Asian Literature and Translation
ISSN 2051-5863
https://doi.org/10.18573/issn.2051-5863
Vol. 4, No. 1, 2017, 33-72

Calendars, Rituals, and Astral Science in India: A Case Study

Alessandra Petrocchi

DOI: https://doi.org/10.18573/j.2017.10129
Date Accepted: 01/02/17

Cardiff University Press
Gwasg Prifysgol Caerdydd

Calendars, Rituals, and Astral Science in India:

A Case Study

Alessandra Petrocchi

Abstract

This paper analyses the complex variety that characterises the Indian calendric system and its relation to culture, history, and society. The aim is to understand the role played in contemporary India by traditional knowledge of astral science. For this purpose, I shall investigate the information provided by a modern Hindi *pañcāṅga*. This denotes a traditional almanac that goes back to a well-established practice of calendar making attested in Sanskrit literature. In medieval India, the *pañcāṅga* forecasted celestial phenomena such as the weather and solar eclipses and was commonly used to establish the dates for religious festivals, to know auspicious moments to undertake activities such as trading, marriage, traveling, and to set up the performance of *vrata*s (religious ceremonies) and *saṃskāra*s (Hindu initiation rituals at important occasions of life). Different versions of *pañcāṅga*s are published nowadays in all the Indian regional languages and even in English by *jyotiṣī*s or 'astrologers'. Since early times, festivals, rituals, and religious ceremonies have been marked in India lunar months and the passage of the seasons. The present paper shows that astrology still plays a major part in every sphere of human life and that, in the course of a month, the changing phases of the moon coincide with the ritual observance of ancient religious practices.

Keywords: Astral Science, Hindu Rituals, Solar and Lunar Calendars, *Pañcāṅga.*

Astral science has played an important role in Indian society throughout history. Yet, 'despite the fact that horoscopic astrology has enjoyed more widespread and lasting acceptance within India than in any other cultural environment, and continues to do so',[1] Sanskrit texts on *jyotiṣa* (*jyotiḥśāstra* denotes the "science of heavenly bodies") have not

[1] Martin Gansten, "Astrology," In *Oxford Bibliographies*, 2014. https://doi.org/10.1093/OBO/9780195399318-0109

received the attention they fully deserve from Indologists. As pointed out by Gansten, while non-scholarly publications on Hindu astrology proliferate, 'academically reliable secondary sources do not, and the same is true of text editions and translations.'[2]

A few decades ago, the pioneering and extensive work by Pingree brought to light the importance of astrology within Sanskrit literature and Indian society. What we know today of the existing manuscripts on astronomy, mathematics, and the various branches of astrology is mainly due to the comprehensive survey carried out by Pingree, published in his *Census of the Exact Sciences in Sanskrit* (henceforth CESS), which he started in 1955 and left unfinished when he died in 2005. An investigation of the CESS clearly shows the large amount of works on astral science; texts on mathematics are relatively small in number compared to the bulk of texts on astrology and other sub-divisions of *jyotiṣa.* Following his predecessor, Neugebauer, who, in 1951, published the influential *The Exact Sciences in Antiquity*, Pingree has shown the Babylonian and Greek influence on the development of Indian *jyotiṣa* materials. Recently, in the light of new textual findings some of his assumptions have been partly challenged by a group of Japanese scholars led by Michio Yano.[3]

Early *jyotiṣa* is concerned with the preparation of calendars to fix the date of sacrificial rituals. Since the period of the early Vedic literature, rules for various rituals and sacrifices have established fixed times for particular rites, such as at the full moon, new moon, and at the equinox. Calendric knowledge was thus of considerable importance to Vedic peoples for various kinds of rituals. The purpose of the practices that were included within *jyotiṣa* shifted somewhat later on. It was no longer as important to decide when the Vedic sacrifices should take place, as it was to fix the proper moments (*muhūrta*) for performing the *saṃskāra*s (Hindu rituals) and to compute the almanac (*pañcāṅga*). The almanac indicated, amongst other things, the following: festivals; auspicious and inauspicious times;

[2] Martin Gansten, 'Astrology'.

[3] Michio Yano, 'Calendar, Astrology and Astronomy.'

the entries of the Sun into zodiacal signs (*saṅkrānti*); and eclipses (*grahaṇa*). As a matter of fact, while early Indian astronomy is intimately linked to the need to perform the Vedic sacrifices at specific times according to the position of the sun and of the moon, after the 2nd century CE, the goal was, more often than not, to compute with accuracy the positions of the planets for the purpose of casting horoscopes. This shift drove the later developments of the astral sciences.

It should not, therefore, be surprising that astrology, together with medicine, is the traditional science that has survived best in modern India. *Jyotiṣ* (the Hindi term for 'astrology' from the Sanskrit *jyotiṣa*) remains an essential, all-pervading, aspect of the lives of many Hindus. Even today, parents of a new baby will visit an astrologer to see how they can best guide their child in the future; the same is true for other important matters such as marriage, travelling, trading, and wealth-related issues. Some Indian Universities offer advanced degrees in so-called 'Vedic astrology', where it is thought to retain a respectful position among modern sciences. In this regard, I would like to consider the expression 'Vedic Astrology'. For some time now, Hindu astrologers have called their art 'Vedic Astrology' even though the development of Hindu astrology does not predate Alexander the Great (who invaded the North-West part of the Indian subcontinent in the 4th century BCE, which coincides with the closing phase of the Vedic period). Even in the West, the expression 'Vedic Astrology' has become strikingly popular; various Western practitioners claim to follow astrology as explained in the Vedas. Many amateur astrologers (Hindu as well as Western) see their art gaining intellectual prestige by being associated, even only in name, with the authority of a traditional discipline practiced in an 'ancestral sacred past'. It is interesting to note that Vedic Astrology has also found very fertile ground in the growth of the New Age movements. A significant amount of books, websites, and even schools and courses throughout India and Western countries advertise the practice of 'Vedic Astrology'. Unfortunately, much of this phenomenon involves people with little or no knowledge of

Sanskrit texts on literate astrology, whose aim is often only economic advantage. One can download *pañcāṅga*s and pay for astrological consultations from India. There are many other ways in which Hindu astrologers and gurus sell religious experiences via the internet. Virtual religious rituals have become a widespread phenomenon. For instance, nowadays one can buy, from anywhere in the world, the ritual offering of a *pūja* that will be performed by a guru in India and will mitigate the effects of bad astrological events. It is even possible to download software generating the basic information of a daily *pañcāṅga* for a given place*;* once the name of the place, the location, altitude, latitude, and the time zone are known, the software will calculate the auspicious moments of the day, the lunar constellation, the lunar day, etc.

The present paper is a study of contemporary Indian practices of astral science and calendrics. Having considered the historical context in which calendric computations were developed, I shall examine the underlying principles of Indian solar and lunar calendars in order to present an analysis of a modern Hindi *pañcāṅga*, which I have drawn from a Hindi astrological website. The case study selected is one of many *pañcāṅga*s; it has been selected for the variety of information it provides. It should be acknowledged at the outset that no two *pañcāṅgas* agree completely. Nevertheless, the present case study compellingly demonstrates that, in India, rituals, religious ceremonies, and daily life are still strongly dependant on astronomical events and astrological beliefs.

1. Early astronomy and calendric knowledge

In Sanskrit literature, works on astronomy, mathematics, and astrology were all part of the traditional and specialized branch of learning called *jyotiḥśāstra.*[4] *Jyotiṣa* was one of the six

[4] I would like to thank Prof. A. Passi and the anonymous reviewer for helpful comments on earlier versions of this paper. Needless to say, I alone am responsible for remaining errors.

*Vedāṇga*s, the six auxiliaries disciplines supporting Vedic rituals. The term *jyotiṣa* denotes a mix of astronomy, mathematics, astrology, and divination that was the chief matrix of literate mathematical and astronomical knowledge in the middle of the 1st millennium CE.[5] The earliest known mathematical exposition of astronomy and calendric knowledge in Sanskrit is the *Jyotiṣavedāṅga.*[6] The *Jyotiṣavedāṅga* has come down to us in two versions: the shorter *Ṛk* recension*,* consisting of thirty-six verses and traditionally attributed to Lagadha, and the *Yajurjyotiṣavedāṅga,* which seems to expand and modify it. According to Pingree,[7] 'the astronomy of the *Rk-recension* [which is the earliest] was formulated in the fifth or fourth century B.C. on the basis of information about originally-Mesopotamian methods and parameters transmitted to India during the Achaemenid occupation of the Indus Valley between ca. 513 and 326 B.C.'[8] In the *Jyotiṣavedāṅga,* some verses clearly reflect the relation between ritual, calendric utterances, and mathematical astronomy in the context of the Vedic sacrifice.[9] The calendric techniques found in this text represent a synthesis of rules and computations from Greco-Babylonian sources. It mentions measures and rules for calendric computations using a year length of 366 days: a day comprises thirty of the units called *muhūrta*s (equal to forty-eight of our minutes) or sixty *ghaṭikā*s (a *ghaṭikā* is half of a *muhūrta*); the *yuga* is a five-year intercalation cycle containing two intercalary months; the

[5] A thorough history of *jyotiḥśāstra* literature is found in David Pingree, *Jyotiḥśāstra: astral and mathematical literature* (Wiesbaden: Harrassowitz, 1981).

[6] Among scholars, the date and authorship of this text has long been a controversial issue.

[7] David Pingree, 'The Mesopotamian Origin of Early Indian Mathematical Astronomy,' *Journal for the History of Astronomy* 4, no.1 (1973): 1-12. https://doi.org/10.1177/002182867300400102

[8] While Pingree argues that *Vedāṅga* astronomy was formed under Mesopotamiam influence during the Achaemenid occupation of the Indus valley, Ōhashi says that *Vedāṅga* astronomy is based on actual astronomical observations in North India. See Yukio Ōhashi, "Development of astronomical observation in Vedic and Post-Vedic India," *Indian Journal of History of Science* 28, no. 3 (1993): 185-251.

