB* (1.5.3). Such a description with demarcation is not explicitly available for the night even though all the 15 day and 15 night *muhūrta* of the dark and bright fortnight are named separately in *TB* (3.10.1). However, allegorical explanation of how the night rites are to be carried out during the *Atirātra* sacrifice, which is a one-day *soma-yāga* already cited in *RV* (VII.103.7), is available in the *Aitareya Brāhmaṇa* (16.5). This starts with the legend of Indra clearing away *asurās* through the night with the help of the seven *chandās* (meters), that are defined in terms of the number of syllables contained in the hymns. This night ritual is carried out by the ordained group of priests in three cycles (*pariyāya*) each comprising four *camasa-gaṇa*. The text reads:

तान्वै प्रथमेनैव पर्यायेण पूर्वरात्रादनुदन्त मध्यमेन
मध्यरात्रादुत्तमेनापररात्रात्।

Here, there is clear mention of three-part division of the night each of which was taken to be of equal duration. Sāyaṇācārya the renowned representative of the practicing sacrificial tradition explains that each division of the night is meant to be of ten *ghaṭikā* (five *muhūrta*).²⁷ The time unit *ghaṭikā* is not met in Vedic texts, but widely used in the medieval period as measured by a water clock. Hence we can infer that Sāyaṇācārya's commentary refers to actual practice among *yājñika* groups during his time. Vedic rituals continue to be performed in India to this day and it should not be surprising to find modern time keeping methods in vogue. How equality of time periods was kept up in the most ancient period is not known but mention of *pariyāya* indicates chanting, oblations and ritual acts that should have been nearly identical in the three cycles and carried out at the same speed. Section (16.6) of the above *Brāhmaṇa* text describes in detail the hymns to be sung in the three cycles on the night of the *Atirātra-yāga* which is a type of *Agniṣṭoma* sacrifice. But this does not make any direct or indirect statement about *akṣara* and the purported time divisions. However, the immedi-

ate next Chapter 17 of the text prescribes the *Aśvinaśāstra* hymns to be chanted covering a part of the night till sunrise. These lauds are made up of all the meters such that the recitation consists effectively 1000 *bṛhatī* verses. This is a modification of the standard *prātaranuvāka* composed of 1000 *bṛhati* verses which is chanted in the night during the *somayāga* and several other Vedic sacrifices. A brief review of this leads to interesting new results on the measure of Vedic *akṣara* in real time, going beyond hymnal congruencies.

11 The Prātaranuvāka

The *Aitareya Brāhmaṇa* and the *Aitareya Āraṇyaka* expound the legends, doctrines and theories connected with the *prātaranuvāka*. Several Vedic *Brāhmaṇa* and *Śrauta* texts also describe in detail the composition and chanting of the *prātaranuvāka* during different Vedic sacrificial sessions. An in depth study of this set of Vedic hymns has been carried out by Gonda (1981) in his monograph *The Vedic Morning Litany*, by collecting and comparing differing details as stated in several ancient texts. For our purpose it is sufficient to determine as closely as possible the starting time and ending time of this important nocturnal recitation.

The earliest reference to the *prātaranuvāka* is in the *Taittirīya Samhitā* (*TS*) where it is enjoined that this should be completed before other voices are heard, indirectly meaning the chant should end by early morning before sunrise.²⁸ The same text in another place mentions that the chant should commence in the deep of the night.²⁹ Both the commentators of *TS* namely, Bhaṭṭa Bhāskara and Sāyaṇācārya take the phrase *mahati rātryai*, for the beginning of the chant, as the vague middle part of the night. This is elaborated in the *Aitareya Brāhmaṇa* (7.5) with the injunction *mahati rātryā anūcyāḥ* repeated four times. The commentary of Sāyaṇācārya leaves no doubt about the approximate beginning and ending time of this litany.³⁰ The chant had to start after midnight when large part of the night was remaining and should end before the birds started chirping early in the morn-

²⁷ क्रमेण निराकरणप्रकारं दर्शयति - दशदश घटिका एकैको भाग इत्येवं रात्रेस्त्रयो भागाश्चत्वारश्चमसगणा एकः पर्याय इत्येवं द्वादशानां चमसगणानां त्रयः पर्यायाः, तैः क्रमेण रात्रिभागत्रयादसुरानपानुदन्त। Sāyaṇa Bhāṣya on the *Aitareya Brāhmaṇa* (16.5).

²⁸ पुरा वाचः प्रवदितोः प्रातरनुवाकमुपाकरोति

यावत्येव वाक् तामवरुन्धे। *TS* (6.4.3).

²⁹ यदि सोमौ संसुतौ स्याताम् महति रात्रियै प्रातरनुवाकमुपाकुर्यात्। *TS* (7.5.5).

³⁰ रात्रेः साम्बन्धिनि शेषे महत्यवतिष्ठमाने सति

प्रातरनुवाकाख्य ऋक्समूहो वक्तव्यः॥ *Sāyaṇa Bhāṣya of AB* (7.5).

ing. The *Sūtra* texts that give the procedural details also say that the chant starts in the *mahārātri* part of the night such that the 1000 verses could be completed (before sunrise).³¹ What is *mahārātri*; is it a particular marker like *madhyarātri* the boundary that divides the night into two equal parts? From the different texts, commentaries and introductory essays in the MPRV (1950) by practitioners of the *Śrauta* tradition, we can gather that in Vedic parlance this means some time after midnight but not too far away. The *Śabdakalpadruma* (Deva 1822) quotes an anonymous *Tantra*, stating that *mahārātri* starts two *muhūrta* after midnight.³² Even though the speed and time limits mentioned in the Vedic texts are qualitative and at best intuitive, the *prātaranuvāka* is a rare instance where the texts, in letter and spirit, exhibit tendency for synchronization with time shorter than *ahorātra* by actual real time chanting. This is not the same as the axiomatic *akṣara* congruence with lunar and solar cycles in longer than *ahorātra* time scales such as the month and the year. Since the *brhatī-sahasra* is a long litany with a specified number of *akṣara* it would be interesting to find what might have been the duration of the chant even though the texts provide only vague starting and ending times. If we take the night (sunset to sunrise) to be of 15 *muhūrta*, the chanting had to start ½ to 1 *muhūrta* after midnight and end ½ to 1 *muhūrta* before sunrise. This essentially means the time taken for chanting would have been 5½ to 6½ or on average 6 *muhūrta*, at the rate of 6000 *akṣara* per *muhūrta*. This number, it may be noted, is based on the equinoctial night of 15 *muhūrtas*. But, in summer due to shorter nights the 1000 verses perhaps got completed in about 5 *muhūrtas* whereas in winter nights the rendering might have got extended. This conjecture, leads to a recitation speed of around 7000 to 6000 *akṣara* per *muhūrta* that is at best theoretical. However, in practice this may vary as the processes of the rituals, though not the *Ṛgvedic* hymns, differ in schools that branched off long before present.

It is known that the *Ṛgveda* (*śākalya* branch) text has been maintained accurately all over the country for several millennia. For maintaining the fidelity of the tradi-

tional chanting a variety of techniques are adopted the theory of which is described in the ancillary *prātiśākhya* texts. As discussed previously the concept of *akṣara* as a countable discrete entity in a hymn is central to Vedic rituals and practices. However, the *traisvarya* (tri-tonal) and even the *ekasvarya* (mono tone) *Ṛgveda* chanting is a continuous process in time and hence marking *akṣara* boundary, for counting purposes, is a matter of definition. The traditional *anukramaṇi* texts have preserved the meters of all the hymns with the stipulated number of *akṣara*. This is the only unambiguous definition we get for counting syllables in continuous recitations or records of the *Ṛgveda*.

Even though versification was the fashion among the *siddhānta* astronomers, the syllabic time in classical poetry remains notional and hence syllable counts can be based on orthography. But, the time of the astronomers being real their 60 *gurvakṣara* audio scale had to be made phonetically accurate by selecting a particular meter, among many possibilities, such that 3600 syllables span half-*muhūrta*. For arriving at such specific refinement there must have been some precedence for quantifying a part of the day or night by a long count of *akṣara*. The readily traceable source for such an effort is the importance given in the Vedas for the meter *brhatī* of thirty-six *akṣara* for representing time intervals. This cannot be treated as a fortuitous coincidence since the astronomical half-*muhūrta* of 3600 *akṣara* is numerically congruent, in true Vedic style, with 100 *brhatī* verses. Nevertheless, such comparison remains qualitative. Hence for getting a better picture of the influence of the Vedic tradition on measuring time with the *gurvakṣara* scale we have collected information on present day chanting of *Ṛgveda* by orthodox Veda specialists.

12 Prātaranuvāka of the Kauṣītakins

Śrauta practices are preserved in India by followers of the Veda who perform *soma-yāga* and such other rituals occasionally apart from regular *grhya* rites. Śri Itti Raveendran Nambūdiri, (Head of the *Veda Śrauta Gurukulam* of Edappal, Kerala) is a venerated scholar renowned for his lifelong devotion to Vedic tradition and his expertise on Vedic practices. He has participated and conducted several *Atirātra* as per the *Kauṣītaki* School. We contacted him to know about the details of *prātaranuvāka* as re-

³¹अथ महारात्रे महाव्रताय प्रातरनुवाकमुपाकुर्वन्ति।

यथा परिसहस्रमनुब्रूयात्। *Sāṅkhāyana Śrauta Sūtra* (17.7).

³²महारात्रिः - अर्द्धरात्रात् परं मुहूर्तद्वयम्।

यथा, “ अर्द्धरात्रात् परं यच्च मुहूर्तद्वयमुच्यते।

सा महारात्रिरुदिता तद्वत्तमक्षयं भवेत्॥”

इति तन्त्रम् ॥ *Śabdakalpadruma*, vol.5.

cited by him in long Vedic rites. He readily explained the procedure and mentioned that his recitals started in the night at 3 a.m. and got completed sometime after 4 a.m. We gathered that the chanting from start to end would need one hour and fifteen/twenty minutes. The chanting is enjoined to be done always in *ekasvara* (single tone), in medium pace maintaining medium loudness. When queried about the number of *br̥hatī* verses as mentioned in the *Aitareya Br̥hmaṇa*, he was quite clear that he follows the *Kauṣītaki Vidhi* inherited from his teachers and not any printed book. He agreed to share all the *Ṛgveda* hymns that appear in the *pr̥taranuvāka* that consists of three subsets: *āgneyam̐*, *uśasam̐* and *āśvinam̐*. He sent a written document noting down the *maṇḍala* and the *sūkta* so that we could identify all the 348 hymns and their canonical meters in the *Ṛgveda*. The number of *akṣara* in the litany as per the *Kauṣītaki School* adds up to 12,396. This gives the speed of chanting of *pr̥taranuvāka* to be 7500–7900 *akṣara* per *muhūrta*.

13 Recorded Ṛgveda

The other data collected comprises of audio records of *Śākalya-saṁhitā Ṛgveda traisvarya* (tri-tonal) *saṁhitā pāṭha* that maintains continuity within a *sūkta*, from Mysore³³ and Vārāṇasī.³⁴ The chanters are professionals trained since their younger days, in the age old oral tradition, inheriting the knowhow of their teachers. Thirty-eight *sūkta* distributed over different *maṇḍala* that consist of varying number of verses are selected for noting the durations of the chant. The *akṣara* (syllable) count and time taken for each *sūkta* of this sample data is presented in the Appendix. In Figure 2 for a quick appreciation of the results, the time taken for each *sūkta* is plotted against the syllable count. From the table in the Appendix, the mean and standard deviation of the chanting speed can be computed. It is found that the southern chant (Mysore) speed is on average 7296 *akṣara* per *muhūrta*, whereas for the northern chant (Vārāṇasī) the average speed is 14457 *akṣara* per *muhūrta*. In both the cases the standard deviation is about 10% of the average value.

³³ *Ṛgveda* audio record of S. S. Sharma and S. K. Bhatta. Published by Sri Ranga Digital Software Technologies, (Pvt.) Ltd. Mysore, 2012.

³⁴ *Ṛgveda* audio record of Vishvanatha Sharma from Vārāṇasī, Private Collection.

14 Discussion

Several interesting results emerge out of the above study. Firstly, the average recitation rate of 7296 *akṣara* per *muhūrta*, of the Mysore school in medium pace, is in magnitude close to the 7200 *gurvakṣara* rate of *siddhānta* astronomers that was the basis for time measurement in India till modern times. This is not a chance result nor a subjective opinion but what can be verified objectively. This close quantitative match, beyond reasonable doubt, leads us to infer that the oral tradition of Vedic learning and chanting, by design or by its very nature, was getting synchronized with numbers 15, 30 and 36 and their simple multiples, as time measures related with *day/night*, *ahorātra*, *pakṣa*, *māsa*, and *saṁvatsara*.

The result of 14457 *akṣara* per *muhūrta* of the Vārāṇasī tradition is twice of its southern counterpart, the difference being less than 1%. This is easily explainable since in the Vedic and in the music tradition, three speeds *vilamba*, *madhyama* and *druta*; each twice faster than the previous one, are recognized. If recitation of a particular fixed text material in the *madhyama* (medium) speed takes one *muhūrta*, the same will take two *muhūrta* in the *vilamba* (slow) speed, whereas in the *druta* (fast) speed only half *muhūrta* would be sufficient to complete the recitation. Bhāskara-I, the commentator on the *Āryabhaṭīya* elaborates the importance (see footnote 7) of the speed being in the medium pace (*madhyama vṛtti*) for the calibration of one *viḡhaṭikā* by 60 *gurvakṣara* of the verse B-I, already experimentally verified for its accuracy in the present study. Bhāskara's comment quite well points to the Vedic origins of the *akṣara* count method of time measurement that was only fine-tuned by the astronomers using classical Sanskrit prosody.

