# Cultural, Philosophical and Spiritual Underpinnings of Indian Knowledge Systems with focus on Mathematics and Astronomy

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**Abstract**

The *Muṇḍakōpaniṣad*, which is embedded in the *Atharva Veda* and is one of the most widely translated spiritual texts, distinguishes between Knowledge as *parā vidyā* (higher knowledge) and *aparā vidyā* (lower knowledge). Knowledge of the Self is *parā vidyā* while all knowledge of the material universe is classified as *aparā vidyā*. This is the unique perspective that one finds in *Bhāratīya Jnana Parampara* or Indian Knowledge Traditions, which indicates that scientific knowledge may be considered as a useful tool and a stepping stone to attainment or realisation of *parā vidyā* or higher knowledge. It may be said that this aspect of thought has not been given sufficient attention in mainstream academic discourse as scientists have been more concerned with scientific discoveries made by Indian stalwarts even as the spiritual moorings of such talented individuals are less regarded or even ignored as being insignificant within the parameters of mainstream academic scholarship. However, this is to elide available evidence such as the fact that Aryabhata (ca. 476-550 CE), invoked *Brahman* at the beginning of his treatise *Āryabhaṭiya* (ca. 510 CE), and Bhāskara II (ca. 1114-1185 CE) employed powerful mystical metaphors to refer to the unknown in algebraic terms. Even as recently as the early twentieth century, the renowned mathematician Srinivasa Ramanujan (1887-1920) openly acknowledged his religious and spiritual experiences as sources of his inspiration for the brilliant mathematical breakthroughs he made. In this paper, we propose to explore the cultural, philosophical and spiritual underpinnings documenting our classical and indigenous *Jnana Parampara* and why it is important to appreciate the cultural milieu in which the heritage of the Indian Knowledge Systems (IKS) evolved. We argue that it would be a serious lacuna to ignore the spiritual aspects of IKS traditions since our understanding of IKS cannot be isolated from these underpinnings.

**Keywords**: Indian Knowledge Traditions, Indian Knowledge Systems (IKS), spiritual underpinnings, *parā vidyā, aparā vidyā*.

## Introduction

The manufactured distinction between the secular and the sacred which Western civilization imported to India did not exist in the pre-colonial period. Beginning with the Polish astronomer Copernicus in the early 16th century, the early 17th century empirical philosophers Francis Bacon of England and Galileo Galilei of Italy, and the Enlightenment (17th-18th CE) philosophers, there was a thrust in the western world for the secularization of thought.

Philosophers like John Locke, Voltaire, and Immanuel Kant advocated the separation of the church and the state, emphasizing reason, individualism, and religion-neutral governance. The modern understanding of secularism encouraged the development of political and scientific thought, independent of religious doctrine. The event of the French Revolution also marked a significant moment in the formal partition between the sacred and the secular. The revolutionary ideals of liberty, equality and fraternity, which had been inspired by the Enlightenment thought led to the secularization of French society, leading to the confiscation of Church lands and the establishment of secular state institutions. Subsequently, secularism became a defining feature of Western culture, particularly after the Industrial Revolution, when the development of scientific and technological thought further distanced secular life from religious influences. The mainstreaming of secular education, legal frameworks, and the rise of secular governments in Europe and the Americas solidified the distinction. (Goldie, M., & Walker, M. 2008).

The fallout of this was that the science *vs* religion conflict in Christendom was exacerbated over time, initially starting with theological disputes during the early modern period, further aggravated by the Scientific Revolution and Enlightenment ideas. This conflict continues to exist today, with some viewing science and religion as mutually exclusive, while others seek ways to find an elusive common ground.

Galileo Galilei's support for the heliocentric theory in his *Dialogue Concerning the Two Chief World Systems* (1632) led to his famous confrontation with the Catholic Church, his trial by the Inquisition and his subsequent house arrest. This event marked a key moment in the divide between religious doctrine and scientific discovery.

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Another significant flashpoint in the science *vs* religion conflict was the publication of Charles Darwin's *On the Origin of the Species* in 1859. Darwin's theory of evolution by natural selection directly contradicted the Biblical account of creation, especially the literal interpretation of the *Book of Genesis*. Many orthodox religious groups within Christianity rejected Darwin's theory, seeing it as a threat to a dogmatic belief in the Bible.

India, on the contrary, had had a long history of the possession of an integral approach to knowledge, an attitude in which both the secular and the sacred blended harmoniously without conflict. The long absence in India of the notion of a division or conflict between secular state and religious doctrine meant that the hard separation of the secular from the sacred which Western civilization has struggled with, did not occur in our country. Indeed, there was never any existence here of a monolithic religious institution with overwhelming political power – with the possible exception, perhaps of the Buddhist *saṅghas* that were maintained and functioned with the patronage of the theocratic Mauryan empire under the rule of Ashoka.