[9] Cf. *Ṛgjyotiṣavedāṅga* 36 and *Yajurjyotiṣavedāṅga* 3 translated in B.V. Subbarapaya and K.V. Sarma, *Indian astronomy: a source-book, based primarily on Sanskrit texts* (Bombay: Nehru Centre, 1985), 1.

tithi or 'lunar day' and the sequence of the 27 *nakṣatra*s or 'lunar constellations' (here each associated with a presiding deity) seem to be fully integrated into lunisolar calendric astronomy.[10]

In order to understand the relationship between astronomy and ritual that, even today, is pervasive in traditional almanacs, it must be remembered that Vedic texts prescribe the performance of periodic sacrifices at particular times, such as the new and full moon, solstices, and equinoxes.[11] Plofker points out that Vedic calendric concepts are '[...] obscured by the brevity of the allusions to them and by the apparent inconsistencies among some of them. Moreover, it is often difficult to tell when a scriptural statement is intended to convey specifically astronomical information and when it should be interpreted otherwise.' [12] Yet, 'by the Middle Vedic period at the latest, attempts were being made to regulate a basic lunisolar calendar arithmetically.' For instance, it is in the *Yajurveda* (*Taittirīyasaṃhitā* 4.4.10.1-3) and in the *Atharvaveda* (19.7.2-5) that the first references[13] to the twenty-seven lunar constellations are found.[14] According to the *nakṣatra* occupied by the moon and observing the position of the sun and moon with respect to the stars, the sacrificial priests were able to identify and record the time in the calendar to

[10] During the later Vedic period, the meaning of the term *nakṣatra* shifted from its original meaning of 'star' to one of the 27 groups of stars regarded as the 'lunar constellations' along the ecliptic.

[11] Vedic new and full moon rituals are sacrificial ceremonies preceding other Vedic rituals. A study of Vedic literature and full moon and new moon sacrifices is that of P.E. Dumont, 'The Full Moon and New Moon Sacrifices in the Taittirīya-Brāhmaṇa,' *Proceedings of the American Philosophical Society* 101 (1957): 216–243; 103 (1959): 584–608; 104 (1960): 1-10.

[12] Kim Plofker, *Mathematics in India* (Princeton, N.Y; Oxford: Princeton University Press, 2009), 20-30.

[13] See Arthur Anthony Macdonell and Arthur Berriedale Keith, *Vedic index of names and subjects,* vol.1, (London: 1912), 409-431.

[14] The first mentions 28 *nakṣatra*s, and the latter 27. On the two systems of *nakṣatra*s, see Michio Yano, "*Calendar, Astrology and Astronomy*," in *The Blackwell Companion to Hinduism*, ed. Gavin Flood (London: Blackwell, 2003) 378-379.

perform the ritual.[15] Vedic literature contains no explicit listing of the five planets by name; in Sanskrit texts explicit references to planets are attested only after the Greek settlement in Bactria (3rd century BCE).[16] In this regard, the *Yavanajātaka,*[17] which dates to the early centuries CE, is considered the first astrological treatise in the Sanskrit language and the first evidence of the introduction of Greek astrology to India.[18] The *Yavanajātaka* presents an Indianised version of traditional Greek astrology and includes the first known appearance in India of the twelve signs of the Greco-Babylonian zodiac.[19]

By the middle of the first millennium CE, the composition of Sanskrit works on astrology had greatly developed. However, in India the elaboration of complex methods for computing tables in order to generate yearly calendars and predictions of planetary positions at desired times goes back to the early pre-modern period, though some of the traditional techniques employed rely on Medieval Sanskrit *siddhānta*s.[20]

---

[15] For instance, the consumption of the juice of the *Soma* plant, which was said to produce immortality, was associated with new and full moon sacrifices.

[16] Indian scholars do not always agree on this point. See for instance P.V. Kane, *History of Dharmaśāstra*, 2nd ed., (Poona: Bhandarkar Oriental Research Institute, 1968-1975), V, 1, 493-499.

[17] For an English translation of this text, see David Pingree, *The Yavanajātaka of Sphujidhvaja*, 2 vols. (Cambridge, Massachusetts: Harvard University Press, 1978).

[18] A recent study of this text is that of Bill Mak, 'The Date and Nature of Sphujidhvaja's Yavanajātaka reconsidered in the light of some newly discovered materials,' *History of Science in South Asia,* 1 (2013): 1-20. some newly discovered materials," *History of Science in South Asia,* 1 (2013): 1-20. https://doi.org/10.18732/H2RP4T

[19] A history of the development in India of *astrology* from early times to the modern day is found in Martin Gansten, 'Astrology and Astronomy (Jyotiṣa),' in *Brill's Encyclopedia of Hinduism*, vol. 2, *Sacred Texts, Ritual Traditions, Arts, Concepts*, ed. Knut A. Jacobsen, (Leiden, The Netherlands, and Boston: Brill, 2010), 281–294.

[20] The medieval *siddhānta* genre was developed by astronomers starting in about the 5th century CE. For a detailed account on the evolution of the *siddhānta* genre and astronomical schools in India see: Plofker, *Mathematics in India*, 66-104 and Clemency Montelle, *Chasing Shadows: Mathematics, Astronomy, and the Early History of Eclipse Reckoning* (Baltimore: The John Hopkins University Press, 2011), 156-284.

Given this background, it may not be surprising that around the middle of the second millennium CE the ultimate goal of Indian practical astronomical computation was linked to the production of the annual *pañcāṅga*.[21] Between the late 15th and 18th centuries, dozens of Sanskrit table-texts called *koṣṭhaka*s and the earlier concise astronomical manuals called *karaṇa*s were produced by astronomers. In 1520, Gaṇeśadaivajña composed a *karaṇa* called *Grahalāghava,* [22] which founded a new *pakṣa* or 'astronomical school' due to its introduction of a new set of computational parameters. This text, together with the *Tithicintāmaṅi*,[23] which is written by the same author and is probably the most famous *koṣṭhaka*, enabled *jyotiṣa* specialists to compute all the data necessary for the elaborate Indian calendar, the *pañcāṅga*.

In 1896, the British administrator Sewell, who was working in the civil service of the Madras Presidency, published *The Indian Calendar*, one of the earliest systematized Western works on that subject. Besides containing a full explanation of the Indian chronological system, thanks to the help provided by the Indian scholar Dikshit, who worked on the publication with Sewell, the volume gives interesting information on Sanskrit texts used as references for preparing *pañcāṅga*s in each region of 19th century India. [24]

The development of astronomy in India is described in D.M. Bose, S.N. Sen, and B.V. Subbarayappa eds., *A Concise History of Science in India* (New Delhi: Indian National Science Academy, Second Revised Edition, 2009), 65-172.

[21] A picture of an ancient *pañcāṅga* is found in Kane's *History of Dharmaśāstra*, V, 1, 667.

[22] Sanskrit text in Kapilasvara Sastri, ed., *Grahalāghavam* (Benares: Kāśī Saṃskṛta granthamālā, 1946).

[23] Sanskrit text in Mātṛprasāda Pāṇḍeya, ed., *The Tithichintamani of Sri Gaṇeśa Daivajña*. Edited with Hindi commentary (Benares City: Chowkhamba Sanskrit Series Office, 1938).

[24] Robert Sewell and Sankara Balkrishna Dikshit, *The Indian calendar: with tables for the conversion of Hindu and Muhammadan into A.D. dates, and vice versa, with tables of eclipses visible in India by Robert Schram* (London: S. Sonnenschein, 1896).

It seems that for the yearly calendar the *Grahalāghava* and the *Tithicintāmaṇi* were used wherever the Marathi language was spoken, as well as in some parts of Gujarat, in Benares, and in the Kanarese Districts of the Bombay and Madras Presidencies. He also adds that the *Āryabhaṭīya,*[25] the Sanskrit astronomical work written around 500 CE by Āryabhaṭa, was an authority in the Tamil and Malayalam countries of Southern India, while the *Brāhmapakṣa*, the astronomical school going back to the *Brāhmasphuṭasiddhānta,* which was written in 628 by the mathematician-astronomer Brahmagupta, was popular in Gujarat and in western parts of Northern India. Another important point made by Sewell is that in many areas throughout the sub-continent, the *Sūryasiddhānta* had been for centuries the standard text.[26] Therefore, since early times, astronomical schools following different parameters and time divisions had been variously popular in different areas.

[25] This work is also known as *Āryasiddhānta.* Āryabhaṭa occupies a special place in the history of Indian astronomy and mathematics. He is the first mathematician-astronomer of the classical age (400-1200 CE) of Indian mathematics and the patterns set by him were emulated by the following generations of practitioners. For the Sanskrit text with the commentary by the astronomer-mathematician Parameśvara (15th c. CE), see H. Kern, ed., *The Āryabhaṭīya: with the commentary Bhatadīpikā of Paramādīçvara* (Leiden: E.J. Brill, 1874). For an English translation of this work, see Walter Eugene Clark, *The Āryabhaṭīya of Āryabhaṭa: an ancient Indian work on mathematics*, *translated with notes* (Chicago: The University of Chicago Press, 1930).

[26] In the history of Hindu astronomy, the *Sūryasiddhānta* occupies an important position. This text does not appear to be the work of a single individual, but rather a synthesis based on periodic revisions. It was composed or revised around 800 CE from an earlier work of the same name and ascribed to direct revelation by the Hindu god Sūrya or 'Sun'. Sanskrit text in Fitzedward Hall, ed., *The Sūrya-siddhānta: an ancient system of Hindu astronomy: with Ranganātha's exposition, the Gūdhārtha-prakāśaka*. With the assistance of Bāpū Deva Śāstrin. (Calcutta: C.B. Lewis 1854-1859). English translation of the text by Ebenezer Burgess, *Sūrya-Siddhānta: a text-book of Hindu Astronomy*, *translated with notes and appendix*, ed. Phanindralal Gangooly, with an introduction by Prabodhchandra Sengupta (Delhi: Motital Banarsidass, Repr.1989).