Tracing the *akṣara* concept backwards takes one to the Vedic *Br̥hmaṇa* texts, which propose congruencies between a variety of *akṣara* counts and time periods and spatial designs of the altars. Jan Gonda (1984) cites more examples of this type of syllable congruence or homology. The congruency relations are neither figurative nor realistic in present day parlance, but indicate gradual growth of an idea following an urge to understand or characterize abstract time in terms of active rituals that use hymns already available to the followers of the Vedas. This represents a stage in the evolution of mathematical concepts in India wherein the mystical unitary

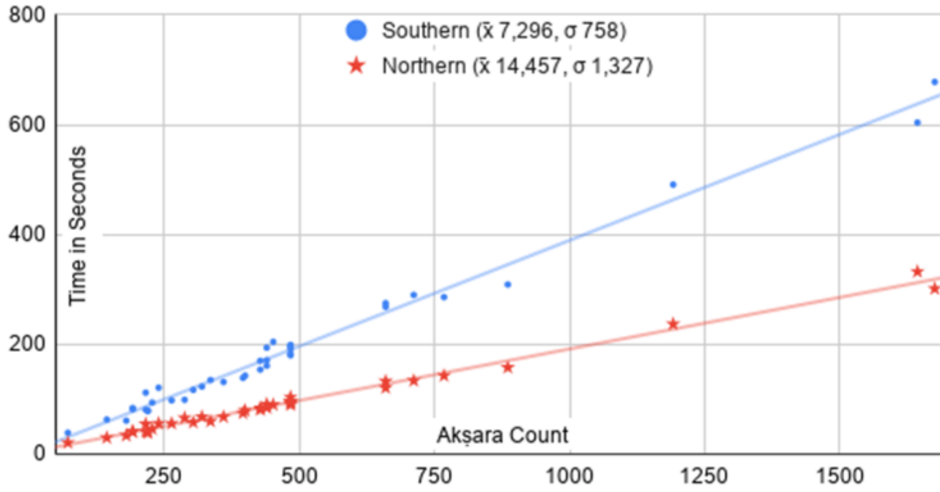


Figure 2 Ṛgveda chant time in seconds vs Akṣara count.

vision of the cosmos of the Vedic seers was transforming into tangible realities for the community through numbers and similarity relations, particularly in rectifying the year, months and still smaller intervals of time.

The principle of correspondence of *akṣara* in sacred hymns to abstract and concrete objects was not limited to time divisions only. The *Aitareya Brāhmaṇa* (5.3) refers to this as a general principle called *rūpasamṛddhi* (fullness-of-form). This principle appears to be the motive force behind some ritualistic actions striving for accuracy in minute details tending towards rigour of a mathematical kind. *Akṣara*, no doubt played a very important role in handling phenomenal time, but it involves discretization in the sense of counting by integer numbers. Going beyond such integral *akṣara*, Vedic texts in many places exhibit deeper analytical ideas about the *akṣara-kāla* itself being further divisible, as many times as one wishes, so much so *time* in reality is extolled to be continuous with no breaks. The *Taittirīya Āraṇyaka* (I. 2.4–5) in the very beginning describes that time is due to sun and that it is continuous like a river flow and is irreversible. Previously, we have referred to the *Sāmidhenī* verses and their perceived syllabic congruence with the year. The *Śatapatha Brāhmaṇa* enjoins that these hymns should be recited continuously without breaks because *ahorātra* flows continuously uninterrupted.³⁵ This continuity of time that is

linked with the continuity in the observable movement of Sun might be leading to congruencies of a different kind. This aspect needs further investigation.

15 Summary and Conclusion

Any physical measuring instrument needs to be calibrated by independent methods to maintain its accuracy. Indian astronomers of the various *siddhānta* texts recognized the necessity to calibrate the water clock that was used to measure time by a bowl sinking exactly 60 times from sunrise to sunrise. It was important to measure one *ghaṭikā* that is (1/60th) of an *ahorātra* by independent means so that the bowl could be fine-tuned properly. An ingenious method of calibrating using an audible oral scale of one *viḡhaṭikā* was developed in the form of a Sanskrit verse in the *līlākhela* meter composed of 60 *gurvakṣaras*. Sixty repetitions of this verse in medium speed would indicate passage of one *ghaṭikā* equivalent to 24 minutes in modern parlance. In the present study the accuracy of this scale has been verified and shown to be very good. It is noted that the time value of this *gurvakṣara* in the particular meter gets fixed phonetically as equal to 0.4 seconds. Such a practice of recitation to estimate passage of time is traceable to the Vedic oral tradition, wherein many ritualistic texts describe congruence relations between *akṣara* and time. We find that in the legend of Indra crossing over the night with the help of the seven *chandas*, followed by the

³⁵ ...तानीमानि संवत्सरस्याहोरात्राणि सन्ततान्यव्यवच्छिन्नानि परिप्लवन्ते ॥ *SB* (1.3.5.16).

starting and ending time prescriptions for the *prātaranuvāka* chanting of 1000 verses, adding to 36,000 *akṣara* (Vedic syllables) there is evidence to the ancient practice of estimating passage of night-time by Vedic recitation at medium pace.

Quite interestingly the theoretical estimate from the books and the actual speed in real performances, although approximations, match well with the classical count of 7200 *gurvakṣara* per *muhūrta* of the astronomers. The *prātaranuvāka* was not always recited with pitch accents. The count of verses to be chanted perhaps varied among the different branches of the Vedic schools. Without the three pitch accents an oral performance would be a mix of only *laghu* and *guru* syllables almost like in classical poetry. This is borne out by the personal information provided by Iṭṭi Raveendran Nambūthiri. In such a chant the time measure of an arbitrary *akṣara* would be less than that of the astronomical *gurvakṣara*. But with the Vedic pitch accents included as in the Mysore record, the basic *akṣara* magnitude approaches that of the *gurvakṣara* time of Āryabhaṭa, Varāhamihira, Bhāskara and others. The Vārāṇasī performance rendered at twice the speed corroborates this observation.

The above analysis and discussion makes a case for recognizing the night-time recitation of the *prātaranuvāka* in different Vedic schools as the precursor for a variety of *akṣara* time units appearing in the works of Lagadha, Parāśara, Suśruta, Vṛddha-Garga, the *Brahmāṇḍa Purāṇa* and other texts. The very diversity in the definition of the basic *akṣara* and its time value is a clear indication of the intellectual tradition in India striving to standardize the vague time-keeping methods inherited from antecedent sources. This eventually was achieved with the calibration of the *vighaṭikā* by the medium pace recitation of a verse with sixty *gurvakṣara* which only could have led to the final design of the sinking bowl type water clock.

16 Acknowledgement

Software help received from M. T. Raghunath and Sunder Chakravarthy in modeling pronunciation rules is thankfully acknowledged.

Abbreviations

KAS – *Kautilīya Artha Śāstra*

VM – Varāhamihira

B-I – Bhāskara I

MAU – *Maitrāyṇīya Āraṇyaka Upaniṣad*

ŚB – *Śatapatha Brāhmaṇa*

TB – *Taittirīya Brāhmaṇa*

AB – *Aitareya Brāhmaṇa*

RV – *Ṛgveda*

LVJ – *Lāgdha Vedāṅga Jyotiṣa*

VP – *Viṣṇu Purāṇa*

TS – *Taittirīya Saṃhitā*

Bibliography

- [1] Apte H. N. (Ed.). *Taittirīyabrāhmaṇam*, Anand Ashrama, Pune, 1898.
- [2] Apte V. G. (Ed.). *Taittirīyāraṇyakam*, Anand Ashrama, Pune, 1923.
- [3] Chandra Lokesh (Ed.). *Śāṅkhyāyana-śrautasūtra, Being a Major Yajñika Text of the Ṛgveda*, Motilal Banarasidas, New Delhi, 1980.
- [4] Chauhan Dalvir Singh (Ed.). *Brahmāṇḍamahāpurāṇam*, Chowkhamba Sanskrit Series, Varanasi, 2016.
- [5] Dvivedi V. P. (Ed.). *Jyautiṣa Siddhānta Saṃgraha, Benares Sanskrit Series No. 152 and No. 154*; Braj Bhushan Das & Co., Benares, 1912, 1917.
- [6] Gonda J. *The Vedic Morning Litany*, E. J. Brill, Leiden. 1981.
- [7] Gonda J. *Prajāpati and the Year*, North-Holland Publication, Amsterdam, 1984.
- [8] Hayashi T. The units of time in ancient and medieval India, *History of Science in South Asia*, 5.1 (2017): 1–116.
- [9] Iyengar R. N. (Ed.). *Parāśaratantra: Reconstructed Text on Astronomy and Natural Sciences*, Jain University Press, Bangalore, 2013.

Appendix

Sample analysis of 38 RV *Sūktas* with their *Akṣara* count as per ascribed meters.

Columns 4 and 5 show the chanting time taken in seconds. The last two columns show the resulting rate of chanting of *akṣara* per *muhūrta*. 1 *muhūrta* = 2880 seconds.

No	Sūкта	Number of <i>akṣara</i>	Chant time seconds		<i>Akṣara</i> per <i>muhūrta</i>	
			Southern	Northern	Southern	Northern
1	1.1	216	112	55	5,554	11,311
2	1.3.(10-12)	72	39	21	5,317	9,874
3	1.9	240	121	56	5,712	12,343
4	1.72	440	194	91	6,532	13,925
5	1.164.(15-52)	1676	678	301.5	7,119	16,010
6	1.165	660	275	133	6,912	14,292
7	1.166	712	290	134	7,071	15,303
8	1.167	484	199	93	7,005	14,988
9	1.180	440	171	85	7,411	14,908
10	2.1	768	286	143	7,734	15,467
11	2.7	144	63	30	6,583	13,824
12	2.32	336	135	60	7,168	16,128
13	2.33	660	268.5	121	7,079	15,709
14	3.35	484	180	96	7,744	14,520
15	4.6	484	197	104	7,076	13,403
16	4.7	428	170	81	7,251	15,218
17	4.8	192	84	41	6,583	13,487
18	4.9	192	82	41	6,743	13,487
19	4.10	228	94	46	6,986	14,275
20	4.33	484	192	96	7,260	14,520
21	4.34	484	183	90	7,617	15,488
22	4.35	396	139	75	8,205	15,206
23	4.36	428	154	84	8,004	14,674
24	4.37	304	117	58	7,483	15,095
25	4.38	440	161	85.5	7,871	14,821
26	5.74	320	123	68	7,493	13,553
27	5.75	360	131.5	68	7,884	15,247
28	5.76	220	79	39.5	8,020	16,041
29	5.77	220	79	40	8,020	15,840
30	5.78	288	99	66	8,378	12,567
31	5.79	400	143	79.5	8,056	14,491
32	6.13	264	98	56	7,758	13,577
33	6.14	216	81	41	7,680	15,173
34	6.15	886	309	158	8,258	16,150
35	6.16	1192	491	237	6,992	14,485
36	6.61	452	204.5	90	6,366	14,464
37	10.85	1644	604	332.5	7,839	14,240
38	10.164	180	61	34	8,498	15,247

- [10] Kulkarni R. P. A water instrument to measure the time of one *nālikā*, *Annals of the Bhadarkar Oriental Research Institute*, Poona, 69.1/4 (1988): 279–281.
- [11] Mitra Rajendralal (Ed.). *Aitareya Āraṇyaka* (with the commentary of Sāyaṇa), Asiatic Society of Bengal, Calcutta, 1926.
- [12] MPRV (1948–1961). *Ṛgveda Saṃhitā*; with the commentary of Sāyaṇa; edited by a group of traditional and modern scholars; published by the Mysore Palace from 1948 onwards. This thirty-six volume series is with *Saṃhitā*, *Padapātha*, *Khila*, *Anukramaṇi*, *Ṛgvidhāna*, *Aitareya Brāhmaṇa*, *Āraṇyaka*, *Brhaddevatā* and the *Nirukta* which are all indispensable in understanding the Vedic tradition.
- [13] Narayan Ram (Ed.). *Suśrutasaṃhitā*, Nirnaya Sagar Press, Mumbai, 1945.
- [14] Radhakanta Deva. *Śabdakalpadrumam*, (in 5 vol.) Jain Publ. 1822, Calcutta. Reprint 1967.
- [15] Samasrami Satyavrata (Ed.). *The Aitareyabrāhmaṇam of the Ṛgveda*, Asiatic Society of Bengal, Calcutta, 1906.
- [16] Samasrami Satyavrata (Ed.). *Śatapathabrāhmaṇam with the commentary of Sāyaṇa*, Asiatic Society of Bengal, 1926.
- [17] Sarma S. R. Indian astronomical and time-measuring instruments: a catalogue in preparation, *Indian Journal of History of Science*, 29.4(1994): 507–8.
- [18] Sarma S. R. Measuring time with long syllables: Bhaskara-I's commentary on the *Āryabhaṭīyā*, *Kālakriyāpāda* 2, *Indian Journal of History of Science*, 36.1/2, (2001): 51–54.
- [19] Sarma S. R. *The Archaic and the Exotic: Studies in the History of Indian Astronomical Instruments*, Manohar Publishers, 2008.
- [20] Sarma S. R. Water clock and steelyard in the *Jyotiṣkaraṇḍaka*. *International Journal of Jaina Studies* (Online), 14.2 (2018): 1–49.
- [21] Sarma, S. R. *A Description Catalogue of Indian Astronomical Instruments*. (http://crossasia_repository.ub.unu-heidelberg.de/4167)
- [22] Sastri T. G. (Ed.). *Samarāṅgaṇa sūtradhāra*, Central Library, Baroda, 1924.
- [23] Sastry T. S. and Sarma K. V. *Vedāṅga Jyotiṣa of Lagadha, Critical Edition, Translation and Notes*. Indian National Science Academy, New Delhi, 1985.
- [24] Sastry T. K. and Sarma K. V. *Pañcasiddhāntikā of Varāhamihira, Critically Edited with Notes and Translation*, PPST Foundation, Adyar, Madras, 1993.
- [25] Satvalekar S. D. (Ed.). *Maitrāyaṇī Saṃhitā*, Government Press, Bombay, 1941.
- [26] Shamasastri R. (Ed.). *Kautilya's Arthashastra*, Government Branch Press, Mysore, 1924.
- [27] Shukla, K. S. (Ed.). *Āryabhaṭīyā of Āryabhaṭa with the Commentaries of Bhāskara - I and Someśvara*, Indian National Science Academy, New Delhi, 1976.
- [28] Sontakke N. S. and Dharmadhikari T. N. *Taittirīyasaṃhitā with Commentaries of Sāyaṇa and Bhaṭṭabhāskara*, Vaidika Samshodhana Mandala, Varanasi, 1970.
- [29] The Inscriptions of Nagai. *Hyderabad Archaeological Series*, No. 8, Calcutta, 1928.
- [30] Tripathi V. (Ed.). *Vṛttaratnākara of Kedārabhaṭṭa with Commentary of Bhaṭṭa Nārāyaṇa*, Bharatiya Vidya Sansthan, Varanasi, 2008.
- [31] Vaidya C. V. *History of Sanskrit Literature, Vol. I (Śruti) Vedic Period*, Poona, 1930.
- [32] Vidyasagar Jivananda (Ed.). *Viṣṇupurāṇam with Śrīdhara's Commentary*, Nirnaya Sagar Press, Mumbai, 1881.