**India's integral approach**

The Vedic seers classified knowledge into two categories – spiritual and non-spiritual (loosely translated as higher and lower knowledge in popular parlance). This approach is clearly delineated in the *Muṇḍakōpaniṣad* (approx. 800-1000 BCE), considered as one of the ten principal Upanishads on which Adi Sankaracharya (8th century CE) wrote commentaries. Presented as a dialogue between Rishi Angirasa and an educated householder called Śaunaka, the text begins with the mother of all questions which forms the substratum of the pursuit of all knowledge in the Indian philosophical framework: *kasminnu bhagavo vijñāte sarvamidaṃ vijñātaṃ bhavatīti* [What is that, by knowing which, all this becomes known] (*Muṇḍakōpaniṣad,* 1.1.3). Finding the source of all knowledge or the source of the creation would ultimately lead the seeker to transcend the veil and attain *brahma jnana* and *moksha*. Further, the *Muṇḍakōpaniṣad* classifies knowledge into two distinct categories – *parā vidyā* and *aparā vidyā*: *tasmai sa hovāca | dvevidye veditavye iti ha sma yadbrahmavido vadanti parā caivāparā ca* (*Muṇḍakōpaniṣad*, 1.1.4).

Swami Paramarthananda explains this clearly in his lectures on the *Muṇḍakōpaniṣad* thus*:*

The knowers of Brahman say that there are two kinds of knowledge – spiritual knowledge and all the rest that is non-spiritual… Therefore, *parā vidyā* is mokṣa *vidyā, rāja vidyā*. Then, what is *aparā vidyā*? Very simple. Every science, other than this! All non-spiritual knowledge. All non-spiritual knowledge, all material branches of knowledge will come under *aparā vidyā*. Whether it is quantum physics or cosmology or it is physics or medicine or music or economics, any branch of science you take, they all will come under *aparā vidyā* only. (Paramarthananda, Sw., 2017).

So, though there was a well-defined hierarchy in which *parā vidyā* was considered higher than *aparā vidyā,* these two were not pitted against each other or considered exclusive in such a way that the pursuit of one would prevent an individual from gaining the other.

This is one of the reasons perhaps why India excelled in the pursuit of not only spiritual knowledge but in scientific domains too. While India's spiritual influence over the ancient world is well-established and recognized, her contributions to science are slowly regaining the recognition it deserves in the history of science.

Bibhutibhushan Datta (1888-1958), the well-known historian of Indian mathematics, endorses this view in his preface to the *Śulbasūtras*:

But the Vedic Hindu, in his great quest of the *Parā vidyā* ("Supreme knowledge"), *Satyasya Satyam* ("Truth of truths," "Absolute Truth"), made progress in the *Aparā vidyā* ("inferior knowledge," "relative truths"), including the various arts and sciences, to a considerable extent, and with a completeness which is unparalleled in antiquity. (Datta, B., 1932, p. vii).

We try to argue with examples from various ancient Indian scientific texts that Indian Knowledge Systems (IKS) evolved in a unique cultural and spiritual milieu which encouraged a fluid interflow of ideas between the sacred and secular. From the Vedic times to the 20$^{th}$ century, the life and works of great Indian mathematicians, astronomers, scientists and innovators from various disciplines stand as a testimony to the cultural and spiritual underpinnings of IKS.

**Sacred Geometry of the Fire Altars**

The *Brāhmaṇas* (900-700 BCE) are Sanskrit texts attached to the *Saṃhitās* of the Vedas. The Brāhmaṇas contain instructions on performance of Vedic rituals and also explain the scientific knowledge needed for the performance of these rituals such as the astronomical details and the geometry involved in the construction of the fire altars known as *vedi* or *citi*. The Vedic rituals required accuracy and perfection in the construction of the fire altars with no scope for error as the fruition of these rituals depended on it:

According to the strict injunctions of the Hindu *Śāstra* (or "Holy Scriptures") each sacrifice must be made in an

altar of prescribed shape and size. It is stated that even a slight irregularity and variation in the form and size of the altar will nullify the object of the whole ritual and may even lead to an adverse effect. So, the greatest care has to be taken to have the right shape and size of the altar. (Datta, B., 1932, p. 20).

Even the design of the fire altars and their shape has deep symbolism embedded in it:

The complexity in the design of these brick-altars arises from their rich symbolic significance. For instance, the *śyenacit* (falcon altar) is a symbolic representation of the aspiration of the spiritual seeker soaring upward. (Datta, A, K., 2022).

This is a wonderful example of the symbiosis that existed between science and religion in ancient India. The need for the construction of these geometrically precise fire altars led to the earliest known development of the principles of geometry in ancient India enumerated in the *Śulbasūtras* (800-200 BCE). The earliest principles of geometry in India evolved to fulfil the most sacred fire rituals which are at the core of the Vedic religion. This symbiosis stemmed out of a holistic and integral vision which did not divide the world into dualities and opposites but sought to unify and could deftly move from the scientific to the spiritual and vice-versa.