This historical overview has sought to delineate the milieu in which early astronomical computations were developed in India. We will turn now to a detailed exposition of the principles of Indian solar and lunisolar calendars.

2. Solar Calendars

The basis of all solar calendars is the solar year, which represents the return of the sun to the same reference point in its apparent path in the sky. This reference point may be chosen in two different ways and this is what distinguishes the sidereal from the tropical systems, which will be explained in the subsequent paragraphs. On the other hand, the time period of the successive return of the moon in conjunction or opposition to the sun in relation to the earth, which is the time period from new moon to new moon or full moon to full moon, is the measure of the lunar month, and twelve such months form the lunar year. The fact that the lunar year is shorter than the solar year by about eleven days means that the Indian lunar calendar is kept adjusted to the solar calendar and therefore to the seasons by the addition of an intercalary month at suitable intervals. Such a calendar is called a 'lunisolar calendar'. The Indian calendar system comprises of both solar and lunisolar calendars.

In the Indian case, however, this simple division does not take into account all the heterogeneous elements found in each region's calendric practices. Though apparently the more obvious way to classify Indian calendars is by the region of usage, the truth is that the tremendous socio-cultural variety of the Indian subcontinent is reflected in the calendar system. The result is a complex combination of different traditions. Now, a reasonable way to deal with this complexity is, as suggested by Regulagedda, to take into account the following components: a) the basis of the calendar; b) regional variation; c) the time at

which the new *saṃvatsara* or 'year' begins; [27] and d) the era followed. [28] I have mentioned that the reference point to which the sun returns every year, as a consequence of its apparent annual path across the celestial sphere, which is called the 'ecliptic', can be determined in two different ways, leading to two different notions of the length of the year:

a) according to the *nirayana* or sidereal system, followed by the traditional Indian system, a year is the time taken for the Sun to return to the same position with respect to the fixed stars; [29]
b) according to the *sāyana* or tropical system, the length of a year is equal to the time interval between vernal equinoxes or between summer solstices.

Sidereal and tropical are the terms also used to describe two different systems of ecliptic coordinates used in astrology. Basically, both divide the ecliptic into the zodiac,[30] which is a celestial coordinate system constituted by a circle of twelve 30° divisions of longitude commonly known as 'signs' and named after the twelve constellations to which however these signs do not exactly correspond, as the divisions correspond to equal arcs of 30° each. However, while the sidereal system defines a zodiac sign based on the fixed stars, the tropical system defines the same sign based on the position of the vernal equinox.

The sidereal system is used in Hindu astrology (and in some 20th century systems of Western astrology), while the tropical system was adopted during the Hellenistic period

[27] In the Indian tradition, there are sixty *saṃvatsara*s, each of which has a name. Once all sixty *saṃvatsara*s are over, the cycle starts again. Occasionally, one *saṃvatsara* will be skipped, as the count is based on the zodiac position of Jupiter, whose period around the Sun is slightly less than twelve years (the full cycle of sixty covers five Jovian years).

[28] See Akshay Regulagedda, 'Panchanga-Tantra: The Magic of the Indian Calendar System' (Undergraduate Research Opportunities Programme in Science (UROPS) Thesis, National University of Singapore, 2002).

[29] The correct length of the *nirayana* year is 365.256363 days.

[30] The name 'zodiac' derives from the Greek *zōon* or 'animal'. In the Greek tradition, many signs of the classical zodiac were represented as animals.

and remains prevalent in Western astrology. The traditional Indian solar calendar, based on the *nirayana* system, follows the calendric principles laid down in *Sūryasiddhānta.* The *nirayana* year comprises of twelve solar months and these are directly linked to the twelve respective *rāśi*s or 'zodiac signs'. The *Sūryasiddhānta* in fact defines a solar month as the time taken by the Sun to traverse a zodiacal sign, which is thus the difference between one *saṅkrānti* or 'passage' of the Sun into one zodiacal sign and the next one. Only solar months share their names with that of each of the corresponding *saṅkrāntis.* For instance, if the *meṣasaṅkrānti* ('the passage into Aries') occurs on a certain day, then the period until the next *saṅkrānti* will be the *meṣamāsa* or the 'month of Aries'.[31] Table 1 below gives the names of the zodiac signs/solar months and those of the corresponding lunar months:[32]

[31] In regions following the solar calendar, the names by which solar months are known, though linked to the names of the zodiac signs, vary according to different languages.

[32] The Hindu annual cycle consists of six *ṛtu*s or 'seasons'. The spring months (corresponding to the months of the Gregorian calendar March-May) are *Caitra* and *Vaiśākha*, the summer months (May-July) are *Jyaiṣṭha* and *Āṣāḍha*, the rainy season months (July-September) are *Śrāvaṇa* and *Bhādrapada*, the autumn months (September-November) are *Āśvina* and *Kārttika*, the pre-winter months (November-January) are *Mārgaśīrṣa* and *Pauṣa,* and the winter months (January-March) are *Māgha* and *Phālguna.*

Zodiac signs/Solar Months	Lunar Months
Meṣa (Aries)	Caitra
Vṛṣabha (Taurus)	Vaiśākha
Mithuna (Gemini)	Jyaiṣṭha
Karka (Cancer)	Āṣāḍha
Siṃha (Leo)	Śrāvaṇa
Kanyā (Virgo)	Bhādrapada
Tulā (Libra)	Āśvina
Vṛścika (Scorpio)	Kārttika
Dhanus (Sagittarius)	Mārgaśīrṣa
Makara (Capricorn)	Pauṣa
Kumbha (Acquarius)	Māgha
Mīna (Pisces)	Phālguna

Table 1: The correspondence between zodiac signs/solar months and lunar months.

Another point to emphasize is that the dates of the beginning and the end of each month vary from region to region. This is because a *saṅkrānti* may take place at any time of day or night and that in the traditional calendar *pañcāṅga* the solar day starts with sunrise, depending on the time of the *saṅkrānti,* the convention followed to determine the starting day for the month varies from place to place. Due to these regional variations, sometimes the same month has a different number of days in different regions. Also, the same month in the same region may have a different number of days in different years. There are four main conventions for four different regions according to which the month may commence either on the same day as the *saṅkrānti* or on the next day or on the day following it:

1. In Orissa and Punjab, where solar calendars are used, the solar month begins on the same day as when the sun enters the concerned zodiac sign.
2. According to a system followed in Tamil Nadu, if the *saṅkrānti* takes place before sunset, the month begins on the same day. If it takes place after sunset, the month begins on the next day;
3. In the Malayali convention, which is generally followed in Kerala, the month begins on the same day so long as the *saṅkrānti* happens before *aparāhṇa*, i.e. before $3/5^{th}$ of the time from sunrise to sunset has passed. Otherwise, it begins the next day;
4. In Bengal and Assam, if a *saṅkrānti* takes place between sunrise and the following Midnight, the solar month begins on the next day, but, if it begins after midnight, the month begins on the day following it.

A further interesting point, which will be taken up again below, is the link between calendric events and rituals. Curiously, while in Assam, Bengal, Tamil Nadu, Kerala, Orissa, Punjab, and Haryana the sidereal solar calendar is usually followed, in all these states, for fixing the dates for religious practices and festivals and for deciding the *muhūrta*s or auspicious moments to undertake important activities,[33] the lunar calendar is followed. Beyond the differences in the way the beginning of the month is calculated and the time the beginning of the year falls,[34] the Indian solar calendars of these regions differ also in the

[33] In early literature, the term *muhūrta* had two meanings: "short time" and "a period of two *ghaṭikā*s" (thus equal to 48 minutes). Sometime later, as particular *muhūrta*s of the day came to be considered auspicious, a third meaning came to be attached to it. Thus, by the period of early medieval literature, *muhūrta* denoted an "auspicious time" for undertaking all kinds of important activities.

[34] For instance, in Assam, West Bengal, Orissa, and Tamil Nadu the year starts in Mid-April with the *meṣasaṅkrānti* (Sun-crossing into sidereal Aries), while in Kerala the year starts on *siṃhasaṅkrānti* (Sun-crossing into sidereal Leo).

era followed.[35] Among the various eras used throughout the Indian subcontinent,[36] the most common are:

- the *Kali* era, starting on 3102 BCE;
- the *Vikrama* era, starting on 57 BCE;
- the *Bengali San* era, starting on 593-4 CE;
- the *Śaka* era,[37] starting on 78 CE;
- the *Kollam* era, starting 824 CE.

In 1957, the attempt to unify the variety of the Indian calendric systems resulted in the promulgation of a National Calendar. This is the official civil calendar in use; it follows the tropical system and the *Śaka* era.[38] This calendar did not become popular because the use of tropical year is very much against the Indian tradition of sidereal calendar. In fact, despite this effort, local variations based on older sources, such as the *Sūryasiddhānta,* still exist.

3. Lunisolar Calendars

A lunisolar calendar follows a system based on both solar and lunar cycles.[39] It tries to achieve the following: in the case of the tropical solar year, it combines the phases of the

[35] Often, one official era is used in addition to local eras. For a general concordance of each Indian state calendar, the era followed, and the starting time of the New Year, see Regulagedda, "Panchanga-Tantra," 9-11.

[36] In this regard, see Sewell and Dikshit, *The Indian Calendar*.

[37] The *Śaka* era has been one of the most extensively used throughout India. In the *karaṇa*s, it is used almost exclusively.

[38] Its year length and its leap year rules are the same as those of the Gregorian calendar, but the New Year's Day and the year count differ. The New Year's Day is the Vernal Equinox day that falls around March 21-22.

[39] The Hebrew, Buddhist, Tibetan, as well as the traditional Chinese, Japanese, and Mongolian are examples of lunisolar calendars.

moon and the seasons, as for instance in the Chinese and Hebrew lunisolar calendars; if the year is taken as the solar sidereal year, the calendar also gives an idea of the position of the full moon among the constellations (as for instance in the Buddhist and Hindu lunisolar calendars).