L14-15

Comets, Planets and Eclipses: Vedic, PT, VGJ

L-18

Influence of Vedic astronomy on Indian view of history

Refer enclosed QJMS publication

L-19

Suggestions for Further IKS Research



Characterisation of Elapsed Time as Historical Past in Hinduism

R.N. Iyengar*

Abstract: Vedic Hinduism styles itself as *sanātana dharma*, that is, eternal and perpetual. Hinduism, as is well known, is not a book-based religion. Nevertheless, the Vedas, Purāṇas and the ancillary texts, being the primary sources of the intellectual, religious, and cultural traditions of India, play significant roles in the day-to-day lives of Hindus. The traditional *saṅkalpa* rite observed all over India, at the start of socio-religious ceremonies like house warming, laying a foundation stone, marriage functions, etc., refers clearly to the most ancient past, historical past and the present time. What theoretical underpinnings are there in such an inherited cultural tradition to delineate the concept of historical past as elapsed time from the birth of the Sun, is explored in this article from an emic perspective.

Keywords: Saṅkalpa, Yuga, Kāla (Time), Manvantara, Kalpa, Purāṇas, Abhaya-Dhruva (Pole Star), Śiṣṭācāra, Mahāmeru, Ayanas (Uttarāyaṇa/Dakṣiṇāyaṇa), Pralaya, Civilisational Memory

1. Introduction

A topic that is hotly debated in academic and other circles is the need to present the History of India from an insider's perspective. This felt need is due to the fact that the available narrations about India are written following Western models and theories of history. It is generally known that such narratives are biased by Eurocentric perceptions of time, chronology, culture and society suited to the so-called Aryan migration into India in the middle of the 2nd millennium BCE. Now, as IKS (Indian Knowledge Systems) is becoming a buzzword, a trend is developing where chronology is taken as the totality of

* Distinguished Emeritus Professor, (IISc), Centre for Ancient History & Culture, Jain University, Bengaluru-560078. Email: RN.Iyengar@Jainuniversity.ac.in

history and efforts are made to fix the dates of the Vedas, the Maha Bharata and the heroes of our epics, some claiming extravagantly ancient dates. As a reaction to this, at the other extremity, there are people arguing that Hinduism lacks a sense of history as evidenced by the relatively recent era starting from the Vikrama Samvat (57 BCE) or the Śakābda (78 CE). The irony is Hinduism refers to itself as *sanātana dharma*, that is, *primaeval*, perpetual and most ancient, even if some were to consider this to be hyperbole. Hinduism is not a book-based religion, although the Vedas, Purāṇas and the ancillaries play seminal roles in the day-to-day lives of Hindus. The historical past that can be unearthed from the texts is the same and common to all Hindus, even if there is variation among the different societal groups, in the way the contents are internalised for leading a peaceful and purposeful life. The history of a culture is a way of perceiving elapsed time and characterising the societal past, abstracted and pictured in broad brush, as the cause of the present. What attitudes, experiences and evidence our ancients had about their own past, and how has this been chained together and passed on to us as *sanātana*? This elusive question is briefly explored in this paper from the emic perspective of a practising Hindu.

2. Historical Identity

History is about the past; there is no debate on this. We need an agreed-upon origin or starting point in time, such that statements about the past can be verified by others. The European model of history introduced a reference origin as Christ's birth, and thus, in our schools, we were mostly exposed to chronological time markers as AD and BC, now slowly changing to CE and BCE. Most of us know the names of our great-grandparents, but perhaps not the family tree prior to them in correct chronological order. Some royal families have written chronicles, and the priests in Haridwar are said to have a record of some families, but this is not really how the majority of Hindus relate themselves to their historical past.

We know the names of Mahāvīra, Chāṇakya, Gupta kings, Chalukyas, Cholas, Hoysalas, the three Āchāryas, Vijaya Nagar, Rajput and Mughal kings and their dates based on an unbroken tradition and material evidences that can be verified, in case we like to check them personally. We also feel happy about our hazy relation with Bodhāyana, Āpastamba, Pāṇini, Bhadrabāhu,

Bharata, Nanda, Ashoka, Umāswāti, Nāgārjuna, Āryabhaṭa, Tiruvalluvar, Pampa, Vemana and thousands of other kings, poets, astronomers, mathematicians, saints, philosophers, teachers, artists, sculptors, as our ancestors. We like to listen to the past glory of Takshashila, Nalanda, Kāśī, Kāñci and also watch a film on Chandragupta. All this is enjoyable, often lulling us into feeling proud about India's past in relation to other contemporary cultures and countries. This cloud of the past provides a sense of belongingness to a great and strong heritage, on which to build a brighter future, more so when the historical timeline is fair and credible with verifiable evidences.

Would it not be nice if we could extend the above pleasant feeling to Kṛṣṇa and Rāma? The answer will invariably be yes, particularly to meet the question of our youngsters awakened to the history of the countries outside India. When did the above *avatāra* happen? There is no need to elaborate on the *avatāra* concept, but it may be noted, the feelings that arise in our connection to Bhāsa, Kālidāsa, Harsha, Jayadeva, Kamban, Tulasidas and Tyāgarāja are entirely different from the deeper emotions evoked by the main characters and the geographical places of the Mahābhārata (MB) and the Vālmīki Rāmāyaṇa. This is a defining character of contemporary Vedic Hinduism to be felt and gauged in proper perspective.

3. Presenting the past

The past is primarily subjective and qualitative for the large majority of people, but can become objective if a measure of phenomenal time in year numbers can be attached to the narratives. Some people certainly thought of this and proposed 4004 BCE as a start, since they believed their God created the world in that year on 23rd October, supposedly a Sunday. Modern astronomers and planetarium software use the Julian day (JD) count that starts on 1 January 4713 BCE to compute the position of planets on a current calendar date. Long before such proposals, Hindu astronomers like Āryabhaṭa (5th cent.) used *abargaṇa* to specify civil days starting from the *kalīyugādi*, now reckoned to be 18th February 3102 BCE.

When we like to dispassionately discuss the past of a broad and widely spread culture, not just of a recently migrated community, a notation for elapsed time, widely understood by the society, is needed. The easiest, also a natural one, is to keep our own generation as the origin and talk in terms of

Before Present (BP). This notation is widely prevalent among archaeologists, biologists, anthropologists, geologists and cosmologists. Modern science has brought in technical words like Cenozoic, Precambrian, Jurassic, Triassic and the more recent Stone Age, Bronze Age, etc., to communicate with the past, but still quantified with respect to ourselves as years BP. On the other hand, cosmologists propose the Big Bang as a notional zero (singularity) point and model mathematically what happened at a nanosecond or less from the imaginary time origin. From such theories, a BP chronology for the galaxies, solar system, Sun, Earth, passing on to Continental Drift, Deccan Volcanism, Vindhya's, Tethys Sea, Himalaya's, can be worked out in terms of million-year-ago units (Mya).

The above observation may seem superficial, but it helps one in appreciating the Vedic and Purāṇic point of view of *kāla* (time), which has led to the unique notion of *historical time* in Hinduism (also known as *sanātana dharma*), starting from the birth of the Sun.

4. Yuga in the Vedas

The Vedas, starting from the Ṛgveda (RV), know and allude to both short and long intervals of time. In this connection, the word *Yuga*, by which the Purāṇas refer to a very long time period, needs some discussion. The inherent meaning of the word *Yuga* gives a sense of conjunction/ coexistence/ combination/contemporaneity of two entities. This may be a wooden yoke, connecting the back of two bullocks or a time period in days/years when the same two celestial bodies appear in conjunction. The word *Yuga* in pre-siddhāntic astronomy is usually qualified as *Pañcavarṣīya-yuga*, *Rāhu-yuga*, *Brhaspati-yuga*, indicating specific periods of time. In the RV, the word *Yuga* and its derivatives appear more than twenty times. In some places, it is an unspecified 'time' like a *generation*, but in some other contexts, it is an unspecified interval of years. The word *Yuga* in the Vedas has been used in a generic sense with variable values, and hence to fix its value now would be absurd. In (RV 1.158) *daśame yuge* need not necessarily mean forty or fifty years; it could as well refer to the tenth decade of one's life. Word forms such as *yuge-yuge*, *yugāni*, *uttare yuge*, *pūrve yuge*, *prathame yuge* (RV 10.72) point clearly to an interval of time in years; multiple of which is meant in the plural. A phrase like *devānām yuga/prathama yuga* could refer to the 'time' of *First Creation*. There is no

maximum value in years for *Yuga* in the Vedas proper. In the Ṛgveda, we come across *triyugam purā* (RV 10.97) and *chaturyuga* (RV 2.18), where the value of time meant is not clear, but an argument like “*triyugam purā* should mean *fifteen years before*, because *yuga* could not have been longer than five” lacks logical sense. RV has contemporaneous information; names of kings, laudations, battles, sages, their progeny, that may be worthy of getting marked in ‘historical time’. But importantly, RV and other Vedic texts contain what is now denoted as natural sciences.

The Vedic cosmological hymns (RV 10.72, 121, 129) are important for all later literature and Vedic-Hinduism, because all creation started from an unquantifiable, nevertheless laudable, *First Beginning* of the Golden Egg, splitting into the fluidic dark matter. Some of these statements sound contradictory, since articulated words cannot unequivocally convey *The First*. Along with the Big-Split, sentient emanation of Brahman, Āditya, Bhṛgu, Aṅgiras, Pracetas, Prajāpati, phenomenal time, *Vatsara*, *Samvatsara*, etc., are recognised to have happened self-similarly.

Vedic texts are voluminous, amorphous, packed with information, tantalizingly coded with multiple meanings, except for number counts that are in the realm of natural truths, cognised without the help of language and hence remain invariant for us also. So, it would be reasonable to take *mānuṣa yuga* to be a hundred years, but *daiva yuga* can be much longer. No estimate of the number of *years* to Creation is available in the extant Vedas till we come to the Purāṇas. But let there be no doubt, the Vedic texts know about long time periods, as in the Atharvaveda

śatam te'yutam bhāyanān dve yuge trīṇi catvāri kṛṇmah | (AV. 8.2.21a)

All commentators recognise this hymn to be about time/life period in years (*bhāyana*), perhaps 100, *ayuta* may be 10,000 (or one Lakh?) and then something done two, three and four times. What is this, if not the seed for the long Purāṇic *Yuga* concept? Whatever may be the actual meaning of the above hymn, the concept of long periods of time called ‘*Yuga*’ juxtaposed with numbers 2, 3, and 4 was already there in the Vedas.

5. Two types of Time

Vedic texts characterise *kāla* (Time) to be of two types. First is the abstract;

the second is the *time* as related to the sun, the moon and the stars. This is the *mūrta-kāla* (concrete or phenomenal time) such as *nimeṣa*, *muhūrta*, day, night, fortnight, year, etc. In the *Maitrāyaṇīya Āraṇyaka Upaniṣat* (MAU), time with form having nameable divisions, starts with the Sun. MAU declares Sun to be the origin or generator of time, since *aborātra* (day-night), based on counting sunrises, is the most natural time unit¹. Additionally, MAU, with its abstract perception, says that before Sun, it was *akāla* (non-time). The word *kāla* for phenomenal time is a derivative of the word *kalā* (part). Hence, *kāla* denotes that which is related to and made up of digits or parts. *Kāla* and *Akāla* are said to be the two forms of the unitary *Brahman*.

MAU is the first text that states the earliest two-part solar zodiac, when the southern sojourn (*dakṣiṇāyana*) of the sun was from the beginning of the *Maghā* nakṣatra till the middle of *Śraviṣṭhā*, and the reverse northern transit (*uttarāyana*) was from half-*Śraviṣṭhā* to the end of *Āśleṣā*. This helps in the historical dating of the text, highlighted later in this article. Secondly, equally important is the esoteric understanding of time in discrete steps forming the *samvatsara* (year or sun's cycle), which, as phenomenal time, is a measure for life itself. People are said to take birth, live and die in a *samvatsara* (time in the form of a year). Thus, in MAU and elsewhere in the Vedas, *samvatsara* is *Prajāpati* (lord of progeny). It is said that, if one meditates on *kāla* as Brahman, for such a person time recedes far away (*yaḥ kalam brahmetyupāsita, kālaḥ tasya atidūram apasarati*). This seems to mean that such a person becomes free from the limitations of phenomenal *Time*, which normally controls ordinary humans.

Vedic tradition classifies all knowledge as *aparā vidyā* and *parā vidyā*. The former is the knowledge of the physical world available to the five senses and the intellect, while the latter, *parā vidyā*, is *beyond* this. Without further digression, in the Vedic worldview the visible *Sun* is the mystical gateway separating the *aparā* and the *parā* and hence the primacy of *sūryopāsana* (sun-meditation / worship) in the original Vedic and in the later sectarian practices of Hinduism, with or without iconic representation. All later Vedāṅga texts and, as a corollary, the religious injunctions and philosophy of Vedic Hinduism are circumscribed by the above tenet of phenomenal time, time that can be measured by humans, emerging after the manifestation of the visible Sun. This point is of seminal importance in any epistemological

discussion on the history of Hindus and Hinduism, from the RV onwards, passing through the *Sūtra*, *Purāṇa*, *Smṛti*, *Siddhānta* and *Śāstra* layers to the present day.

6. Purāṇic Continuity

The Purāṇas have carried on the above *Time/Kāla* concepts in their own fashion, still retaining the eternal universal vision and ideal, which is denoted as *sanātana-dharma*. With eighteen major and eighteen lesser Purāṇas, it is nobody's case that these texts, along with the two epics, are coherent and agree with each other. Much of the material is floating stuff, like the foam seen in the top layers of our sacred rivers. One has to avoid getting stuck in this if one has to draw useful conclusions from the Purāṇas.

Even as per the orthodox tradition, MB was edited twice from the original *Jaya* of 8800 verses; to *Bhārata* with 24,000 verses and then expanded as the *Mahābhārata* (MB) of one lakh (100,000) verses. How to grapple with this known historical tradition in extracting a unique date for the Great War from the MB text? Yardi has demonstrated that there may be more than three recognisable layers in the final MB, a view that has been supported by the editors and other scholars of repute^{2,3}. Thus, the notion that the BORI Critical Edition is the real MB for historical purposes and for dating the MB war is wishful thinking. So, what is the sanctity behind the date of the MB war, variously claimed to be 3162, 2448, 1793, 1478 BC. The first figure is the traditional date widely believed. The second is the date that can be surmised from the *Bṛhat Saṃhitā* of Varāhamihira (6th cent. CE). The last two dates match some of the important and credible astronomical statements in the Epic^{4,5}. Since for Kṛṣṇa we have only textual evidences and an unbroken oral tradition, we can be certain of the historicity of this *avatāra* of Viṣṇu 3500-4000 years BP. There is no doubt that MB is a cultural treasure in the history of Hinduism, but the date of the war is not a unique chronological anchor for ancient history, as some people claim vehemently. The real anchor point is the *Pole Star Dhruva* of the Vedas and the Purāṇas, which will be introduced below.