**Mantras and Metrics**

The Vedas have been transmitted orally from *guru* to *śiṣya* for thousands of years, with rigorous methods to preserve their exact pronunciation. Inaccurate pronunciation can lead to a loss of meaning and efficacy, affecting the integrity of this ancient discipline. Therefore, the Sanskrit language has precise rules of grammar because even small variations in pronunciation can change the meaning and the intended effect of a mantra completely. For example, a misplaced accent (*svara*) or a mispronounced syllable can convey a different intent or meaning. Vedic mantras are thought to influence the practitioner's mind, body, and spirit through their sonic vibrations. Incorrect pronunciation may alter this effect, reducing the mantra's spiritual or meditative benefits.

You must not go wrong either in the enunciation or intonation of a mantra. If you do, not only will you not gain the expected benefits from it, the result might well be contrary to what is intended. So the mantras must be chanted with the utmost care. There is a story told in the Taittiriya Samhita (2. 4. 12) to underline this… The gist of this story is contained in this verse which cautions us against erroneous intonation: *mantro hīnaḥ svarato varṇato vā mithyāprayukto na tamartham āha / sa vāgvajro yajamānaṃ hinasti yathéndraśatruḥ svarato'parādhāt //* (Chandrasekharendra Saraswati, Sw., 1995).

A mantra that is deficient in intonation (*svara*) or articulation (*varṇa*), or is used incorrectly (*mithyāprayukta*), does not yield the intended result (*tam artham*). Instead, it becomes a thunderbolt (*vāgvajra*, destructive speech) that harms the sacrificer (*yajamāna*), just as the mispronunciation of Indraśatru led to disaster due to an error in intonation (*svarataḥ aparādhāt*).

Therefore, ancient Sanskrit scholars like Piṅgala and Pāṇinī evolved precise rules for grammar and prosody. The ancient treatise *Chandahśāstra* of Piṅgala is the foundational work on Sanskrit prosody. It outlines the rules for various meters, explains their construction, and introduces concepts like combinatorics to analyze patterns in the meters. Pingala's mathematical analysis and the rules of *Chandahśāstra* also contain deep spiritual significance:

Piṅgala's mathematical gems were mere incidental offshoots of the study of metres which had deep spiritual significance in the Vedic tradition… Since the Vedic thinkers attributed a great mystic significance to *chandas*, special and careful attention was paid to the study of metres… *Chandas* was called the feet of the Vedas—*Chandaḥ pādau tu vedasya* (Pāṇinīya Śīkṣā). (Dutta, A, K., 2022).

*Chandas* is one of the six Vedangas (ancillary disciplines of the Vedas) and refers to the study of meters in Sanskrit poetry and prose. It is a foundational aspect of Vedic and classical Sanskrit literature, governing the rhythmic and metrical structure of a *sūkta*, *mantra*, or a *kāvya*. *Chandas* provides the framework for composing and chanting Sanskrit texts with precision and harmony, ensuring their spiritual and phonetic efficacy. The term *chandas* originates from the root *chad* meaning 'to cover' or 'to please'. It signifies the structured patterns that 'cover' or 'frame' the words of a verse, making them melodious and impactful. *Chandas* adds rhythm and helps in memorization which is a critical aspect of oral traditions like the Vedas. Some prominent Vedic meters include: *Gāyatrī* (24 syllables in each verse), *Anuṣṭubh* (32 syllables), *Triṣṭubh* (44 syllables), *Jagatī* (48 syllables).

All the six *Vedāṅgas* are well-defined disciplines associated with the study and preservation of the Vedas. While they serve a practical purpose like ensuring accurate pronunciation, grammar, and ritual performance, their foundation is deeply spiritual, aiming to facilitate the understanding and application of Vedic knowledge. The six *Vedāṅgas*, though technical in nature, are rooted in a profound spiritual philosophy. Each discipline contributes to preserving the sanctity and efficacy of the Vedic tradition, contributing to a

harmonious relationship between the individual, society, and the cosmos. Their study not only serves the practical purpose of preserving the purity and sanctity of the Vedas but also nurtures spiritual growth and realization. In the next section, let us examine the spiritual roots of grammar or *vyākaraṇa.*

### *Dharma* and *Ḍamaru* in *Vyākaraṇa*

Grammar (*vyākaraṇa*) is one of the six *Vedāṅgas* (limbs of the Vedas), which are considered essential for understanding and preserving the Vedic texts. Pāṇini, the ancient Sanskrit grammarian, and his unparalleled work, the *Aṣṭādhyāyī*, also have deep spiritual and philosophical underpinnings. They are closely intertwined with the Vedic tradition, metaphysics, and the philosophical worldview of *Vedānta*. The *Aṣṭādhyāyī* serves as a framework for the correct usage of Sanskrit, particularly in the context of preserving the sanctity of the Vedic recitation. Many of Pāṇini's rules address the phonetics and the structure of Vedic chants, ensuring their precision for ritual efficacy.