The basic period of the Indian lunisolar calendar is the lunar month, which is defined as the time interval between two successive *pūrṇimā*s or 'full moons' or the time between two *amāvāsyā*s or 'new moons'. Its length is of approximately 29.530589 days. Twelve such lunar months make a lunar year of 354.530589 days. As previously mentioned, this falls short of a tropical year by about eleven days and, in order to keep a constant relation with the seasons, many systems for keeping the lunar year 'in sync' were developed. Indian astronomers devised a method using the true positions of the sun and moon to add intercalary months to the lunar year at intervals. If two new moons occur within one solar month, two lunar months then occur with the same name based on the solar month. The first lunar month of the two is considered as an intercalary month and it is called *adhika*.[40] The second one starting from the next new moon is considered to be the normal month and is called *śuddha*. Regulagedda tells us that in any given lunar year, if two consecutive *saṅkrānti*s occur between two consecutive new moons then the lunar month, whether calculated from full moon to full moon or from new moon to new moon, and having the same name as the solar month in which this occurs, is dropped.[41]

A basic feature that influences the classification of the three Indian lunisolar calendars mentioned concerns the two systems according to which months are connected to the cycle of the moon:

1) the *amānta* month is the time occurring from one new moon to the next one;
2) the *pūrṇimānta* month is the time occurring from a full moon to the next one.

[40] Sanskrit texts mention acts to be avoided in intercalary months. See Kane, *History of Dharmaśāstra*, V, 1, 673.

[41] See Regulagedda, 'Panchanga-Tantra,' 9.

The *amānta* calendar, based on the *amānta* month, is distinguished in: i) Southern; and ii) Western *amānta* calendars. In the first, followed mainly in South and South-West Indian states, the *tithi* or 'lunar day' of the new moon is considered the last day of the previous month and the intercalary month is added every 2.7 years to compensate for the difference with the solar sidereal year. The Southern *amānta* calendar differs from the Western *amānta* Calendar in its treatment of the intercalary months, the New Year Day, and the Era followed. It follows the *Śaka* era starting in *Caitraśuklapratipadā,* which denotes the first day during the waxing phase of the moon in the *Caitra* month (April-May), as well as the lunar day after the last new moon before *meṣasaṅkrānti* (the entry of the Sun into Aries).[42] The months of the *amānta* lunar calendar are named after the solar months in which the new moon of the lunar month occurs, while the years are named according to the names of the Jovian years.

It must be noted that, in Gujarat and parts of Rajasthan, the lunar year starts on *Kārttika* month (November-December of the Gregorian calendar) with *śuklapakṣapratipadā,*[43] which is the first day during the bright fortnight. In the districts of Kutch and parts of Kathiawar, the lunar year starts on *Āṣāḍha* month (July-August) with *śuklapratipadā.*

On the other hand, the *pūrṇimānta* calendar is most popular in North India. In contrast to *amānta* calendars, the lunar month is reckoned from full moon to full moon and it follows the *Vikrama* era. The lunar year begins on the day after the last full moon day before the *meṣa saṅkrānti*. However, though in a *pūrṇimānta* calendar lunar months start with the *kṛṣṇapakṣa* or 'dark half'. This means that a *pūrṇimānta* month starts a fortnight earlier than the *amānta* month of the same name. Consequently, the year starts in the middle of the

[42] Traditionally, in India the day when the Sun enters the first sign of the zodiac (Aries) is considered spiritually and astrologically very powerful and celebrated with great respect by offering prayers to the Gods.

[43] In astronomy, *pakṣa* (lit. 'side') is a technical term to denote a 'fortnight', a lunar phase of the Indian lunar month.

Caitra month with the *śuklapakṣa* or 'bright half'. In fact, the 'dark half' of the *Caitra* month belongs to the previous year.

Before introducing the Indian traditional almanac called *pañcāṅga*, two characteristics of Indian lunisolar calendars must be explained: i) the set of months named after the ancient system of *nakṣatra*s or 'lunar constellations'; and ii) the division of the lunar month. The system of the lunar constellations derives from the fact that the passage of the moon around the ecliptic is divided into twenty-seven parts, which are each known as *nakṣatra*. In their work on Indian calendars, Chakravarty and Chatterjee point out that each *nakṣatra* division is named after a selected star known as *yogatārā* and that the initial points of *nakṣatra* divisions have changed from time to time, with few corrections recorded in Sanskrit astronomical texts. [44] Each *nakṣatra* denotes a twenty-seventh part of a sidereal month and the time required for the moon to traverse an interval equal to 13°20'. By the period of the *Jyotiṣavedaṅga, nakṣatra*s were associated with a presiding deity and, sometime later, they were also subdivided, along with the lunar days, into 'auspicious' and 'inauspicious' times. In addition, each *nakṣatra* is divided into *pada*s or 'quarters' associated with particular syllables. It is the custom even now in India to name a baby according to the *nakṣatra* the moon occupied at the moment of its birth.

The extensive Sanskrit literature[45] on *muhūrta*,[46] which defines a branch of Indian astrology corresponding to Hellenistic cathartic astrology, consider the time when the Moon, conjoining with a particular *nakṣatra,* is considered propitious or unpropitious for

[44] A.K. Cakravarty and S.K. Chatterjee, 'Indian Calendar from Post-Vedic to AD 1900,' in the *History of Astronomy in India*, ed. K.S.Shukla (New Delhi: Indian National Science Academy,1985), 274.

[45] A list of works on *muhūrta* is found in Kane, *History of Dharmaśāstra*, V, 1, 556-557 and under author's names in David Pingree *Census of the Exact Sciences in Sanskrit* (CESS), 5 vols (American Philosophical Society, 1970-1995). *Muhūrta*s in relation to religious rites are investigated in Kane, *History of Dharmaśāstra*, V, 1, 604-640.

[46] This term traditionally denotes the time auspicious for the performance of an auspicious act.

performing certain acts.[47] In Indian treatises on cathartic astrology, great importance was given to deciding the time for performing ritual acts and this aspect has strongly influenced the Sanskrit literature on legal and religious duties. Though the *nakṣatra*s played a central role before the introduction of horoscopic astrology from the West, they have retained their importance throughout the historical development of Indian astrology.[48]

While solar months named after the *rāśisaṅkrānti* or the 'entry of the Sun into a zodiac sign' have been previously mentioned as found only in solar calendars, the set of months named after *nakṣatra*s is found in both solar and lunisolar calendars, which of course contributes to the complexity of the Indian calendar system. Table 2 shows the relation between the name of each *nakṣatra*, the month named after that *nakṣatra*, and the presiding ruler from the Indian pantheon assigned to it in early times: [49]

[47] Within Sanskrit astral literature, prior to the development of the separate branch on *muhūrta,* and comprehending a massive number of texts, as, for instance, the *Gargasaṃhitā* (later Vedic time), which prescribes actions to be undertaken when the moon is in each *nakṣatra, tithi* and *karaṇa* (the latter denotes a unit of time corresponding to half-*tithi,* thus half of a lunar day). The *Śārdūlakarṇāvadāna*, the *Yavanajātaka*, and the *Bṛhatsaṃhitā* (Sanskrit texts of earlier centuries CE) contain a systematic treatment of units of time that are auspicious for certain acts, such as the building of temples, travelling and marriage, undertaking war, pregnancy, and activities related to sowing and harvesting. The most ancient Sanskrit text fully dedicated to the science of *muhūrta* is the *Ratnakośa,* probably composed by the astronomer Lalla in the 8th C. CE. On time, *muhūrta*, astrology in *dharmaśāstra* and calendars see Kane, *History of Dharmaśāstra*, V, 1, 463, ff.

[48] Interesting early references on the effect of *nakṣatra*s and zodiacal signs on human destiny are found in Varāhamihira's *Bṛhatsaṃhitā* and *Bṛtajjātaka.* See the Sanskrit text with Bhaṭṭotpala's commentary in Avadhavihārī Tripāṭhī, ed., *Bṛhatsaṃhitā.* Śrīvarāhamihirācāryaviracitā. Bhaṭṭotpalavivṛtisahitā. Sampādakaḥ Avadhavihārī Tripāṭhī (Sarasvatībhavanagranthamālā 97, Vārāṇasyām: 1968). For an English translation of the text, see V. Subrahmanya and M. Ramakrishna Bhat, *Brihat samhita = Bṛhatsaṃhitā*, with an English translation and notes (Bangalore City: printed by V. B. Soobbiah, 1947). *Bṛhajjātakam.* Śrīvarāhamihirācāryaviracitaṃ; udāharaṇopapattisahita "Vimalā" Hindīṭīkopetam, ṭīkākāraḥ, Śrīmadacyutānandajhā (Banārasa: Caukhambā Saṃskṛta Sīrija, Āphisa, 1957).

[49] Since early times, lunar months are named after the *nakṣatra* where the full moon is located.

Nakṣatra	Month	Presiding Ruler
Aśvinī	Āśvina	Aśvin
Bharaṇī		Yama
Kṛttikā	Kārttika	Agni
Rohiṇī		Prajāpati
Mṛgaśira	Mārgaśīrṣa	Soma
Ārdrā		Rudra
Punarvasū		Aditi
Puṣya	Pauṣa	Bṛhaspati
Āśleṣā		Sarpa
Māgha	Māgha	Pitaras
Pūrva Phalgunī	Phalguna	Bhaga
Uttara Phalgunī	Phālguna	Aryaman
Hasta		Āditya
Citrā	Caitra	Tvaṣṭṛ
Svāti		Vāyu
Viśakha	Vaiśākha	Indrāgni
Anurādhā		Mitra
Jyeṣṭhā	Jyaiṣṭha	Indra
Mūla		Nirṛti
Pūrva Aṣādhā	Āṣāḍha	Toya
Uttara Aṣādhā	Āṣaḍha	Viśvadeva
Abhijit		Brahmā
Śravaṇa	Śravaṇa	Viṣṇu
Dhaniṣṭhā		Vasu
Śatabhisaj		Varuṇa
Pūrva Bhadrapadā	Bhādrapada	Ajapāda
Uttara Bhadrapadā	Bhādrapada	Ahirbudhnya
Revatī		Pūṣan

Table 2: *Nakṣatra*s, the months named after each *nakṣatra*, and the presiding ruler.