Purāṇas have grown, like MB; from a single seed text originating from the Vedas that is sometimes called *purāṇa saṃhitā*. Among the available texts, Brahmanḍa Purāṇa (BPu) is temporally closest to the Vedas. Like with other texts, parts might have been added into this Purāṇa also at different times by

different people, and now we have three parts (the first and the second are weakly linked; the third part is almost independent) in BPu. The first part, the earliest, is largely free of the two human *avatāra* of Viṣṇu, but has references to the creation of life, Dhruva the Polestar, the four *yugas* and the *manvantaras*. It has the best Meru-centric astronomy model, yet to be critically explored. It has a fleeting reference to River Godāvāri and Rāma, but that particular chapter on geography with mention of China, Tuṣāra, and Bāhlika is a later addition. Similar is the Vāyu Purāṇa with two parts, which some scholars consider to be the earliest. In the second part (*uttarārdha*), we find Rāma and Kṛṣṇa mentioned in brief, while the *pūrvārdha* is free of the *avatāras*. A reasonable working approach would be to take the shortest of the Purāṇas to be the early ones, to which parts got added at later periods in different regions of Greater India. It has to be pointed out, the word *avatāra* stands for the ‘descent of the divine’. The primary historical concern here is about Rāma and Kṛṣṇa, as they were born of human parents. There are *avatāras* of non-human birth, like Rudra, Devi, and Skanda, that are of celestial origin, but their actions are personified in earthly terms in the Purāṇas.

The following points emerge from the above texts taken together with the more popular Viṣṇu, Matsya, Liṅga, Bhāgavata and Skānda Purāṇas.

i) The law of everything in the universe is: creation, sustenance and dissolution (*śṛṣṭi, sthiti, laya*) symbolically controlled by the trinity Brahma, Viṣṇu, and Rudra (*aka* Maheśwara) respectively.

ii) Discrimination between the body and the *ātman* (*debātma-buddhi-vivechana*) is the underlying principle of *sanātana dharma*, that is, Vedic Hinduism. The human body is the most excellent of life forms, which one attains after a very long time, as reflected by the early *avatāras* of Viṣṇu. Dharma in practice includes celebration of the historical *avatāra* in human form, that is also the all-pervasive *antaryāmin* and *paramātman*.

iii) Intellectual effort in threading and weaving a plausible phenomenal timeline, following the Vedic *ākhyāna* style (reasoning through storytelling), starting from the birth of the Sun.

iv) A combination of the above points in different styles, colour and proportion is the self-sustaining dynamo for *sanātana dharma*, along with many social, regional, sectarian, and contradictory corollaries cropping up over centuries.

This is a minimalist interpretation, but in a lively organic system like Hinduism, the above implies a high level of structural complexity. But this is not a case of total randomness and disorder; it is a *fine-structured self-similarity in time and space at different scales* as per Prajāpati's *Manas*, that is considered to be the primordial matter in the Śatapatha Brāhmaṇa (*neva vā idamagre asadāsīt, neva sadāsīt | āsīdīva vā idamagre nevāsīt | taddha tanmana evāsa ||*)

Over some two thousand years, competing social groups, natural disasters, population movements and sectarianism have increased the number of Purāṇas to eighteen and more. The cliché of *vaiṣṇava, śaiva, śākta* classification masks the Vedic majesty of describing the cosmos, *sṛṣṭi, sthiti, laya*, and uni-theism encompassing all the *devatās* (deities), including *Time* as Brahman. It is evident that the Purāṇas in their present form are chronologically later than the Vedas. But it is important to recognise that the contents are deeply influenced by the concept of *Time* of the Vedas. If we dig and sieve patiently, nuggets of the Vedic *aparā vidyā* (worldly knowledge) might be retrievable from the Purāṇas.

7. Avatāra and Eternity

History in terms of number of years, as demanded today, was not the primary goal of the Purāṇas. Since the human *avatāra* of Viṣṇu was the *parabrahman*, possible contradictions were ironed out by making the texts *para-historical* (not un- or anti-historical) in the cosmological time frame of the *yugas* expanded to *manvantaras, kalpa, and parārdha*. This effort was as if time and space were created to situate *parabrahman* as one or more *avatāra*. It was important for the Purāṇas to keep the notional origin as the *First Creation*, for which long time periods of self-similar patterns mimicking eclipses, comet appearances, earthquakes, and floods came in handy. This model is derived from Vedic concepts, including *Dhruva, Meru*, cosmology, bardic genealogy, comets, solar and lunar observations against the background of the *nakṣatras*. Something of all the above entities, topics and events is available in the Vedas and the Purāṇas for anyone to read, analyse and understand.

If we sample the texts for realistic astronomical data, assuming the text to be uncorrupted, and be able to date such observations, footprints on the sands of Vedic and Purāṇic times can be discovered by methods of modern astronomy. This would be a Before Present (BP) year value for some human

groups to have read the skies. The cultural groups associated with such celestial descriptions were at least not later than the resulting BP year.

This way, if we derive the date of the Kurukṣetra war or Kṛṣṇa's birth date, we can be satisfied knowing that Rāma and Kṛṣṇa were great historical personages, although the anecdotes around them might have been picturesque poetry, some historical and some others floating folklore. But when the event is couched in the cosmological timeline, the perception of a stated past event in a measured relation to our generation vanishes. Purāṇas characterise the past mentally (*bhāvanā*) as from the first creation, starting from the *Svāyambhuva manvantara* (Era of the Self-created). This is the first era (each era of 300⁺ million years) of the *kalpa*, with fourteen eras that add to about 4.3 billion years in total length. Purāṇas have attempted this type of creationistic science so as to remain true to the Vedic tenet of the birth of the Sun as the origin of *Kāla* (*Time*), who is a form of *parabrahman* only. This way, Purāṇas do not like readers to be bogged down by the earthly frailties of Rāma or Kṛṣṇa, Śiva or Devī, but think of them to be transcendental for cultivating devotion towards them as all-pervasive *antaryāmin*. Further digression on this leads to the *uni-theistic Vedānta* metaphysics; *jñāna* and *bhakti* (intellectual and emotional) as the two modes of the human psyche to be kept in harmony by *dhārmic karma*. This topic is outside the scope of the present article.

8. Saṅkalpa

All over India, Hindus to this day, even if unknowingly, maintain their link to the putative *First Time* through the *saṅkalpa* (mental resolution) before any religious or important activity. This is a daily fixture among the orthodox. Among the lay Hindus also it is a must before special functions, such as laying a foundation stone, house warming, religious bathing and the like. Even many governmental bodies observe this in some form in public inaugurations and opening ceremonies, since this has a strong cultural background of millennia.

“...ādya brahmaṇah dvitīya-parārdhe śri sveta-varāhakaḷpe, vai-vasvata-manvantarekaliyuge, prathame pāde, jambūdvīpe,.... bhāratakhaṇḍe....śakābde,asminvartamāne, vyāvahārike....samvatsare....ṛtau, māse, pakṣe, nakṣatre, vāsare, tithau, muhūrte, śrīman

*nārāyaṇa/ śri parameśvara/ prītyartham ...śilānyāsam/ vāstuhomam/
samudrasnānam/ rudrābhiṣekam / kṛṣṇajayanti-pūjām/ yajñopavi-
ta-dhāraṇam/ kanyādānam/.....darśa-śrāddham/ dakṣiṇa/uttara/ayā-
na-puṇyakāle pitṛ- tarpaṇam/kariṣye”*

All over India, Hindus use very nearly the above template in Sanskrit, modified by local customs to suit the context of the event. If the above text is carefully checked, one can see stamps of three time scales. These are: the local calendar date and time (*nakṣatra, tithi, vāsara, samvatsara*), the intermediate scale historical era (*śakābda, śālivāhana, vikrama, kaliyuga*), and the very long time *manvantara, kalpa* reaching the *First Creation*. All three are important elements in the Hindu *saṅkalpa* and have to be correct, as ideally envisioned by the Vedas, but formulated per human intelligence over time. This *saṅkalpa*, the key to lifelong *dhārmic* activities of a practising Hindu, seamlessly incorporates historical past as phenomenal *Time* in three orders of magnitude Before Present (BP). Here, the ingrained concept of very long scale (cosmic, natural, geologic, evolutionary), intermediate scale (human history), and short scale (common era years), ending with local personal time, is dynamically enshrined as central to *dhārma*.

First, let us consider the intermediate time scale that has spurred many Hindus to question their own history and identity as believers of *sanātana dhārma*. This timescale is the historical time related to the rise of human civilisation as understood today. As one wades through the ancient texts for relevant data, what strikes the reader most are the tens of hundreds of names (persons, objects, abstract entities) that appear in the Purāṇas and the Vedas. These are of gods, kings, sages, ordinary people, celestials, demons, serpents, birds, hybrids, rivers, lakes, trees, forests, hills, heavens, hells, winds, years, months, lunar phases, stars, planets, time, numbers, mental concepts and whatnot! In the Sanskrit language, adjectives are also like proper names with grammatical gender endings. In fact, objects take their names in terms of their dominant properties, colour or actions, leading to multiple names for the same object.

Time and space (*kāla and deśa*) manifest together; accordingly, we have to recognise, *dyauh, antarikṣa* and *pṛthivī* as the strata on which the above names/adjectives/objects/ states/forces/*devatā*/gods have existence. For human history, it makes sense only to ask about what is on *pṛthivī* that is

generally, but not in all contexts, equated with earth as we know it now. It is important to note that the names of many kings, sages and even time stamps (*anumati*, *sinivali*, *kubū*) can also be the names of *devatas* (deities) in the Vedas and in the Purāṇas. In such a scenario, one has to be mindful about the figures of speech and whether the text is talking about personified celestial objects or about human ancestors, or kings or *gotra* progenitors. When time units and numbers are personified, one could suspect some scientific concept to be hidden behind the legends. The strong astral connection seen in Indian culture is due to the Vedic dictum *dyaugh pitā, pṛthivī mātā* (sky is the father, earth is the mother) and the theory of (*ṛṣṭi*, *sthiti*, *laya*) being cyclic, as per which, all life and death are repetitive, but on differing time scales.

9. Abhaya-Dhruva the Pole Star

The Vedic text *Taittirīya Āraṇyaka* (TA) clearly says that the seven seers, *Saptaṛṣi* and *Agastya*, are blessed, being with the asterisms.

*ṛṣayah saptātriśca yat | sarve atrayo agastyāśca | nakṣatrainiḥ śamkṛto av-
asan||* (TA 1.11.2)

This indicates these eight Sages (*Viśvāmitra*, *Jamadagni*, *Bhāradvāja*, *Gautama*, *Atri*, *Vasiṣṭha*, *Kaśyapa* and *Agastya*) were on earth like us before the two constellations (Ursa Major and Canopus) were named after them by the Vedic society. The above eight sages are the *gotra-starters*, to whom Hindus spread all over India trace their origin.

*viśvāmitro jamadagnirbhāradvājō'tha gautamaḥ | atrirvasiṣṭaḥ kaśya-
pa ityete saptarṣayah | saptānām ṛṣīnām agastyāṣṭamānām yadapa-
tyam tadgotramityācakṣate||* (Āśvalāyana Śrauta Sūtra Pariśiṣṭa)

There is much more than what meets the eye here. The celestial disposition of the constellation of *Saptaṛṣi* and of *Agastya* taken together reflects the sacred geography of the subcontinent *Bhāratakhanda* of the previous *saṅkalpa* text, sanctioned from north to south. This was strengthened by the legend of Sage *Vasiṣṭha* (also star *Mizar*) and Sage *Agastya* (also star *Canopus*), who migrated to the South of the *Vindhyas*, being brothers. The fuller integration of the terrestrial space of *sanātana dharma* as greater India was carried out by *Rāmāyaṇa*, the *ādikāvya*.

The *Taittirīya Āraṇyaka* is indispensable for anyone interested in the history of science, religion and culture of the Vedic society, leading to later refinements in Hindu astronomy. The concept of *mahāmeru*, the imaginary tower-like axis connecting earth with the heavens, appears for the first time in TA (I.7). The text alludes to seven suns and one more, the eighth called *Kaśyapa*, who does not leave *meru* but goes round the *mahāmeru* (*kaśyapoṣṭamah sa mahāmerum na jahāti*).

The above Vedic text (TA II.19) also describes the *Śiśumāra* (Draco) constellation with fourteen stars, the last one *Abhaya* (star Thuban or α -Dra) being stationary, with respect to other stars, to be called *Achyuta* and *Dhruva*⁶. Such a naked eye observation would have been possible only in (2830±200) BCE⁷. Thus, *kaliyugādi*, usually taken to be around 3000 BCE, is not wholly imaginary. On the other hand, through the story of the child prince Dhruva, who was blessed by Viṣṇu to be the Pole Star, the Purāṇas have coded an anchor point in the long-term societal memory of Hindus. The above Vedic text is now traditionally preserved and followed, as far as known, only in South India. But this tradition holds that some parts of the TA text are originally from the now defunct *Kaṭha* branch of Kṛṣṇa Yajurveda (KYV), which flourished once upon a time in the North. Thus, we can say that historically, ancestors of present-day KYV followers made the above *Śiśumāra-Dhruva* observation near Kurukṣetra. In this sense, the long-forgotten constellation *Śiśumāra*, which also appears in other Brāhmaṇa texts, is a celestial marker for history before and after *circa* 3000 BCE.

Agastya, as a star rising for short heights (altitude) in the southern horizon, would have been visible to the Vedic people around Kurukṣetra several centuries before 3000 BCE. The earlier name of this southern star was *Māna* (*a short measure*) and *Mānya* (one related to *Māna*) in the Ṛgveda (RV 1.166, 1.168). With the passage of time, the visibility interval of this star increased but remained at low altitudes without attaining height, unlike other stars. This celestial effect is attributable to Agastya's depiction as a dwarf in later iconography. Sage Agastya, who was perhaps the first to recognise the importance of this star for knowing the cardinal south direction, holds a high place in Hinduism.

The concept of celestial bodies going round *Meru*, held by the Pole Star, has been the inspiration for the *dhruvadarsana* ritual in Hindu marriages. In

the accented text *Ekāgni-kāṇḍa* of KYV hymns to be used in household rites are given. The hymn for observing and addressing the Pole Star, Dhruva, is

*dhruvakṣītiḥ dhruvayoniḥ dhruvamasi dhruvataḥ sthitam | tvam
nakṣatrāṇām methyasi sa mām pābi pṛtanyataḥ || (Ekāgnikāṇḍa 1.9)*

This hymn almost follows the last part of TA (II.19) describing the constellation *Śiśūmāra*; further alluding to the astronomy of that period. Here, the quality of fixity becomes the name for the star *Dhruva*. *Dhruva* is praised as the *methi* or the central point of a fixed column by which the *nakṣatras* are controlled. This is an empowering hymn for the newly married bride, so that she is stable in her new home, with the assurance that the siblings of her husband will obey her. The commentator Haradatta explains the word *methi* as *khalevālī*, a thick wooden peg fixed in the ground, to which animals are tied so that they do not stray away⁸. This *methi* became the *medhī*, a pole or column in the Purāṇas, highlighting the fixity of the star *Dhruva* and the importance of *Meru* in the development of early astronomical models.

10. Effect of Precession

Axial precession of Earth is a reality, like sunrise and sunset. Apart from the daily and annual periods, Earth has a very long period of about 26000 years, called the precession cycle. No star-worshipping culture can escape experiencing this, and, in some manner, this would have found expression in the form of special rituals, unprecedented questions and doubts. Change in the celestial scenario around the Pole is extremely slow to be observed with the naked eye, but could be felt over generations in comparison with past beliefs and narrations. Today, with the knowledge of Earth as just another planet in the solar system, the fixity or otherwise of a star at the North Celestial Pole may not mean much. But for our ancients with a geocentric world view, any change in the behaviour of the Pole Star in the *Śiśūmāra* constellation would have had strong repercussions on their belief system and the way life on earth related itself to the visible sky. Available Yajurveda texts richly attest the experiential effect of precession on the rituals, social practices and the spiritual quest of the Vedic people.

10.1 Dhruva Graha

The stability of the star *Dhruva* in the sky is reflected in the Vedic *Agniṣṭhoma* rite, where *Soma* juice is drawn in the morning in nine cups (*graha/sthāli*), the ninth being the *dhruva-graha*. In the *Taittirīya Saṁhitā* (TS), we come across the hymns for invoking the *dhruvagraha* in TS (1.4.13) and the reasons for this in the (*Brāhmaṇa*) part TS (6.5.2). If the two parts are not studied together, the meaning of the *dhruvagraha* gets translated literally as a cup, which, for the sacrificial process, is lexically correct, with no insight into the astral imagery behind the Vedic mantra. In the first place, the TS text adopts RV (6.7.1) for invoking *vaiśvānarāgni* overhead in the sky as *samrāt* (emperor) and to laud the *dhruva* cup in the sacrifice as the abode of fixity, firm among the firmest, and the most permanent among the permanents⁹. All this laudation is for the star named *Dhruva* in the north will be clear, only when we read the explanatory *Brāhmaṇa* part for the mantra in TS (6.5.2). The relation between the *Dhruva* cup on the sacrificial ground and the eponymous star is made clear through an etiological legend.¹⁰

The demons (asurāḥ) from the north attempted to turn the earth around; the gods (devāḥ) firmed it up with Dhruva; that is how Dhruva gets his name, for Dhruva is placed in the north for fixity. (TS. 6.5.2)

The above Vedic statements uphold that indeed a star known as *Dhruva* in the northern sky was considered to be fixed in the sky, but then there was apprehension that it was susceptible to some perturbation, felt with respect to the earth. The initial fixity for several centuries and later slow change of the star *Dhruva*, perceptible to the naked eye, must have had many social, philosophical and religious implications for the Vedic people. The experience of this change would have had deep impressions on the Vedic society, some of which are available in the KYV texts, carried on to the *Purāṇas* with many colourful modifications.

The *Maitrāyaṇīya Saṁhitā* (MS) belongs to the group of *Taittirīya*, *Kaṭha* and *Kaṭha* texts of KYV. Like with the TS text, *agniṣṭhoma* and *soma-graha* (*soma* cups) are met with in the MS also. The broad picture is the same in all four Yajurveda texts, but a special ritual, hitherto not widely known, is available in MS about the *Dhruva-graha* and its connection with the star of the same name. *Dhruva-sthāli* is an earthen pot filled with *soma*

juice kept in the northern shed on a special seat, unlike the other eight kept on bare ground in the southern shed. MS (4.6.6) is a long text of which only an extract is presented here¹¹.

Dhruva is verily the length of life (āyuh)... This [Dhruva cup] is kept on a piece of gold for one desiring long life..... Rājaputra (the prince) protects the Dhruva vessel; this way, he protects the life of all the people; hence, he (prince) becomes the strongest. If the patron (yajamāna) likes to do black magic (abhicāret), he [the priest] says 'hereby for so and so I disturb the life' by turning the Dhruva [cup]..... 'I displace you, Dhruva, from this fixed abode; this way, he displaces him [the targeted individual] from his exalted seat; he is liable to perish when Dhruva is displaced; all the worldly beings are prone to be displaced. The patron (yajamāna) may also be displaced. He touches the Dhruva cup and prays 'Protect the celestials in the sky, intermediaries in the atmosphere and humans on the earth'.

10.2 Dhruva Moves

All the texts associate Dhruva with *āyu*, that is, life span. The principle behind the *abhicāra* (black magic) of turning and disturbing the *Dhruva cup* to displace a human king from his office can be attributed to a religious custom based on observed changes to a star that was, over generations, believed to be stationary and fixed. The felt effect of the unsuspected anomaly in the Pole Star is further substantiated in the *Maitrāyaṇīya Āraṇyaka Upaniṣat* (MAU). King Bṛhadratha expresses his anguish about the phenomenal world to ask Sage Śākāyanya, a long set of questions, part of which reads.¹²

Why the oceans are getting dried up, why are the peaks of mountains are falling down, why is Dhruva moving, why are the air strings (holding celestial bodies) are cut and dipped, why the earth moves from its place.
MAU (1.4)

King Bṛhadratha laments about the transient nature of life, listing sixteen of his predecessors: *Sudyumna, Bhuridyumna, Indradyumna, Kuvalayāśva, Yauvanāśva, Vadbrya, Aśvapati, Śasabindu, Hariścandra, Ambarīṣa, Nanaktu, Śaryāti, Yayāti, Anarāya, Akṣasena* and the more ancient Marutta and Bharata before him. The King wonders why orbits of celestial bodies dip,

why the Earth shifts, and why the peaks of mountains fall. He continues to ask why even *Dhruva* moves, which doubt is due to the felt effect of precession, notwithstanding the belief of his predecessors that the Pole Star remains always stationary. With further data in the text about *dakṣiṇāyana* starting from *Maghā nakṣatra* to *half-śraviṣṭha* (fn.. 1), the above episode can be dated to about 1800 BCE. Beyond a reasonable doubt, the above sixteen kings preceding Br̥hadratha were historical and lived during the centuries around 1800 BCE. The above date is of special interest as this fits exactly with the Purāṇa observation of equinoctial full moons in the *Kṛttika-one fourth* and *Viśākha-three fourth* sectors¹³.

Archaeo-astronomical study of the Sanskrit texts is the only rigorous and objective approach to arrive at chronology prior to Chandragupta and Chāṇakya. Once the meaning of the Sanskrit texts on celestial description is agreed upon as credible in modern terminology, error estimation is possible, and the results can be verified by others. Vedic texts have been preserved with great fidelity, but the same cannot be said about the Purāṇas. The astronomical parts of some of the Purāṇas are consistent, even though the reasons for the reported numbers may not be clear. When reliable statements of sky observations are analysed, consistent historical dates can be obtained as described above. The unique period of (2830±200) BCE from TA, the rituals and aetiology associated with the Pole Star in KYV amply demonstrate the civilizational historical past of Vedic Hinduism. The convergence of the MAU and the Brahmāṇḍa Purāṇa sky pictures, a thousand years later, *c* 1800 BCE, speaks for itself about the spiritual link between the Vedas and the Purāṇas in *sanātana dharma*.

11. Archaeology

If the textual geographical names of towns, villages, forests, lakes, and coastlines are believed to be the same as the current names, archaeology would be helpful to unearth history. Excavations and consistent match of textual data with field stratigraphy and cultural artefacts can lead to reasonable dates. For example, drying of the River Sarasvati is described in the Skānda Purāṇa, MB and several other texts. This can be verified scientifically to present-day standards on the ground in the Brahmāvarta region, to have happened *circa* 4000 BP, that is, around 2000 BCE. The texts have perpetuated the memory of this

slow natural event in umpteen different ways, and there is no denial that this has remained in the societal memory, as evidenced by the migrant community with the moniker *Sāraswata* spread all over India. Considerable caution is necessary in archaeological excavations since displaced people usually name new settlements with their previous city/village/river names of fond memory. In some of the Purāṇas, this shows up as a discontinuity or a contradiction in the geo-environment, purportedly of the same sacred site. For example, the present-day towns of Dwaraka and Somanath (also known as Prabhasa Patan) do not answer to the descriptions of the places with the same names in the MB and in the Harivamśa¹⁴.

12. Genealogy

Names of Kings, sages and their genealogy are too fluid and diverse. Even though a reliable royal succession line could help in estimating the time intervals, the recorded names may be *gotra* names, which are still used even now. As can be easily verified, Nārada's name comes up in so many places, starting from the Vedas, in the sky, on earth and in almost all legendary royal courts. Parāśara's name appears in the Veda, Purāṇa, *smṛti*, astronomy, and astrology texts. Similar is the case of many famous Kings and their priests. Pargiter laid out a formal framework of mapping this mosaic, that has been followed and refined by his followers^{15,16}. In this approach, there are too many possibilities, and hence it is difficult to arrive at a consensus among a group of people. Genealogy studies are helpful to arrive at a broad picture of the historicity of the Vedic Sages and ancient heroes. But specific questions may remain unanswered. For example, it is not possible to say whether the Ambarīṣa mentioned by Bṛhadratha in MAU, cited above, is the same as the one in the Bhāgavata Purāṇa. The texts are clear that *Daśaratha Rāma*, as a historical person, preceded Kṛṣṇa, the son of Vasudeva and Devaki. But the linkages between the two, as per the Uttarakāṇḍa and the Harivamśa, are not exactly compatible. Similar is the case of *Rāma* appearing in the 10th *maṇḍala* of RV. This cannot be asserted to refer to the son of Daśaratha of the epic Rāmāyaṇa.

13. End of an Era

Talking about the not-too-distant past, one should wonder why elapsed years are recollected as in the Śaka Era (*śakābde*) in the religious *saṅkalpa*. The

word *śaka* in current parlance is used in the sense of *Era/Epoch*. But, in reality, the word *Śaka* refers to the violent tribes of Scythians who came from outside, created havoc and established themselves in parts of northern India, till they were routed out by the Guptas. In the *saṅkalpa*, Hindus are made to recollect a turbulent period of their past, when Scythians invaded and destroyed well-established *dhārmic* kingdoms of Pāṭaliputra, Sāketa, and Avanti (100BC-100AD). The famous Purāṇas do not have much to say on this period, but some of the Sanskrit dramas and Jaina texts allude to the tragedies of this period. There is a tiny text with just 115 verses, called *Yugapurāṇa* (YP), that provides some real history of this period. This Purāṇa is like a conversation between Śiva and Skanda, but the present-day *Skānda Purāṇa* editions do not have this chapter. This short YP text remained submerged as a part of the larger Vṛddhagārgīya Jyotiṣa (VGJ) manuscripts, till recognised for its importance first by Mankad¹⁷ and later critically edited by Mitchiner¹⁸. The identity of the author is not known, but that does not reduce the importance of this text, that has nothing to do with either astronomy or astrology, but is about the political history of India subsequent to the misery caused by the Śakas. The YP text is in Purāṇa style, primarily aimed at linking its narration chronologically with the heroes of MB.

As per YP, very briefly, the first *Kṛtayuga* ended with the *Tāarakā war* (*devāsura yuddha*, a metaphor for an ancient period when the sky was disturbed with extra-terrestrial impacts causing disasters in India). The *Tretā-yuga* ended with Rāma destroying *ksatriyas* twenty-one times, which is a clear reference to Paraśurāma and not to Daśaratha Rāma. Keśava (Vāsudeva Kṛṣṇa) and Pāṇḍavas were at the closing part of *Dwāpara*; whereas Janamejaya Pārikṣita (son of Parīkṣit) was at the start of *Kaliyuga*. This *yuga* was said to have gradually transitioned after the Yavanas and Śakas were pushed back. Northern India was devastated by famine, followed by people resettling peacefully in twelve different regions of India, including the South, waiting for a new era as though *Kaliyuga* was ending! This text helps one to appreciate how *śakābda* got mandated, in parts of India, into the *dhārmic* vocabulary.

It may be inferred that YP and other relatively short texts must have originated from the same ancient source, which is cryptically mentioned as *purāṇam* by Nārada in the Chāndogya Upaniṣat. The popular Purāṇas, when scripted in the royal courts, were expanded in their size and also in the length

of the *yuga*, so that they became *para-historical* by design. Several other *smṛti* and *āgama* texts also appear *para-historical* with their authorship ascribed to Vedic sages; Manu, Vasiṣṭha, Kaśyapa, Parāśara, Agastya, Nārada, Viśvāmitra, Hārīta, and Yājñavalkya. One may wonder why so; were the original *Purāṇa* bards unethical, or did they have a greater nobler ideal in front of them for a special purpose? It appears they had set for themselves to give to society a taste of what had been lost due to one or more apocalyptic events with widespread destruction, denoted by the generic word *Pralaya*. The people directly bearing the brunt could not have left any record. Only the survivors and their progeny, gathering their lives and spiritual strength, could have said or written about their ancestral past. Possibly, the School of Vyāsa not only organised the family texts of the Vedas for proper preservation, but also sowed the seeds for the *Purāṇa Saṁhitā* meant for public consumption in the storytelling tradition. We have no access to the original deliberations, but the *Brahmāṇḍa Purāṇa* provides some clues to this.