Another division of time related to lunisolar calendars is the aforementioned division of the lunar month into two *pakṣas* or 'fortnights', namely the *kṛṣṇapakṣa* or 'dark fortnight', which denotes the period of the waning moon, and the *śuklapakṣa* or 'bright fortnight, which denotes the period of the waxing moon. There are thirty *tithi*s or 'lunar days' in a lunar month, each fortnight having hence fifteen *tithi*s. As in *amānta* lunisolar calendars, the lunar month starts and ends with a new moon, the first half of a lunar month is the waxing moon (*śuklapakṣa*). On the other hand, in *pūrṇimānta* lunisolar calendars the lunar month starts and ends with a full moon. Therefore, the first half of a lunar month is the waning moon (*kṛṣṇapakṣa*). Table 3 lists the names of the *tithi*s of an Indian lunar month:

No.	Kṛṣṇapakṣa	Śuklapakṣa
1	pratipadā	pratipadā
2	dvitiīyā	dvitīyā
3	tṛtīyā	tṛtīyā
4	caturthī	caturthī
5	pañcamī	pañcamī
6	ṣaṣṭī	ṣaṣṭī
7	saptamī	saptamī
8	aṣṭamī	aṣṭamī
9	navamī	navamī
10	daśamī	daśamī
11	ekadaśī	ekadaśī
12	dvadaśī	dvadaśī
13	trayodaśī	trayodaśī
14	caturdaśī	caturdaśī
15	amāvāsyā	pūrṇimā

Table 3: Names of the *tithi*s (lunar days)

4. The Indian Traditional Almanac: the *pañcāṅga*

The *pañcāṅga* is the Indian traditional almanac based on the ancient astronomical-astrological principles laid down in earlier Sanskrit texts on *jyotiṣa.*[50] It has already been mentioned that, prior to the medieval period in India, astronomical tables and manuals developed by Indian astronomers were directly or indirectly linked to the art of almanac making. This traditional calendar, still extensively used and published in different versions and in all the regional Indian languages, forecasts celestial phenomena such as solar eclipses, the weather, mundane occurrences, as well as establishing the dates for Hindu religious festivals. It contains tabulations of the positions of the Sun, Moon, and other planets for every day of the year at a fixed place and time. It also gives details of the daily ascendants and the most auspicious hours in a day, ruled by a particular planet. It gives information on the dates of religious festivals, religious practices such as fasting, pilgrimage, offerings to the Gods and the recitation of prayers.

The Sanskrit term *pañcāṅga* means 'five-limbed' and it denotes the five units of time that characterize this almanac and that contribute to determining the *muhūrta*s:

- the *tithi* or 'lunar day' is the time taken for the longitudinal angle between the moon and the sun to increase by 12 °. It is slightly shorter than a day and it corresponds approximately to one-thirtieth of a synodic (lunar) month;
- the *vāra* or 'weekday' is measured usually from sunrise to sunrise. Since the *tithi* and the *vāra* are of different and of varying lengths, a particular *tithi* in a given month usually contains one *vāra*-beginning, but sometimes two, or none;[51]
- the *nakṣatra* or 'lunar constellation' is approximately one-seventieth of a sidereal month;[52]

[50] Manuscripts of Sanskrit *pañcāṅga*s are listed in Pingree's *Census* (1970-1995), as well as in his *Catalogue of Jyotiṣa manuscripts in the Wellcome Library: Sanskrit Astral and Mathematical Literature* (Leiden: Brill, 2004).

[51] Following Hellenistic sources, in India, the weekdays are named after the planets: *Ravivāra* or lit. 'the day of the Sun' (Sunday), *Somavāra* or 'the day of the Moon' (Monday); *Maṅgalavāra* or 'the day of Mars' (Tuesday); *Budhavāra* or 'the day of Mercury' (Wednesday); *Guruvāra* or 'the day of Jupiter' (Thursday)'; *Śukravāra* or 'the day of Venus' (Friday); *Śānivāra* or 'the day of Saturn' (Saturday).

- the *karaṇa,* denoting half of a *tithi* ,[53] is the time required for the angular distance between the sun and the moon to increase by 6° ;
- the *yoga* [54] represents a time interval in which the sum of the eastward motions of the sun and moon amount to an increment of one *nakṣatra* length or 13° 20' .

A typical *pañcāṅga* covers the year according to the era of the region in which it is published. The basic information is similar, but regional variations deeply influence the final shape of each almanac, as well as the fact that it contains tabulations of positions of Sun, Moon, and other planets for every day of the year at a fixed place and time.

4.1 The Analysis of a modern Hindi *pañcāṅga*: a Case Study

Though the Indian calendar system has been studied by scholars in considerable detail, no one has so far presented an analysis of a modern *pañcāṅga*.[55] In the section that follows, I investigate relevant parts of the first page, which represents a calendar month, of a Hindi

[52] The number of *nakṣatra*s reflects the number of days in a sidereal month (approximately 27.32 days). A *nakṣatra* can be also defined as one of the 27 sectors along the ecliptic.

[53] Since 1 *karaṇa*= 2 *tithi*s and since there are 30 *tithi*s in a lunar month, one would expect the *karaṇa*s to be 60, which they are not. Chakravarty and Chatterjee explain how the system of *karaṇa*s works. They also add that this item, which was most likely introduced later, seems not to have any special reference for the *tithi*, which is really the basic element. Chakravarty and Chatterjee, 'Indian Calendar', 276.

[54] According to Chakravarty and Chatterjee, *yoga* was introduced later as an item of the *pañcāṅga* and exclusively for astrological purposes. In fact, it is not found in the calculations of early astronomers such as Āryabhaṭa (5th century CE), Varāhamihira (6th century CE), and Brahmagupta (7th century CE).

[55] In Hindi, it is called *pañcāṅg*.

pañcāṅga[56], which can be found at the web address http://hindupad.com/shri-brajraj-kaldarshak-panchang-2014/.

In the top left, a colourful image shows the Hindu god Kṛṣṇa playing the flute alongside a female partner. In the central position, still at the top, the name of the *jyotiṣī* or 'astrologer' and publisher of the almanac stands above the expression *kāldarśak pañcāng* (*kāldarśak* means 'calendar'), while his picture is found on the right. Below it, one finds the words: *Vikram Saṁvat* 2070, *Janvarī* 2014, and *Śak Saṁvat* 1935. These give the current year according to the *Vikrama* era, the Gregorian calendar, and the *Śaka* era respectively. I have already mentioned that the *Vikrama* is followed in North India and in lunisolar *pūrṇimānta* calendars, while the *Śaka* era is followed by the official civil Indian calendar. A column on the left lists the *vāra*s or 'weekdays'. On the right next to it, under the title *vrat evaṁ tyauhār,* a small box presents a collection of writings in twenty-four lines. This is a list of religious practices (*vrat*) and festivals (*tyauhār*) of the calendric month of January (in Hindi *Janvarī*). Below, taking up the main part of the page, there are thirty-one boxes each corresponding to one weekday of the month. Among these, the following have been selected for an analysis:

[56] Currently (June 2014), the page here analysed can be found at the web address http://hindupad.com/shri-brajraj-kaldarshak-panchang-2014/. The almanac is published by Shri Brajraj.

Fig. 1. Seven days of the month January 2014 from the *pañcāṅga* in Hindi that can be found at the web address http://hindupad.com/shri-brajraj-kaldarshak-panchang-2014/

In the box of January1st, on the right, one can see a black moon. The top central writing, in dark blue, reads *amāvasyā*, which, as I have explained, denotes the day of the new moon. Therefore, according to the time zone of this *pañcāṅga,* January 1st of the Gregorian year 2014 is a new moon day. From this information, we can already infer that this is not a solar calendar but a lunisolar calendar. On the very top left, written in light blue, one reads *pauṣ kṛ.*, which is an abbreviation for *pauṣ kṛṣṇ.*[57] From tables 1 and 3 above, one can see that *Pauṣ* is the name of a lunar month of the Indian calendar that falls approximately in the Gregorian month of January, though its dates vary from region to region.[58] In the expression *pauṣ kṛ,* the formula *kṛ,* which is an abbreviation of *kṛṣṇ,* denotes in which phase of the lunar month the 1st day of the solar month of January is. As table 3 shows, *kṛṣṇ pakṣ* is the dark fortnight of a lunar month.[59] At this point, one may ask: how can one understand if

[57] *Pauṣa kṛṣṇ* corresponds to the Sanskrit *pauṣa kṛṣṇa.*

[58] In North India, *Pauṣ* 2014 begins on December 18th of the Gregorian year 2013 and ends on January 16th of the Gregorian year 2014.

[59] *Kṛṣṇ pakṣ* corresponds to the Sanskrit *kṛṣṇa pakṣa.*

this *pañcāṅga* is a lunisolar *amānta* or *pūrnimānta* calendar? Looking carefully inside each box of the thirty-one days of January and comparing the data, the following is apparent: [60]

- January 1st is under *pauṣ kṛ.* ;
- on the 2nd, there is a change, as we get the writing *pauṣ śu.* (standing for *pauṣa śukla*), which we find in each box of the next days until the 16th;
- on the 17th there is a change again, as one reads *māgh kṛ*, [61] found in each box of the next days until the 30th;
- on the 31st another change occurs, as one reads *māgh śu.*

Clearly, on the very top left, the writing in light blue tells us the course of the lunar months on this page of the almanac, which is the solar month of January. Thus we observe the change between *pauṣ kṛ.* and *pauṣ śu.* from January 1st to 2nd and, because January 2nd is the day after *amāvasyā* or 'new moon', we understand that January 1st is the last day of the *kṛṣṇ pakṣ* or 'dark fortnight' of the month *Pauṣ*, while January 2nd is the first day of the *śukl pakṣ* or 'light fortnight' of the month *Pauṣ.* [62] From this, one can conclude that the other part of the *kṛṣṇ pakṣ* of the lunar month *Pauṣ* falls in the last part of the solar month of December of the Gregorian year 2013. Consequently, we can infer that this is a *pūrṇimānta* lunisolar calendar, since, in this kind of calendar, the period of the waxing moon (which corresponds to the fortnight called *kṛṣṇ pakṣ*) is the first half of a lunar month, while in an *amānta* calendar it is the period of the waning moon (corresponding to the bright fortnight or *śukl pakṣ*). In fact, an additional proof is the writing we find on January 17th, where *māgh kṛ* occurs. We also find on the box of the 16th that there is a white moon accompanied by the term *pūrṇimā* or 'full moon' written in dark blue, and, in light blue, the abbreviation *pauṣ śu.*

[60] In order to understand how a modern Hindi *pañcāṅga* presents the lunar cycle, I have here selected the days in which these changes are clear.

[61] *Māgh kṛṣṇ* corresponds to the Sanskrit *māgha kṛṣṇa.*

[62] *Śukl pakṣ* corresponds to the Sanskrit *śukla pakṣa.*

From table 1, one can see that *Māgh* is the name of the month following the month *Pauṣ.* Therefore, we understand that, after the full moon on the January 16th, the second half of the lunar month *Pauṣ* ends and the new lunar month *Māgh* starts with the *kṛṣṇ* fortnight, as the abbreviations *kṛ* tells us. We can now conclude that this *pañcāṅga* presents a double system: the main block of which is constituted by the solar month January, but which also gives information according to a *pūrṇimānta* lunisolar calendar, with the lunar cycle recorded inside the boxes of the solar days. To sum up, we can understand that the solar month January of the Gregorian year 2014 is constituted, according to a *pūrṇimānta* calendar, by the following lunar months:

- the last day (January 1st) of the first fortnight (the *kṛṣṇ pakṣ*) of the month *Pauṣ* (the remaining part of the *kṛṣṇ pakṣ* of the lunar month *Pauṣ* falls approximately on the last two weeks of the preceding solar month of December) followed by the second fortnight (the bright one) until the 16th ;
- the first half (the *kṛṣṇ pakṣ*) of the new lunar month *Māgh* from January 17th to the 30th;
- the second half (the *śukl pakṣ*) of the month *Māgh* starting on the 31st, which will obviously continue on the first half of the following solar month of February.

At the top right of each box here presented (as well as on the remaining boxes of the days of this solar month January, which are not shown here), one can see the following terms: *mūla, mṛgaśira, punarvasu, puṣya, maghā, uttarāṣāḍā*, and *śravaṇa* respectively. These are the names of the *nakṣatra*s, of which a list is found in table 2. This *pañcāṅga* therefore informs us that the *nakṣatra* of the 1st solar day of the solar month January is *mūla*, on the 14th the *nakṣatra* is *mṛgaśira,* etc. On the top of each box, the writing in dark blue reads: *amāvasyā, caturdaśī, pūrṇimā, pratipadā, tṛtīyā, amāvasyā,* and *pratipadā* respectively. These are the names of the *tithi*s, which are found in table 3. So far, we have seen e.g. in a *pūrṇimānta* lunisolar calendar that the 1st solar day of the solar month January of the Gregorian year

2014 corresponds to the *tithi* called *amāvasyā* of the *kṛṣṇ pakṣ* of the lunar month *Pauṣ* of the *Vikram* era 2070 and of the *Śak* era 1935. The *nakṣatra* of that day is *mūla*. Also, this *tithi* is the last lunar day of the first half of the lunar month *Pauṣ*.

In each box, on the very top right and on the very bottom right, one finds two abbreviations followed by numbers. For instance, on the very top of January 1st, we read the expressions '*bhā*.11' in black and, on the very bottom, '*gate*.17' in green. These writings were initially obscure; no external references have ever mentioned them to my knowledge. Expressions of this type give, in fact, data only included in modern *pañcāṇga*s. A thorough comparative analysis of the data provided in all the boxes of the solar days of this page of January has helped me to clarify that the abbreviations mentioned provide astrological data: '*bhā*.11' indicates that eleven solar days have elapsed from the current *rāśisaṅkrānti*. According to the tropical zodiac, January 1st is under the sign of Capricorn, while the previous sign is Sagittarius, which ends on December 21st. These are the eleven elapsed days. On the other hand, '*gate*.17' provides information according to the sidereal system, which is the one followed in India. According to the sidereal zodiac, on January 1st, the Sun is in Sagittarius. The previous *rāśi* is Scorpio, which ends on December 15th. Therefore, seventeen days have elapsed from the entry of the Sun into the current sign. Moreover, on January 14th, '*gate*.1', in green writing, can be seen. This is because, according to the sidereal zodiac, on January 14th, the Sun enters into Capricorn. Thus January 14th is the first day of the new *rāśi* Capricorn. As a matter of fact, inside the box of the 14th, the writing *makar saṅkrāṅti* in fuchsia says that this is the day that the Sun enters into Capricorn (*makar*). Furthermore, inside the box of January 21st one finds, at the very top right, '*bhā*. 1'. This indicates that this is the first day of the new sign (which is Aquarius according to the tropical zodiac calendar). Thus, with remarkably economy, the two abbreviations we have observed refer to the zodiac according to both tropical and sidereal systems. Finally, at the very bottom, the *pañcāṅga* under consideration provides astrological diagrams similar to

those that can be observed in Sanskrit astrological texts.[63] These include the following: a list of inauspicious hours during the days; a list of *muhūrta*s of the month, which are the moments considered auspicious for undertaking four specific activities *viz*., marriage, travel, trade, and construction.[64]

4.2 Calendrics, Hindu Rituals, and Festivals

I now turn to calendric events that regulate various Hindu rituals.[65] It would take us far afield to go into details of the religious milieu and cultural-historical context of these practices. For reasons of space, I shall refer only to the events of the calendar days analysed in the previous paragraph. I shall also discuss the information provided by the almanac on celebrations of religious and political events, as well as the performance of Hindu rites of passage (*saṃskāra*s) and the observance of religious duties (*vrata*s).[66] A point to be

[63] Interesting examples of astrological diagrams from Sanskrit texts are found in Kane, *History of Dharmaśāstra*, V 1, 556, 603, 628-629.

[64] Traditionally, all the five elements of the *pañcāṅga* (which are the five units of time, namely the *tithi, vāra, nakṣatra, yoga*, and *karaṇa*) are taken into consideration while selecting a *muhūrta*.

[65] In this regard, the *Ācārasaṃgraha* by the astronomer-mathematician Parameśvara (15th c. CE) is a significant text. It lists *muhūrta*s during which to perform Hindu *saṃskāra*s according to astronomical-astrological events such as lunar phases, *nakṣatra*s, and auspicious lunar days. For instance, it mentions auspicious moments to perform *saṃskāra*s such as the *garbhādhāna* and the *vivāha* ceremonies, which are Vedic rituals mentioned in *Dharmasūtra* literature. The first is a rite of passage performed before conception, while the second is a rite of passage associated with marriage. See the Sanskrit text of the *Ācārasaṃgraha* in Amma Viśveśvari, ed., *Ācārasaṅgrahaḥ* of Parameśvara (Trivandrum: Paurasatyabhāṣāgaveṣaṇahastalikhi-tagranthaprasādhana Kāryālaya, 1981).

[66] A wealth of information on Hindu rituals (also related to astrology) is found in Kane, *History of Dharmaśāstra.* A list of *vrata*s is found in Kane, *History of Dharmaśāstra*, V, 1, 253-462.

emphasised is that these events can vary depending on local customs and that they can, in any given year, occur on slightly different dates according to lunar phases.

The analysis of this *pañcāṅga* presents a clear example of the continual legacy of Hindu *saṃskāra*s over two millennia. [67] 'The *saṃskāra*s had been treated from very ancient times as necessary for unfolding the latent capacities of man for development.'[68] They are more than just rites and ceremonies; *saṃskāra*s reflect the Hindu worldview and 'constitute an idea, a belief about human beings and their development in the world.' [69]

The performance of Hindu rituals depends not only on auspicious lunar days and auspicious lunar constellations but also on solar events. In the *pañcāṅga* presented here, all the colourful writing that is found below the number representing each solar day gives information on Hindu religious practices and festivals[70] (of the lunar months *pauṣ* and *māgh* of the Gregorian year 2014, corresponding to *Vikram* era 2070 and *Śaka* era 1935). It is interesting to note that many of these celebrations have been characteristic of Hindu culture since early times and are mentioned in Sanskrit ritual manuals. For instance, the *pañcāṅga* informs us that January 14th is *makar saṅkrānti* or the 'entry of the Sun into Capricorn'. On this date, a very popular festival is celebrated. This is the only celebration falling, by and large, on the same date every year (though it may also fall on January 13th or

[67] On Hindu rituals and society in contemporary India, see Dermot Killingley, Werner Menski, and Shirley Firth, *Hindu Ritual and Society* (Newcastle upon Tyne: S.Y. Killingley, 1991).

[68] Kane, *History of Dharmaśāstra*, II, 1, 191.

[69] Mary McGee, 'Saṃskāra,' in *The Hindu World*, ed. Sushil Mittal and Gene Thursby (New York: Routhledge, 2007), 333. On Hindu *saṃskāra*s, see also Rajbali Pandey, *Hindu Saṁskāras: Socio-religious Study of the Hindu Sacraments* (Delhi: Motilal Banarsidass, Repr. 2002); Heramba Chatterjee, *Studies in Some Aspects of Hindu Saṁskāras in Ancient India* (Calcutta: Sanskrit Pustak Bhandar, 1965).