14. Śiṣṭācāra

A very powerful phrase, *śiṣṭāchāra*, is usually cited by *dharmasāstra paṇḍits* when questioned about the validity of some peculiar socio-religious practices. The word *śiṣṭa* in current Sanskrit means one who is exceptionally pious/ learned/cultured/eminent. Hence, *śiṣṭāchāra* would mean what is done by such persons or role models, as an answer for some knotty questions and doubts. But as per the *Purāṇa*, the original sense of the word was closer to the etymological meaning of ‘*remainder* or *left back*’ from the past,

*śeṣaśabdah śiṣṭa iti śeṣam śiṣṭam pracakṣate|
manvantareṣu ye śiṣṭā iha tiṣṭhanti dhārmikāḥ||* (BPu.1.32.37)

The word *smṛti* is also defined as what is remembered from previous historical epochs. Not everything can be written down, nor remembered. This permitted flexibility in practice, avoided fanatical fundamentalism, but still bound the society by the eight principles (*lakṣaṇa*) of *dhārmic śiṣṭāchāra* (BPu. 1.32.41). These are declared as *dāna* (charity), *satya* (truth), *tapas* (penance/meditation), *jñāna* (knowledge), *vidyā* (learning), *dayā* (compassion), *ijyā* (*pūja*/ritual worship), and *vrajana* (*yātra*/renunciation/emigration/resettlement).

The oft-repeated *pañcha lakṣaṇa*, namely, *sarga*, *pratisarga*, *vaṁśa*,

manvantara, *varṁśānucharita*, are there in the Purāṇas, but these are mere supporting crutches to promote and continue the practice of the above eight principles, bequeathed by our most ancient ancestors as the essentials of *sanātana dharma*.

15. Structure of Sanātana

The word *sanātana* in the sense of *very ancient* is traceable to the *Śatapatha Brāhmaṇa*. The word *sanātana* refers to a concept that is ancient, pramaeval, perpetual and eternal. It is apparent that Vedic-Hinduism promoted by the Purāṇas, epics and the *āgamas*, expect *sanātana-dharma* followers to connect themselves emotionally and intellectually with the First Matter/Creation/Creator as their source! One among Viṣṇu's thousand names in the *Anuśāsana Parva* of MB is *sanātsanātanatamaḥ*; *ancientest than the ancient*. This is not just a dictum for those meditating with their eyes and ears closed. Hinduism helps average people with a hundred-year life period, also, to link elegantly and objectively with a very long-time scale, in the practice of *dharma*.

The *sāligrāma*, widely worshipped in public temples and in private homes, is a direct manifestation of Viṣṇu. No special *prāṇa pratiṣṭhā* (infusion of life energy) is needed, unlike in the case of large metallic and granitic icons. The *Garuḍa Purāṇa* and the *āgama* texts extoll worship of *sāligrāma*. How and why did this practice spread all over India? Is it purely by chance, or is there any special significance? A votary of modern science can say without contradiction that the *avatāra* of Viṣṇu as *Ammonite/Sāligrāma-śila* happened during the epoch 500-566 Mya. The earliest visualizers of the divine on earth also realised primitive life forms to be modes of Viṣṇu and selected *sāligrāma* to represent a very ancient period (*manvantara*) in the course of an average Hindu's life. One can say that for a good Hindu, it is not sufficient to know the *avatāra* stories of Rāma, Kṛṣṇa, Śiva, and Śakti for developing *Bhakti*, but it is necessary to ponder also the origin of life on earth.

There seems to be no direct statement about *sāligrāma-śilā* in the Vedas, although there may be links to Vedic rituals, based on the principle of similarity in creation. In the Vedic rites of *agnichayana* and *pravargya*, an important *sambhāra* (component) to be collected is the *valmīka-vapā*. This is the special mud with a thin white fungus-like cover (*vapā*) from a termite mound.

Without digressing on the rituals, it is noted here that the Vedas laud termites (*vamrīḥ*) as the firstborn of this creation on earth (*devīrvamrīrasya bhūtasya prathamajā rtāvarīḥ*| TA. 4.2.3). Modern science estimates this life form to have evolved about 250 million years BP. One wonders whether this could have been the precursor for *sāligrāma* worship in Hinduism.

The above are not isolated cases of ancientness (*sanātanatā*) built into the worldview of Vedic-Hinduism. The Skānda Purāṇa in the Prabhāsa-khaṇḍa (PK) describes an ancient extraterrestrial impact as part of the physical features of the old Prabhāsa region. This provides the aetiology for worshipping *Liṅga*, literally an insignia, but commonly taken to be Śiva's phallus fallen on earth. The text graphically describes;

yo'sau kālāgnirudreti procyate vedavādibhiḥ |
so'yam bhairavanāmnā tu prabhāse suvyavasthitaḥ ||
agninā yatra taptantu divyābdānām caturyugam |
meghavāhanakalpe tu tatra liṅgam babhūva ha ||
agnimīdheti vedokta prabhāvaḥ surasundari |
kālāgnirudranāmā ca devaiḥ sarvairudābryam ||
agni īśāneti deveśi nāma tritayamucyate | (PK 4.68,71-73)

This means, one who is called *Kālāgni-rudra*, by the followers of the Vedas, is in Prabhāsa by the name Bhairava. When *Agni* burnt continuously for a length of four *yugas* in the *Megha-vāhana Kalpa*, a *Liṅga* manifested. This *Liṅga* is said to have three Vedic names, *Agnimīdha*, *Kālāgni-rudra* and *Agni-īśāna*. This manifestation of fiery Rudra as *Liṅga* is easily recognisable as Śiva or Īśvara, one among the *Trinity* of Hinduism responsible for disaster and dissolution. In the eleventh Chapter of PK, the Purāṇa narrates the legend of the Sun falling down on the Prabhāsa region. Here again, the concept of a very ancient epoch is introduced. Sun's birth is said to be at the beginning of the present *Śvetavarāha Kalpa*, that is, about 2300 Mya. The descent or fall of a part of the Sun is said to have happened in the *Svārociṣa manvantara*, which works out to be 1665 Mya. It is said that the sea near Prabhāsa receded for a thousand years and also overflowed after a long time. The text also identifies that out of the first fifteen parts of the falling Sun, the discus of Viṣṇu, the trident of Śiva, the spear of Skanda, the weapons of all the gods and demons got formed (PK 11.195-205). This alludes to the celestial origin and

inspiration for the sacred religious symbols. All of this strange but powerful narration in the Purāṇa is combined with the vanishing or drying up of the River Saraswati in a picturesque and poignant style¹⁹.

It should be noted here that the historical event (*circa* 4000 years BP) of the River Saraswati vanishing in a place called *vinaśana*, and the inherited memory of meteorite impacts and craters on the ground, have had the effect of the Vedic people asking questions about their own ancient past. Consequently, as plausible explanations, methods were devised to quantify long periods of time, punctuated by natural disasters. One may wonder how the Purāṇa authors could have estimated the length of the *manvantaras* and the time to the birth of the Sun as 2.3 billion years BP. There are no clear-cut answers, except that we can speculate that this might be connected with the slow drift of the original Pole Star.

Even though the Purāṇas profess to describe what has been left over by the survivors of one or more natural disasters, it is still possible to decipher the relevance of some of the stories. For example, in the *Bhāgavata Purāṇa*, we come across the narration of Dhruva marrying Śiśumāra's daughter by name *Bhrami* (*one-who-rotates*), the union of the two leading to two offspring named *vatsara* and *kalpa*,

prajāpaterdubitarā śiśumārasya vai dhruvaḥ |
upayame bhramim nāma tatsutau kalpavatsarau || (Bhā. 4.10.1)

This is obviously a euphemism for star Dhruva-the-fixed, acquiring the property of rotation, which is taken to produce the short-time-period *vatsara* (year) and also a long-time-period called *kalpa*. The constellation of Śiśumāra, having fourteen stars emphasised forcefully in several of the Purāṇas, could have been the inspiration for proposing fourteen *manvantaras* to be in a *kalpa*.

16. Common Era

The recent timeline of Hinduism, from the beginning of the *Śaka Era*, almost the same as CE, is well known to be repeated here. Two new time parameters, namely *Vāra* (seven weekdays) and *Rāśi* (twelve signs: *meṣa.....karkāṭaka,.....tulā,....makara... mīna*), not available in the Vedic oral tradition, got introduced into the Hindu religious vocabulary. Vedic time characterisation had been an interlacing of the solar and lunar phenomena by direct experience

of the sky. Some of the Purāṇas extended this to planets also, to introduce special religious observations. Always, the background of the moving bodies was specified with respect to eighty-six stars, grouped into the twenty-seven nakṣatras along the ecliptic. Siddhānta astronomers of CE refined the above, with sophisticated mathematical models, spherics and computational trigonometry. Somehow, notwithstanding the growth of intellectualism and mathematical astronomy, horoscope astrology and the printed word gained the upper hand in the last few centuries, to the detriment of direct observation of the sky. Somewhere along the line, conversation between astronomers and *Dharmaśāstra* interpreters took a back seat, with distorted notations getting introduced for solar standstills and equinoxes. This has made the last section of the tripartite timeline in the *saṅkalpa* part somewhat disconnected from the Vedic ideal of harmony with the Sun's transits.

The earliest twelve divisions of the year was with respect to the two *ayanas* and the six seasons, which in turn depended on the summer solstice being the longest day (*abhas*) of the year, reckoned as the beginning of the *varṣa ṛtu* (rainy season) of two months named appropriately *nabha*, *nabhasya*. Similarly, the longest night (*rātri*) of the year, which indicated the winter solstice, such that consecutive sunrise points started moving northward (*uttarāyana*), was the onset of the *śiśira ṛtu* (winter) of two months; *tapa*, *tapasya*. The other two solar phenomena of equal day and night were at the *middle* of the *vasanta* (*madhu*, *mādhava*) and the *śarat* (*iṣa*, *ūrja*) seasons. Even now, these are the four Vedic invariants or fixed points experienced directly in terms of the duration of the *abhas* (day) and *rātri* (night) within observational errors. The Vedāṅga Jyotiṣa texts discussed previously introduced additionally early morning *nakṣatra* rise as season markers, recognising fully well that these named asterisms will change over centuries, but not the *ayana*, *viṣuva day markers* along with *ṛtu* and their given names.

The above points should make it clear that, as per *sanātana dharma*, in the *saṅkalpa* rite, the two yearly *ayana* (*uttarāyana*/*dakṣiṇāyana*) and the invariant four solar *aborātra* have to be in synchrony with the Sun's transit each and every year; past, present and future. It has been pointed out by many that the present *makara saṅkrānti*, as per the *rāśi* notation in the published almanacs of many Hindu religious institutions, does not correspond to the real northern turning point of the sun, and hence the other three fixed points

and the six seasons are also faulty by about three weeks. Surely, some people will say, if the new year is celebrated on different days by different linguistic groups, there can be no grave harm to Hinduism in general. True, but the issue here is not just about the name of a month, or some day in the year and the celebration associated with it.

All ancient religious feasts, fasts and life events of Hindus have been connected with the solar *ayana* and *ṛtus* since the Vedic period. To cut a long story short, many pious Hindus awaiting their last days wish to pass away when the Sun is in northward transit, even as the Grand Sire Bhīṣma waited for *uttarāyana* to start, for leaving his earthly body after the MB war. All over India, Hindus honour Bhīṣma as an exemplar *dhārmika* and hold him as a role model. Now, imagine the horrendous psychological impact of the error by marking *uttarāyana* and the older Vedic month *taisya* (*tai* in Tamil) to start on 14th January, instead of on or around 21st December in the current civil calendar. The reason for this mistake is not difficult to guess. Some influential sectarian religious text seems to have ignorantly equated the computed *Rāśi* divisions (*meṣa*, *vṛṣabha*, etc.) with the then prevalent twelve solar months (*chaitra*, *vaiśākha*, etc.) somewhere around the 12th century. Let the *makara saṅkrānti* and the *pongal* day be any day, but the fault of showing the period between 21st December and 14th January as *dakṣiṇāyana* cannot be brushed aside nor excused as *śiṣṭācāra*. This is not a small error but a serious mistake to be addressed and corrected by the followers of Vedic Hinduism.

The heads of religious institutions and learned astronomers should prevail upon the interpreters of *smṛti* texts to introduce corrections into the almanacs, as per observable *ayana*, and *ṛtu* and not be carried away by the definition of *Rāśi* notation that became fashionable in the country only around the 3rd century CE.

17. Scientific Temper

New thoughts, corrections and explanations in characterising time were always encouraged, so much so that astronomy was defined long ago, as *kālavidhāna śāstra*, that is, *the science of time determination*. Historically, this has been cultivated by following the seasons, sun, moon, planets and comets in the background of the *nakṣatras*. Checks and balances were always invoked to introduce corrections wherever needed. This system depended on

observation, analysis and synchronisation of the ‘time’ of the mathematical *Jyotiṣa* and the practical *Dharmaśāstra* disciplines, which now remains nearly broken. An example of how a correction was introduced, keeping the Vedic spirit in mind, may not be out of place here.

The star *Abhaya-dhruva* in the Vedic *Śiśumāra* constellation was not just the pivot for Vedic history and astronomy, but over centuries, weathering the effects of precession, *Dhruva* merged with the very fabric of the Hindu society, so as to have an ethereal existence even when the star could not be physically seen. The marriage manuals of the Common Era following the *Pāraskara Sūtra* mandate that the bride should say ‘I see’ even if she is unable to see *Dhruva* (*astamite dhruvam darśayati, dhruvamasi dhruvam tvā paśyāmi... iti| sā yadi na paśyet paśyāmi ityeva brūyāt ||*)²⁰. This *Sūtra* belongs to the Śukla Yajurveda branch, largely followed in North India and Nepal. Interestingly, this tradition does not have the additional *arundhatī-darśana*, as with the *gr̥hyasūtra* of KYV, followed in the South.

The long-lasting memory of the times when there was a fixed Pole Star has been immortalised in the poem *Kumārasambhavam* of Kālidāsa (5th cent.), where the marriage of the divine couple includes *dhruvadarśana*

*dhruveṇa bhartrā dhruvadarśanāya prayujyamānā priyadarśanena|
sā dr̥ṣṭa ityananamunnamayya hr̥sannakaṅṭhī kathamaṇḍapuvāca || (7.85)*

Here, Śiva lovingly shows to the shy Pārvatī the star *Dhruva*, prompting her to raise her head coyly and somehow say *dr̥ṣṭaḥ* (seen).

It is quite possible, lay people, without serious concern for the meaning of the Vedic hymn, showed the bride some star in the night sky, just as in another ritual. But the paradoxical situation did not escape the attention of Kamalākara Bhaṭṭa, a reputed astronomer of Vārāṇasi in the 17th century. He seems to have faced the ethical (*dharma-saṅkaṭa*) question of which star should be seen by the bride in Hindu marriages. This issue should have been very relevant, since the prescribed Vedic hymns laud the fixity and the unchanging nature of *Dhruva*. Furthermore, even if one were to know the location of the original Vedic star in the Draco constellation, it would be at low altitudes, deviated from the north direction. True to the spirit of the Vedic *mantra*, Kamalākara in his treatise *Siddhānta-tatva-viveka* (1658 CE) declared

*cale'calepi dhruvabbe svameṣādrāśitrayam taddhruvakah śarastu |
 ṣaṭṣaṣṭibhāgāḥ pariṇitanāryāḥ mahatphalam darśanato'sti yasya ||
 (Bhagrabhayuti v 8)*

This meant that the ecliptic coordinate of the star to be seen by the bride was at 90° longitude and 66° latitude. This was clearly the star at the mouth of the *Dhruvamatsya* (U. Minor), the new *Dhruva* (Polaris) that continues to be the current Pole Star, prescribed to be shown to the bride in Hindu marriages.

17. Discussion

The concept of past and historical time in the practice of Vedic Hinduism has been explored in this article from an emic perspective. The *sankalpa* rite, which applies to Hindus of all traditions and is practised widely in social, secular and religious contexts, has been used as a touchstone to bring out the intricacies of the tripartite historical time scales of Hinduism. These are: (i) the most ancient, deemed to be from Sun's birth, (ii) the intermediate and (iii) the recent past merging with the present. The three connected seamlessly provide the substratum of *Kāla* (Time) in the practice of *sanātana dharma*. The original Vedic hymns about cosmology, *kāla* and *akāla*, the Pole Star *Abhaya-Dhruva*, felt the effect of precession, rituals connected with *dhruvagraba*, *dhruvasthāli*, and chronological coherence among the cited Vedic, epic and Purāṇa texts, characterise the first two timescales. The first, by definition, starts from the birth of the Sun, whereas the second, which underlines the civilisation dimension of Vedic culture, has had its anchor in *Abhaya-Dhruva*, the Pole Star in the constellation *Śiśumāra* (Draco) during (2830±200) BCE. The perfect match between the solstice points of the Vedic MAU and the equinoctial full moon stations of the Brahmāṇḍa, Vāyu, Viṣṇu, and Matsya Purāṇas, on the solar *nakṣatra* zodiac of the epoch 1800 BCE, upholds the chronology on the intermediate time scale. This period can be said to be the historical beginning of post-Vedic Indian astronomy or *Vedāṅga Jyotiṣa*, as described in the “*Mahāsalīlam*” preserved in the Vṛddha-Gārgīya Jyotiṣa²¹. Further chronological benchmarks are available in the astronomical works of Parāśara and Vṛddhagarga when the winter solstice day was observed to occur at the beginning of the *Śraviṣṭhā* (Aquarius/Delphinus) sector correspond-

ing to 1400-1300 BCE. The *Ṛtuswabdhāva* chapter of VGJ provides another observational date of *c* 500 BCE²². With this, one arrives at the end of the intermediate timeline line transitioning to the known historical period of Mahāvīra, Gautama Buddha, Chandragupta, Chāṇakya and the third timeline of the *Śaka Era* starting from 78 CE.

The *meru-dhruva* centric kinematic astronomy model, as available in the Purāṇas, is yet to be evaluated for its scientific content. Although some of this material may sound fanciful, the numbers and possible correlations challenge one to wonder what experience might have inspired such large astronomical numbers. In the *Brahmāṇḍa Purāṇa*, Dhruva is said to be fixed and stationary, holding the other celestials by air strings. The Śīsumāra constellation with fourteen stars, the last four ending with Dhruva, being circumpolar, is systematically described. However, in another place, the diurnal circular movement of Dhruva in harmony with the day-night of thirty *mubūrtas* is mentioned²³. It seems, as an improvement of a previous idea, the autorotation of Dhruva was taken to be the cause of the rotation of the Sun, the Moon and other bodies. In the present state of the Purāṇas, very delicate statements as above are mixed up with stories of child prince Dhruva going to the forest for penance and getting the boon to stay as the Pole Star till the end of the world, along with his mother *Sunīti* as a companion star. Indeed, the ancient Pole Star α -Dra has a companion star ι -Dra as *Sunīti*, which could have helped the identification of star *Dhruva* in religious rites before the Common Era.

The Purāṇic *kalpa* of 43,20,000 years was adopted by astronomers to state accurately the integral number of revolutions of the moon and other planets. As is known, Āryabhaṭa was the first person to state that the earth rotates on its axis, causing day and night. It would not be wrong to infer that he knew the Purāṇic lore of star *Dhruva* doing diurnal rotation in the same place for *thirty mubūrtas* and interpreted this to be a relative motion as seen from earth, to propose his new model of a rotating earth, while the stellar cage (*bhapañjara*) remained fixed.

18. Conclusion

The religious and cultural practices in Hinduism are the results of a deep desire to align human activities with natural rhythms and cycles for all time; past, present and future. This does not mean time in Vedic Hinduism is

cyclic, as some mistakenly interpret. Such an explanation is similar to a casual observer misunderstanding the waves for the ocean. The *Taittirīya Āraṇyaka* of KYV, in the very beginning (1.2), explains time to be like a river with small streams (time units) adding up to form the *samvatsara* (year), flows continuously and is irreversible. The sense of past as historical time in Hinduism is esoteric, although in religious practices, it is tangible to all as a combination of ancient Vedic tenets, Purāṇic societal memory, recent past and the present continuous.

The Vedic definition of measurable time, stated to be from the birth of the Sun, is textually evidenced in a technical sense in the historical period of MAU (*c* 1800 BCE), but this concept must have come down from the time of the Ṛgveda or even earlier. A unique concept of evolutionary modes of life forms is also inherited from the Vedic past. The natural history of the *Iriṇa* (Rann-of-kutch) and the *Arbuda* (Arāvali) mountainous region, including the episode of the drying of River Saraswati, is available in the Vedic texts and the Purāṇas. It is remarkably symbolic and also realistic that *Kālāgni-Rudra* should be hailed as *Iriṇya* in the Yajurveda. The rationale for devising long time intervals in the Purāṇas approaching the *infinite past* must have been due to deep reflection on the gradual drying of the sacred river Saraswati, extraterrestrial impacts and the transience of *Abhaya-Dhruva*, the pole star, once extolled as *Achyuta*. The Purāṇic concept of *sanātana dharma*, deemed to be coeval with the Sun's manifestation 2.3 billion years ago, may sound emotional, imaginary and fanciful, but the number is remarkable for its order of magnitude being in harmony with similar modern cosmological and natural history estimations.

The Vedic injunction, *kālam brahmetyupāsīta*, applies equally to all followers of *sanātana dharma*, whether they be *vaiṣṇavas*, *śaivas*, *śāktas* or atheists. True to this, the primary sources of Vedic Hinduism have preserved verifiable celestial events for their historical past at least up to about 3000 BCE. Prior to this period, the texts and equally well the continuing religious practices prompt Hindus to picture the natural history of Greater India, and to contemplate on the cosmogony and cosmography of the solar system and beyond.

Notes

1. अथान्यत्राप्युक्तमन्नं वा अस्य सर्वस्य योनिः कालश्चात्रस्य सूर्यो योनिः कालस्य । तस्यैतद्रूपं यन्निमेषादिकालात् संभूतं द्वादशात्मकं वत्सरमेतस्याग्नेयम् अर्धम् अर्धं वारुणम् । मघाद्यं श्रविष्ठाधमाग्नेयं क्रमेणोत्क्रमेण सार्षाद्यं श्रविष्ठाधान्तं सौम्यम् । यः कालं ब्रह्मेत्युपासीत कालस्तस्यातिदूरमपसरतीत्येवंह्याह ।..... द्वे वाव ब्रह्मणो रूपे, कालश्च अकालश्च, अथ यः प्रागादित्यात्सो अकालो अकलो, अथ य आदित्याद्यः स कालः सकलः, सकलस्यवा एतद्रूपं यत्संवत्सरः, संवत्सरात् खल्वेमाः प्रजाः प्रजायन्ते संवत्सरेणेह वैजाता विवर्धन्ते संवत्सरे प्रत्यस्तं यन्ति तस्मात्संवत्सरो वै प्रजापतिःकालः..... । (MAU 6.14; 6.15).
2. Yardi, M.R., 1986.
3. *Ibid.*, 2001.
4. Iyengar, R.N., 2003, pp.77-115.
5. Bhatnagar, A.K., 2017.
6. यस्मै नमः तच्छिरो धर्मो मूर्धानम् ब्रह्मोत्तराहनुः यज्ञो अधरा विष्णुर्हृदयम् सम्बत्सरः प्रजननम् अश्विनौ पूर्वपादौ अत्रिर्मध्यम् मित्रावरुणौ अपरपादौ अग्निः पुच्छस्य प्रथमम् काण्डम् तत इन्द्रस्ततः प्रजापतिः अभयम् चतुर्थम् । सवा एष दिव्यः शाक्रः शिशुमारः तंह । य एवम वेदाप पुनर्मुत्सुं जयति जयति स्वर्गं लोकं । नाध्वनि प्रमीयते नाग्नौ प्रमीयते नाप्सु प्रमीयते नानपत्यः प्रमीयते लघ्वान्नो भवति । ध्रुवस्त्वमसि ध्रुवस्य क्षितमसि त्वम्भूतानां अधिपतिरसि त्वम्भूतानाम् श्रेष्ठोसि त्वाम्भूतानि उपपर्यावर्तन्ते नमस्ते नमः सर्वं ते नमो नमः । शिशुकुमाराय नमः ॥ (TA. II.19)
7. Iyengar R.N., 2011, pp.23-39.
8. *Ekāgnikāṇḍa*, 1902.
9. मूर्धानं दिवो अरतिं पृथिव्या वैश्वानराय जातमग्निं । कविम् सप्रजाजमतिथिं जनानामासन्ना पात्रम् जनयन्त देवाः ॥ध्रुवासि ध्रुवक्षितिः ध्रुवाणां ध्रुवतमः । अच्युतानां अच्युतक्षित्तम्... ॥ (TS 1.4.13)
10. ... असुरा वा उत्तरतः पृथिवीं पर्याचिकीर्षन् तान्देवा ध्रुवेण अहंहन्तद्भ्रुवस्य ध्रुवत्वम् यद्भ्रुवः उत्तरतः साद्यते । (TS 6.5.2)
11. आयुर्वै ध्रुवस्तमुत्तमं गृह्णात्युत्तमं ह्यायुः...हिरण्येऽधिसादयेदायुःकामस्य... । ...राजपुत्रो ध्रुवं गोपायति, सर्वासां वा एतत् प्रजानामायुर्गोपायति, तस्माद्राजपुत्रो वीर्यवत्तमो, यद्यभिचरेत् ॥ इदमहममुष्यामुष्यायणस्यायुः प्रवर्तयामि ॥ इति ध्रुवं प्रवर्तयेदायुरेवास्य प्रवर्तयति.... ध्रुवं त्वा ध्रुवक्षितिममुमास्थानाच्यावयामि ॥ इत्यास्थानादेवैनं च्यावयति, प्रमायुको भवति, ध्रुवं वै प्रच्यवमानं विश्वा भूताऽनु प्रच्यवन्ते, प्र यजमान आस्थानाच्च्यवते तदभिमृश्यो, दिविं दिव्यान् दृहान्तरिक्षे अन्तरिक्ष्यान् पृथिव्यां पार्थिवानिति ॥ (MS 4.6.6)
12. ...अथ किमेतैर्वारण्यानाम् शोषणं महार्णवानां शिखरिणां प्रपतनम् । ध्रुवस्य प्रचलनं ब्रश्चनं । वातरजूनां निमज्जनं पृथिव्याः स्थानादपसरणम् ॥ MAU (1.4)
13. Iyengar R.N. and Chakravarty S., 2023, pp. 241-49.

14. Iyengar R.N. and Radhakrishna B.P., 2005, pp. 285-92.
15. Pargiter F.E., 1922.
16. Roy S.B., 1975.
17. Mankad D.R., 1951.
18. Mitchiner J.E., 1986.
19. Iyengar R.N., 2004, pp. 11-49.
20. Bakre, M.G. (ed.), 1982.
21. Iyengar, R.N., 2024.
22. Iyengar R.N. and Chakravarti S., 2021, pp.159-70.
23. ततो मन्दतरं नाभ्यां चक्रं भ्रमति वै तथा। मृत्पिण्ड इव मध्यस्थो ध्रुवो भ्रमति वै तथा ॥
त्रिंशन्मुहूर्तानेवाहुः अहोरात्रं ध्रुवो भ्रमन्। उभयोः काष्ठयोर्मध्ये भ्रमते मण्डलानि तु ॥
कुलालचक्रनाभिश्च यथा तत्रैव वर्तते। ध्रुवस्तथाहि विज्ञेयः तत्रैव परिवर्तते ॥ (B.Pu. 1.21.94-96)

References

- Bakre, M.G. (ed.), 1982, *Pāraskara Gr̥hyasūtram with five commentaries*, N. Delhi.
- Bhatnagar, A.K., 2017, 'Date of Mahābhārata War Based on Astronomical References' *Indian Journal of History of Science* 52.
- Srinivasacharya L., 1902, *Ekāgnikāṇḍa with the Commentary of Haradatta*, Mysore.
- Iyengar R.N., 2004, 'Profile of a natural disaster in ancient Sanskrit literature.' *Indian Journal of History of Science* 52. 39, pp.11-49; 2011, 'Dhruva the Ancient Indian Pole Star: Fixity, Rotation and Movement', *Indian Journal of History of Science* 46, pp.23-39.
- Iyengar R.N. and Chakravarti S., 2021, 'Transit of Sun through the seasonal nakṣatra cycle in the Vṛddha-Gārgīya Jyotiṣa,' *Indian Journal of History of Science* 56, pp.159-70; 2023, 'Equinoctial full moon of the Brahmāṇḍa Purāṇa and the nakṣatra solar zodiac starting from summer solstice,' *Indian Journal of History of Science* 58, pp.241-49.
- Iyengar R.N. and Radhakrishna B.P., 2005, 'Evolution of the Western Coastline of India and the Probable Location of Dwārakā of Kṛṣṇa: Geological Perspectives,' *Journal of Geological Society of India*, 66, pp.285-92.

- Iyengar, R.N., 2003, 'Internal Consistency of Eclipses and Planetary Positions in the Mahābhārata,' *Indian Journal of History of Science* 38, pp. 77-115; *Ibid.*, 2024, *Mahāsalilam (Critical edition with introduction, translation and notes)*, N. Delhi, Central Sanskrit University.
- Mitchiner J.E., 1986, *Yuga Purāna*, Kolkata, The Asiatic Society.
- Pargiter F.E., 1922, *Ancient Indian Historical Tradition*, London, Oxford University Press.
- Roy S.B., 1975, *Ancient India, a Chronological Study*, N. Delhi, Institute of Chronology.
- Yardi, M.R., 1986, *The Mahābhārata, its Genesis and Growth*, Pune, Bhandarkar Oriental Research Institute; *Ibid.*, 2001, *Epilogue of Mahābhārata*, Pune, Bharatiya Vidya Bhavan.