[70] On Hindu festivals, see Chitralekha Singh and Prem Nath, *Hindu festivals, fairs and fasts,* (New Delhi: Crest Publishing House, 1999) and Guy R. Welbon and Glenn E. Yocum, eds., *Religious festivals in South India and Sri Lanka* (New Delhi: Manohar, 1982).

15th). It is a major Hindu festival, regarded as the beginning of an auspicious period. It is celebrated with religious fervour and under various names and cultural forms in different parts of the country. As it signifies the beginning of the spring season, *makar saṅkrānti* is a harvest festival, where Gods are worshipped to ensure prosperity, success, and fortune. It is a kind of new-year festival marking the end of the inauspicious month *Pauṣ* and the completion of the solar year.[71]

January 16th is the full moon day (*pūrṇimā*). In India, religious rituals and practices such as fasting, prayers, and the taking of a holy bath in the rivers Ganga and Yamuna have been carried out during the full moon as well as on new moon days, both of which are considered to be particularly auspicious. The almanac says that this is also the day in which *Śakambari*, the incarnation of the goddess Durga, the goddess of fruits, vegetables, and leaves, is celebrated.

January 17th is *pratipadā,* which is the first lunar day of the dark fortnight. During the *pratipadā*s, celebrated at various times all over India, several festivals and ceremonies are performed. For instance, in the South, *balī pratipadā* is celebrated on the month of Kārttika on the first day of the bright fortnight. The *pañcāṅga* tells us that January 19th is *Gaṇeśacaturthī,*[72] one of the auspicious days dedicated to the Hindu God Gaṇeśa, who symbolizes the removal of obstacles and is worshipped with fasting, offerings, and prayers. The main celebration of Gaṇeśa is carried out on the day of his birthday, which falls in August/September.

[71] Singh and Nath, *Hindu festivals, fairs and fasts,* 110.

[72] On *Gaṇeśacaturthī*, see Kane, *History of Dharmaśāstra*, V, 1, 145-149.

January 30th is the lunar day *amāvasyā* of the dark fortnight of the lunar month *Māgh.*[73] On this date, the *pañcāṅga* says that *maunī amāvasyā* is celebrated. This day is considered auspicious for the acquisition of divine blessings and for being freed from previous *karmas.*

On January31st, *navarātri* is performed. This is a major festival dedicated to the worship of Durga and celebrated in different ways. The expression *navarātri* means 'nine nights' referring to the nine nights and days during which the nine forms of this Hindu deity are worshipped. It is celebrated five times a year, always during the waxing phase of the moon. This celebration is also called Durgāpūjā.[74]

An interesting aspect of the relation between Indian lunisolar calendars and rituals is that traditionally all the *saṅkrāntis* days have been considered auspicious, [75] as well as those weekdays that are under the rule of the Moon, Mercury, Jupiter and Venus (hence Monday, Wednesday, Thursday, and Friday respectively). On the other hand, those under the Sun, Mars, and Saturn (Sunday, Tuesday, and Saturday respectively) are considered inauspicious. Also, each weekday is considered to be more convenient for the undertaking of specific activities. For instance, from Vedic times onwards, *parvan* days have been the occasion for special ritual observances. *Parvan* days are those on which the lunar phase changes, namely the new moon day, the full moon day, the eighth, and the fourteenth day of each half month.[76] Among the months, *Vaiṣaka* is considered one of the most auspicious

[73] In India nowadays, *āmavasyā*s or 'new moon days' are considered auspicious for the worship of ancestors and various offerings are made. Religious people are supposed neither to work nor to travel, but rather to concentrate on these rites on new moon days. If such a day falls on a Monday, it is of special significance.

[74] On the celebration of *navarātri* in Modern India, see Singh and Nath, *Hindu festivals, fairs and fasts,* 54-55 and Kane, *History of Dharmaśāstra*, V, 1, 154-187.

[75] On *saṅkrāntis*, festivals, and religious observance in ancient India see Kane, *History of Dharmaśāstra*, V, 1, 211-226.

[76] Worship and specific acts performed on *parvan* days are for instance mentioned in the *Arthaśāstra* (4.8.21, 28, 38) and in the *Rāmāyaṇa* (5.1.9, 5.2.54, 5.46.15, 5.57.16). In ancient India, *parvan* days influenced all kinds of

and is dedicated to the worship of the god Viṣṇu. In regard to the lunar days, the eleventh day, called *ekadaśī,* is considered a spiritually beneficial day.[77] During this day, fasting and other religious ceremonies are observed. According to Kane, 'a voluminous literature has grown round *Ekādaśī* in the Pūrāṇas and medieval digests. There are separate treatises on *Ekādaśī* written by medieval writers [...]'.[78]

The *nakṣatra*s and the *yoga*s are also divided into auspicious and inauspicious and are crucial for finding the best *muhūrta* for the undertaking of all kinds of activities.

Another interesting aspect of this *pañcāṅga* is that one finds images of religious figures from various Indian traditions represented in the boxes of some weekdays. For instance, on the box January 7th, one finds, together with calendric and astrological information, the image of someone who clearly seems to be a spiritual teacher. The almanac informs us that January 7th is the day of Guru Govind Singh, the tenth and last guru of the Sikhs. During the day of *Guru Govind Singh jayaṁtī* ('jubilee'), the devotees gather in large processions to sing devotional songs. Prayers are held at places of worship; poems are recited as part of praising the guru on his birthday, and special dishes that are unique to the occasion are shared.

In the present calendar, on the very same day, below the writing *guru govind singh jayaṁtī,* one finds *guru rājendrasūri janm + puṇyaḥ*. This refers to the celebration of the birth (*janam*) and the marking of respect to the virtues (*puṇya*) of the 19th century Śvetāmbara Jain *ācārya Rājendrasūri.* In the box for January 12th of this *pañcāṅga*, at the very top, one can also see an image of the Indian spiritual thinker Vivekānanda (1863-1902). This day commemorates his birth.

---

activities, including sexual life. In this regard, see Johann Jakob Meyer, *Sexual life in Ancient India: a study in comparative history* (New Delhi: Motital Banarsidass Publishers, Repr. 1989), 243.

[77] See also in Kane, *History of Dharmaśāstra*, V, 1, 62.

[78] Kane, *History of Dharmaśāstra*, V, 1, 95. On *ekādaśī* and *vrata*s, see in the same volume pp. 62-121.

On January 13th, one finds an image of a group of people surrounding a big fire. Below, we are told, in fuchsia writing, that, on this day, *soma pradoṣ vrat* is observed. This is a religious rite commemorated on the lunar day *trayodaśī.* When this occurs on Monday, as it is on January 2014, is called *soma pradoṣ*. *Pradoṣ vrat* is a Hindu religious practice for the worship of Śiva and Parvati. The performance of this *vrat* mainly involves fasting from sunrise to sunset, which is considered highly auspicious and beneficial, as well as the offering of prayers and acts of worship. It is believed that one will be blessed with wealth, children, happiness, and freedom from previous *karmas.*[79]

On January 23rd, a picture of a man in military dress is found. Below, we are informed: *netājī subhāṣ jayaṁtī.* This informs us that this is the jubilee of the political activist Netajī Subhāṣ (Subhas Candra Bose 1897-1945), who was an Indian nationalist leader.

On the 28th, there is an image of a man, who we are told is Lālā Lājapatarāya (Lal Lajpat Rai 1865-1928), a Punjabi author and politician, who is remembered as a leader in the Indian independence movement. On that day, his birth is commemorated (1865-1928).

I have already mentioned that, under the title *vrat evaṁ tyauhār*, our *pañcāṅga* gives a list of religious practices (*vrat*) and festivals (*tyauhār*), which occur on various days of the month of January. According to the calendric system followed by this almanac, and according to the lunar phases of the year that it considers, on January 2nd, the ritual called *candradarśana* is observed.[80] This is a rite of passage celebrating the birth of offspring, during which a New Born is taken out of the house for the first time and shown the moon.[81] The *pañcāṅga* informs us that on January 12th *rohiṇivrat* is observed. This is one of the

[79] *Pradoṣavrata* is mentioned in Kane, *History of Dharmaśāstra*, V, 1, 350.

[80] On the Vedic ritual *candradarśana* performed by the householder, see Jan Gonda, *Vedic ritual: the Non-Solemn Rites* (Leiden: Brill, 1980), 126.

[81] Among Vedic rituals celebrating the auspicious occasion of birth, the New Born is also shown the sun. This rite is called *sūryadarśana.*

*nakṣatravrata*s,[82] which are *vrata*s performed under the influence of the different lunar mansions. [83] This *vrat* is performed on the day when *Rohiṇi* prevails, as it does on the 12th of January according to the calendric system followed by this *pañcāṅga.* It is believed that the performance of *rohiṇivrat* frees one from suffering and poverty. [84] The succession of birthdays and rites creates an inclusive and demanding image of religious observances and cultural memory.

5. Conclusion

This paper has analysed the Indian solar/lunisolar calendar system and its relation to ancient and modern ritual practices. We have seen that, since the *Veda*s, rules for various rituals and sacrifices have been described as having to take place at particular times, such as the full moon, the new moon, or at the equinox. Calendric knowledge was thus of the utmost important for Vedic peoples in performing various kinds of rituals. Already, in this early period, attempts to develop a lunisolar calendar were made. The first explicit description of calendric knowledge in ancient India is found in the *Jyotiṣavedāṅga*, an ancillary Vedic text intended to support the establishment of the dates and times for the performance of the various sacrifices prescribed in the Vedic corpus. The Indian calendar attained its established form (although there were many variations in the ways in which its features were combined in practice) in the early centuries CE.

This essay has also discussed the characteristics of the traditional Indian almanac called *pañcāṅga* (lit. 'five-limbed'), whose name derives from the five time units tracked by it: the

[82] *Rohiṇi* is the *nakṣatra* of birth of the Hindu god Kṛṣṇa.

[83] *Rohiṇivrat* is a fasting day in Jain community.

[84] Traditionally, there are twelve *Rohiṇi* fasting days in a year.

tithi, the *vāra*, the *nakṣatra*, the *yoga*, and the *karaṇa*. Sanskrit textual sources reveal that, around the middle of the second millennium CE, the ultimate goal of Indian practical astronomical computation was linked to the production of the *pañcāṅga*. This denotes a calendar which forecasts celestial phenomena such as the weather and solar eclipses, and was commonly used to establish the dates and times for both religious festivals and for the undertaking of daily activities and important undertakings, such as travel, marriage, trade and construction. In modern-day India, this yearly almanac is still very popular and published in different languages and styles all over the country, following the astronomical principles laid down in ancient astronomical treatises such as, for instance, the *Sūryasiddhānta,* the *Grahalāghava,* and the *Tithicintāmaṇi*. Not only are there many different versions of the *pañcāṅga*, but basically no two of them are the same as any other. In this regard, this paper has presented an analysis of the elements of the solar month January of the Gregorian year 2014 of a modern *pañcāṅga* in Hindi, in order to understand the way in which traditional knowledge is integrated into the contemporary practices of astral science. The translation and analysis of the information found in the almanac presented indicate that this is a lunisolar *pūrnimānta* calendar whose main body shows a solar structure, with lunar phases given inside the box of each solar day. Here, one finds the solar day (*vāra*), lunar day (*tithi*), the lunar constellation of the day (*nakṣatra*), numerical astrological data relative to the sidereal and tropical zodiac, and information on religious observances, festivals, and rituals. Overall, this almanac presents explicit information on three of the five elements of a *pañcāṅga*, as the terms *yoga* and *karaṇa* are not given. In conformity with traditional Sanskrit literature on *muhūrta*, a list of the auspicious and inauspicious moments of the month is found.

The present paper demonstrates that the connection between rituals, astrology, and astronomical phenomena is still a significant aspect of contemporary Indian culture; practices such as fasting and the making of offerings to the gods are performed during

particular lunar days. Seasonal festivals and ancient rituals all over the country also accompany each passage of the Sun into a new zodiac sign (*saṅkrānti*). Lastly, an interesting aspect of the almanac under consideration is the character of the information provided, which is a mixture of tradition and modernity, and of the religious and the mundane. Also, one finds references to various Indian cultural and religious traditions. It can be seen, therefore, that traditional knowledge is substantially integrated with modern cultural practice. Having explored just one month of a modern Hindi almanac, which has offered us such a rich blend of the ancient and the modern, the religious and the social, it is clear that further exploration of this important cultural phenomenon is required.

BIBLIOGRAPHY

PRIMARY SOURCES

Āryabhaṭa. *The Āryabhaṭīya: with the commentary Bhatadīpikā of Paramādīçvara.* H. Kern ed., Leiden: E.J. Brill, 1874.

Gaṇeśadaivajña, *Grahalāghavam,* Kapilasvara Sastri ed., Varanasi: Saṃskṛta Granthamālā, 1946.

The Tithichintamani of Sri Gaṇeśa Daivajña, Mātṛprasāda Pāṇḍeya ed. and comm., Varanasi: Chowkhamba Sanskrit Series, 1938.

Parameśvara, *Ācārasaṅgrahaḥ,* Viśveśvari Amma ed., Trivandrum: Paurasatybhāṣāgaveṣaṇahastalikhitagranthaprasādhana Kāryālaya, 1981.

The Sūrya-siddhānta: an Ancient System of Hindu Astronomy with Ranganātha's exposition, the Gūdhārtha-prakāśaka. Fitzedward Hall ed., with the assistance of Bāpū Deva Śāstrin, Calcutta: C.B. Lewis, (1854-)1859.

Varāhamihira, *Bṛhajjātakam*, Acyutānanda Jhā ed., Varanasi: Chowkhamba Sanskrit Series, 1946.

Bṛhatsaṃhitā, Avadhavihārī Tripāṭhī ed., Varanasi: Sarasvatībhavanagranthamālā 97, 1968.

SECONDARY SOURCES

Bose, D. M., Sen S. N., and B.V. Subbarayappa, eds., *A Concise History of Science in India.* New Delhi: Indian National Science Academy, Second Revised Edition, 2009.

Burgess, Ebenizer, *Sūrya-Siddhānta: a Text-Book of Hindu Astronomy*, *Translated with Notes and an Appendix*, *Edited by Phanindralal Gangooly; With an Introduction by Prabodhchandra Sengupta.* New Delhi: Motilal Banarsidass, Repr. 1989.

Chakravarty, A. K. and S. K. Chatterjee, 'Indian Calendar from Post-Vedic Period to AD 1900', in *The History of Astronomy in India,* S.N. Sen, and K.S. Shukla eds., New Delhi: Indian National Science Academy, 1985, 252-307.

Chatterjee, H., *Studies in Some Aspects of Hindu Saṁskāras in Ancient India*, Calcutta: Sanskrit Pustak Bhandar, 1965.

Chitralekha, S. and P. Nath., *Hindu Festivals, Fairs and Fasts.* New Delhi: Crest Publishing House, 1999.

Clark, Walter E., *The Āryabhaṭīya of Āryabhaṭa: an Ancient Indian Work on Mathematics and Astronomy, Translated with Notes.* Chicago: The University of Chicago Press, 1930.

Dumont, P. E., 'The Full Moon and New Moon Sacrifices in the Taittirīya-Brāhmaṇa', *Proceedings of the American Philosophical Society,* 101 (1957): 216-243; 103 (1959): 584- 608; 104 (1960): 1-10.

Gansten, M., 'Astrology and Astronomy (Jyotiṣa)', in *Brill's Encyclopedia of Hinduism*,

vol. 2, *Sacred Texts, Ritual Traditions, Arts, Concepts*, edited by Knut A. Jacobsen, Leiden: Brill, 2010. 281–294.

- 'Astrology', in *Oxford Bibliographies*, 2014. https://doi.org/10.1093/OBO/9780195399318-0109

Gonda, Jan, *Vedic Ritual: the Non-Solemn Rites*, Leiden: Brill, 1980.

Kane, P. V., *History of Dharmaśāstra,* 2nd ed., 5 vols., Poona: Bhandarkar Oriental Research Institute, 1968-1975.

Killingley, Dermot, Werner Menski, and Shirley Firth, *Hindu Ritual and Society*, Newcastle upon Tyne: S.Y. Killingley, 1991.

Macdonell, Arthur A. and Arthur B. Keith. *Vedic Index of Names and Subjects*, 2 vols. London: Murray, 1912.

Mak, Bill, 'The Date and Nature of Sphujidhvaja's Yavanajātaka reconsidered in the light of some newly discovered materials', *History of Science in South Asia* 1 (2013): 1-20. https://doi.org/10.18732/H2RP4T

McGee, Mary, 'Saṃskāra', in *The Hindu World*, Sushil Mittal and Gene Thursby eds., New York: Routledge, 2007.

Meyer, Johann J., *Sexual life in Ancient India: a Study in Comparative History*, New Delhi: Motilal Banarsidass, Repr., 1989.

Montelle, Clemency, *Chasing Shadows: Mathematics, Astronomy, and the Early History of Eclipse Reckoning*, Baltimore: The John Hopkins University Press, 2011.

Neugebauer, Otto, *The Exact Sciences in Antiquity*. Princeton N.J.: Princeton University Press, 1951.

Ōhashi, Yukio, 'Development of Astronomical Observation in Vedic and Post-Vedic India', *Indian Journal of History of Science,* 28, 3 (1993): 185-251.

Pandey, R., *Hindu Saṁskāras: Socio-Religious Study of the Hindu Sacraments*, New Delhi: Motilal Banarsidass, Repr. 2002.

Pingree, David, *Census of the Exact Sciences in Sanskrit* (CESS), 5 vols., Philadelphia: American Philosophical Society, 1970-1995.

- 'The Mesopotamian Origin of Early Indian Mathematical Astronomy.' *Journal for the History of Astronomy* 4, no. 1 (1973): 1-12, https://doi.org/10.1177/002182867300400102
- *The Yavanajātaka of Sphujidhvaja*, 2 vols., Cambridge, Mass.: Harvard University Press, 1978.
- *Jyotiḥśāstra: Astral and Mathematical Literature*, Wiesbaden: Harrassowitz, 1981.
- *Catalogue of Jyotiṣa Manuscripts in the Wellcome Library: Sanskrit Astral and Mathematical Literature,* Leiden: Brill, 2004.

Plofker, Kim. *Mathematics in India*, Princeton, N.J.: Princeton University Press, 2009.

Regulagedda, A., 'Panchanga-Tantra: The Magic of the Indian Calendar System', Undergraduate Research Opportunities Programme in Science (UROPS) Thesis, National University of Singapore, 2002.

Sewell, Robert and Sankara Balkrishna Dikshit, *The Indian Calendar: with Tables for the Conversion of Hindu and Muhammadan into A.D. dates, and vice versa, with Tables of Eclipses Visible in India by Robert Schram*, London: S. Sonnenschein, 1896.

Subbarapaya, B.V. and K.V. Sarma, *Indian Astronomy: a Source Book Based Primarily on Sanskrit Texts,* Bombay: Nehru Centre, 1985.

Subrahmanya, V. and M. Ramakrishna Bhat, *Brihat Samhita=Bṛhatsaṃhitā, with an English Translation and Notes*, Bangalore City: V. B. Soobbiah, 1947.

Welbon, Guy R. and Glenn E. Yocum, eds., *Religious Festivals in South India and Sri Lanka.* New Delhi: Manohar, 1982.

Yano, Michio. 'Calendar, Astrology and Astronomy', in *The Blackwell Companion to Hinduism*, Gavin Flood ed., London: Blackwell, 2003, 376-392.