Ancient Indian Astronomy and Cosmography – Tutorial L7, L12

Sunder Chakravarty — CAHC, Jain University

Purpose

This is a two-session tutorial showing how modern tools help us **see, test, and illustrate ideas from ancient Indian astronomy and cosmography**.

The sessions complement Prof. Iyengar's academic sessions, which provide the textual, historical, and conceptual foundation. The tutorial focuses on demonstrating these ideas visually and computationally — testing astronomical claims in texts against what the sky actually looked like at candidate epochs.

Core principle throughout:

These tools are most useful when they reduce repetitive effort and leave more time for careful scholarly thinking.

Format

- Two sessions, approximately 90 minutes each
- Lecture-demonstration format; not a hands-on lab
- Scheduled in post-lunch slots
- Audience: mixed scholars and interested learners; no prior Stellarium experience assumed

Session 1 — Seeing the Ancient Sky with Stellarium

Focus: Building a visual grammar for ancient astronomical ideas.

Topic

-
- | | |
|---|--|
| 1 | Stellarium basics — location, epoch, ecliptic, sky culture |
| 2 | Dhruva, Thuban, Śiśumāra — the pole star is not timeless |
| 3 | Sun: daily path, annual swing, Dakṣiṇāyana and Uttarāyana |
| 4 | Nakṣatras — visible stars, shapes, arc-zones, tour |
| 5 | Precession as a dating tool — seasonal markers and textual constraints |
-

Session 1 develops the observational and visual vocabulary. It ends with examples from the *Vṛddhagārgīya Jyotiṣa* (Ādityacāra and Ṛtusvabhāva) showing how precession is used to date texts, and introduces the Abhijit-elision transition from the 28-nakṣatra to 27-equal-nakṣatra framework.

Session 2 — From Visual Demonstration to Research Workflow

Focus: How visual intuition connects to analysis, search, and digital tools.

Topic

1 Moon and the equinoctial full-moon problem — Brāhmaṇḍa Purāṇa ch. 21

2 Astropy as analytical support — epoch scanning and plotting

3 Eclipses — Parāśara Tantra and verification with NASA/JLEX

4 Meru — interactive cosmographic visualization

5 Digital tools — CAHC search portal, Patra Darpan, Sanchaya

6 AI-assisted chores — anvaya support, kaṭapayādi, prototyping

Session 2 extends the same precession arc to Moon-focused examples, introduces computational epoch scanning, and surveys the broader digital and AI tools useful in the research workflow.

What the Tutorial Does Not Cover

- Live coding or script-writing during the session
- Claims that AI tools replace scholarly judgment
- Siddhānta-period astronomy (focus remains on Vedic and early texts)

Rainfall in Ancient India

Lecture-16-17

R.S. Hariharan

The Big Picture

Long before modern weather science, ancient Indian thinkers developed a surprisingly complete understanding of the monsoon. They asked how clouds form, why it rains in one place and not another, and what makes some years wet and others dry. They didn't stop at asking - they built instruments to measure rainfall, created forecast tables, and identified multi-year rainfall patterns that modern science has confirmed are real.

This handout summarises the key ideas from two sources:

Mahāsalilam - the 24th aṅga (section) of the *Vṛddhagārgīya Jyotiṣa*, a large astronomical text of the Garga school. MS is a dialogue between Mahārṣi Viśvāmitra (questioner) and Mahārṣi Vṛddhagarga (answerer), written in archaic prose in the style of the Vedic Brāhmaṇa texts. It dates to the Maghādi era (c. 1800–1600 BCE, based on the summer solstice being at Maghā nakṣatra), making it older than the Parāśaratantra and arguably the most ancient surviving text of Indian Jyotiṣa. The *Vṛddhagārgīya Jyotiṣa* also contains sections on rainfall that survives only in manuscript form and has not yet been critically edited or published.

Parāśaratantra - an astronomical text (c. 1350–1130 BCE) attributed to sage Parāśara, surviving through quotations by later commentators. It gives us the *measurement and forecasting* system - standardised rain gauges, seasonal forecasts, and multi-year rainfall cycles.

1. How Does Rain Occur? - The Mahāsalilam's Answers

The Mahāsalilam asks questions that any scientist would recognise:

*"How do the clouds rain and hold water? From where, having brought water, do they rain?
How does it rain in one place but not another?"*

Vṛddhagarga answers by presenting multiple theories - a genuine debate within one text.

On cloud formation: Three different explanations are offered. One describes hot air rising and being pushed sideways by crosswinds until it hardens into clouds - essentially what meteorologists call convection with wind shear. Another describes water vapour rising from the ground and mountains, energised by sunlight, and clumping together. A third uses the beautiful metaphor of the Sun drawing water upward "as through a lotus stalk."

On where it rains: The sage Garga gives what may be the most elegant meteorological statement in ancient literature: *"Wherever the wind stops, there it rains."*

On what causes rain: The text keeps the old Vedic names (Indra, Parjanya, Mārutaḥ) but then explains them as natural forces. After describing the divine "command chain" for rain, it immediately adds: *"Impacted by wind in the atmosphere and breaking due to their mass and fluidity, the waters fall down."*

2. Reading the Atmosphere - Parāśara's Observations

Parāśara developed a detailed system for watching the sky, the wind, and even animal behaviour to understand rainfall.

Wind direction was key. He noted that southwest and northwest winds with clouds bring heavy rain, east wind creates clouds, and west wind destroys them during the monsoon. This is spot-on - the Indian summer monsoon IS a southwest wind system.

Clouds told a story. Thick towering clouds in green and blue meant heavy rain. Clouds shaped like animals meant quick but damaging rain. Three-coloured clouds covering the Sun were the worst sign.

Nature gave warnings. Salt becoming wet, ants carrying eggs to higher ground, sudden cold breezes, cattle stamping and lowing - these were all read as signs of approaching rain. Many of these genuinely reflect changes in humidity and atmospheric pressure.

The "cloud nucleation" idea. Parāśara proposed that atmospheric conditions about six months before the monsoon determine how the rainy season will perform. Winter conditions "conceive" the summer rains. Climate science confirms that pre-monsoon conditions (like El Niño patterns developing months earlier) do influence monsoon strength.

3. Measuring Rain - The Ancient Rain Gauge

This is perhaps the most remarkable achievement. Parāśara defined a standardised instrument for measuring rainfall - a cylindrical vessel of specific dimensions. When it fills with rainwater, the amount collected equals one *ādhaka*. Four *ādhakas* make one *droṇa*, the standard unit of seasonal rainfall.

- Units: 4 *ādhaka* = 1 *droṇa*
- Method: A cylindrical vessel of 20 (or 24) *aṅgula* diameter × 8 *aṅgula* height. When completely filled = 1 *ādhaka*.
- Thumb rule: Water pooled on ground in a dhanus-diameter (~1 metre) circle = 1 *droṇa*.
- Conversion: 1 *droṇa* ≈ 5.1 to 6.4 cm precipitation (depending on the *aṅgula* value used).

Kauṭilya's Arthaśāstra (c. 4th century BCE) - the famous treatise on statecraft - prescribes the same type of vessel and reports actual rainfall figures for different regions of the Mauryan empire. Rainfall measurement was a **state administrative function** - officials measured, recorded, and reported to the central government for revenue planning.

4. Forecasting the Season - The 27-Star Table

Parāśara created a forecasting system based on the 27 nakṣatras (star-divisions of the sky). The rule: observe which nakṣatra the Moon is in when the season's first rains arrive. Each nakṣatra has an assigned rainfall value - the expected total for the year.

Some nakṣatras predict an excellent year (25 droṇa under Rohiṇī or Pūrvaphalgunī). Others predict drought (just 4 droṇa under Svātī or Jyeṣṭhā). Most fall in the middle range.

Punarvasu	20	Śravaṇa	14
Puṣya	15	Dhaniṣṭhā	16
Āśleṣā	13	Śatabhiṣak	4
Maghā	14	Pū. Bhādrā	15
Pū. Phalgunī	25	Ut. Bhādrā	25
Ut. Phalgunī	25	Aśvinī	12
Hasta	16	Bharaṇī	14
Citrā	16	Kṛttikā	10
Svātī	4	Rohiṇī	25
Viśākhā	20	Mṛgaśirā	16
Anurādhā	14	Ārdrā	18
Jyeṣṭhā	4	Revatī	16
Mūla	14		
Pū. Āṣāḍhā	16		
Ut. Āṣāḍhā	20		

These 27 ancient values against a hundred years of actual rainfall data from the India Meteorological Department. The result: the spread of the ancient numbers - how much good and bad years differ from average - matches current data. The standard deviation captured by the ancient table (37%) falls right within the range measured at recent weather stations in the same region (31–42%). These numbers were not invented - they were derived from generations of real observation.

5. Good Years and Bad Years - The Multi-Year Cycles

The ancients noticed that wet and dry years follow patterns. They identified several cycles:

The Venus cycle (~3 years). Parāśara attributed "control over Sun-induced rainfall" to the planet Venus. Kauṭilya made it practical: if Venus is visible in the eastern sky during the monsoon, expect good rain. Venus's visibility pattern repeats roughly every three years - and by coincidence, the El Niño climate cycle that dominates monsoon variability also runs on roughly the same timescale. The ancients detected a real pattern, even though the true cause (Pacific Ocean temperatures, not Venus) was unknowable to them.

The five-year cycle. The ancient Vedic calendar used a five-year unit. Each year was assigned a character - one year in five was expected to bring less rain.

The eighteen-year cycle. Based on the revolution of the Moon's nodes (Rāhu). Traditional almanacs still use this cycle.

The seven-year cycle. The Kṛṣiparāśara prescribes a seven-year cycle based on planetary rulership: compute the remainder of $(3N+2)/7$ for Śaka year N. The two "best" years (Mercury and Venus) recur at intervals of 2 and 5 years - echoing the Venus visibility rhythm.

Remainder of $[(3N + 2)/7]$	Associated celestial object	Expected rainfall in the year N
1	Sun	Average, moderate (Cittalā)
2	Moon	Heavy (Ugra)
3	Mars	Gentle or feeble (Mandā)
4	Mercury	Very good (Uttamā)
5	Jupiter	Satisfactory (Śobhanā)
6	Venus	Excellent (Uttamā)
7	Saturn	Dry and dusty (Hīnā)

Several centuries later, the classical astronomer Varāhamihira also discussed rainfall variability in the *Bṛhat Saṃhitā*.

Using the same **27 nakṣatra framework**, he grouped them into probability classes and assigned expected rainfall values measured in *drona*. This produces a statistical distribution of wet and dry years.

Serial number of 27 nakṣatra (starting from Kṛttikā)	Rainfall (Drona)	Rainfall (1D = 6.4cm)	Probability of occurrence
1	10	64	1/27
2, 9, 10, 24	25	160	4/27
3, 11, 12, 18, 21, 25	16	102.4	6/27
4	18	115.2	1/27
5, 14, 19	20	128	3/27

6, 23	15	96	2/27
7	13	83.2	1/27
8, 15, 17, 20, 27	14	89.6	5/27
13, 16, 22	4	25.6	3/27
26	12	76.8	1/27

This table effectively describes a **probability distribution of rainfall**, indicating how frequently different levels of precipitation occur.

6. Putting It Together

Two ancient traditions, one monsoon:

	Mahāsalilam	Parāśaratantra
Main question	<i>How</i> does rain work?	<i>When</i> and <i>how much</i> will it rain?
Key contribution	Physics of clouds and rain	Measurement and forecasting
Most striking idea	"Where wind stops, rain falls"	Standardised rain gauge

Together they form a remarkably complete picture - the Mahāsalilam explains the mechanism, the Parāśaratantra provides the instruments and statistics. The essentials they got right:

- The Sun drives the monsoon
- Southwest wind carries the rain
- Rain falls where wind slows down
- Pre-monsoon conditions predict the monsoon
- Rainfall varies year to year
- Multi-year cycles of roughly 3, 5, and 18 years exist
- Rainfall should be measured with standardised instruments

A Few Technical Terms

- **Mean (Average):** Add up all values, divide by how many there are. Tells you what a "typical" year looks like.
- **Standard Deviation:** How far individual years tend to stray from the average. Bigger number = more variability.
- **Coefficient of Variation (CV):** Standard deviation as a percentage of the mean. Answers: "relative to normal, how much does the monsoon swing?" A CV of 37% means the spread is about one-third of the average.

- **Probability Distribution:** A picture of how often different outcomes occur - how many droughts, how many floods, how many average years.
- **Synodic Period:** Time for a planet to return to the same position in the sky as seen from Earth. For Venus, about 584 days.
- **ENSO (El Niño):** A natural 2-7 year cycle in Pacific Ocean temperatures that strongly influences whether India's monsoon will be good or poor.

Bibliography

1. Shamasastri, R. 1961. *Kautilya's Arthashastra*. Seventh Edition. Mysore Printing and Publishing House, Mysore, India. 488 pp. (First edition published in 1915).
2. Sadhale, Nalini (Tr.). 1999. *Krishi-Parashara (Agriculture by Parashara)*. Agri-History Bulletin No. 2. Asian Agri-History Foundation, Secunderabad 500009, India. 94 pp.
3. *Mahāsalilam: A Vedāṅga Text on Astral Sciences* — R.N. Iyengar (ed.), Central Sanskrit University, New Delhi, 2024
4. *Parāśaratantra: Reconstructed Text with Translation and Notes* — R.N. Iyengar, Jain University Press, 2013
5. Iyengar, R. N. "Description of Rainfall Variability in *Bṛhat-saṃhitā* of Varāhamihira." *Current Science* 87, no. 4 (25 August 2004): 531–533.
6. Iyengar, R. N. "Monsoon Rainfall Cycles as Depicted in Ancient Sanskrit Texts." *Current Science* 97, no. 3 (10 August 2009): 444–447.
7. Nene, Y. L. "Indigenous knowledge in conservation agriculture." *Plenary Session* (2009): 21.
8. Dubey, Umashankar. 1986. *Prācīna Varṣā Vijñāna* (प्राचीन वर्षा विज्ञान). Kanpur: Shri Hanumat Jyotish Mandir, 22/121 Phoolkhana, Kanpur–208001.