In the Indian worldview, *ṛtam* and *dharma* (cosmic order and righteousness) permeate all aspects of life, including language. The *Aṣṭādhyāyī* reflects this perspective by treating grammar as a tool for upholding the proper order and purity of speech, which is considered as a verbal manifestation of dharma. The ancient belief in the divinity of *Vāk* (speech) connects Pāṇini's work with spiritual practice. Speech is considered sacred, an expression of divine consciousness, and therefore grammar ensures its proper expression. In Vedic tradition, *vāk* (speech) is closely connected to the element of fire because speech ignites thoughts into action, much like fire transforms matter into energy. The *Taittirīya Saṃhitā* (2.6.8) directly links Agni to speech, emphasizing this symbolic connection: *Agnir vāgvai nāmāsi* (Agni is indeed the name of speech).

According to tradition, Pāṇini received inspiration for his grammar from Lord Shiva's *ḍamaru* (drum). The sounds produced by the drum are said to have given rise to the *Māheśvarāṇi Sūtrāṇi*, a set of fourteen terse aphorisms (phonetic system), which are foundational to Pāṇini's grammar. Memorizing and reciting these *sūtras* is considered a disciplined spiritual practice.

*Nandikēśakāśikā* (c. 5th–2nd century BCE) is a Sanskrit text attributed to Nandikēśvara. It contains twenty-seven verses providing a mystical explanation of the *Māheśvarāṇi Sūtrāṇi*. The opening verse of the text describes the story of the origin of the fourteen aphorisms of the *Māheśvarāṇi Sūtrāṇi:*

*nṛttāvasāne naṭarājarājo nanāda ḍhakkāṁ navapañcavāram |*
*uddhartukāmassanakādisidhā netadvimarśe śivasūtrajālam ||1||*

[At the close of his dance, Naṭarāja (Śiva), the lord of dance, in order to uplift Sanaka and other siddhas (mystics) sounded the hand-drum fourteen times. I comment upon the collection of these aphorisms of Śiva.] (Balasubramanian, K. S., & Vasudeva, T. V. (2009)

*Vyākaraṇa* is therefore not just a linguistic discipline but is deeply embedded in the spiritual fabric of ancient India. It acts as a bridge between the material and the transcendental, treating language as both a practical tool and a sacred medium for engaging with the ultimate reality. Through his work, Pāṇini ensured that Sanskrit remained a living and precise vehicle for the preservation and transmission of spiritual wisdom. Thus, Pāṇini's work has a spiritual function beyond its linguistic value.

### *Śūnyatā*– the philosophy of nothingness behind the zero

In their quest to grasp the origin of the Universe, the Vedic seers gave expression to the earliest idea of nothingness in the beautiful *Nāṣadīya Sūkta* of the *Ṛg Veda* (10:129):

nắsad āsīn nó sád āsīt tadánīṃ nắsīd rájo nó víomā paró yát kím ắvarīvaḥ kúha kásya śármann ámbhaḥ kím āsīd gáhanaṃ gabhīrám || (Agrawala, V. S., 1963).

Then was not non-existent nor existent: there was no realm of air, no sky beyond it. What is covered in, and where? and what gave shelter? Was there water there, unfathomed depth of water? (Griffith, 1889, as cited in Agrawala, V. S., 1963).

It is this quest for expressing the idea of *śūnyatā* or nothingness in mathematical form that led Indian mathematics to one of the most significant developments in numerals – the zero or *śūnya*. Ancient Indian mathematicians recognized that the absence of a number in a designated place had to be represented by a symbol to maintain the integrity of numerical notations and arithmetical operations. In ancient Indian texts, there is evidence of the placeholder function of zero in the context of the place value system. For instance, in the Brahmi numerals, used around 3rd century BCE, spaces were sometimes left vacant to denote the absence of a value in a specific place in larger numbers, which can be considered as a precursor to the modern use of zero.

The *Bakṣālī Manuscript* (ca. 3rd-7th centuries CE) contains one of the earliest known symbols for zero. The manuscript, which was discovered in modern-day Pakistan, uses a dot to represent zero. While it is debated whether the dot symbol specifically represents zero or simply a placeholder, it marks an important step

towards the later formalization of the zero symbol. In his work *Brahmasphuṭasiddhānta* (628 CE), Brahmagupta explicitly defined zero as the result of subtracting a number from itself. Brahmagupta's work was foundational for systematizing zero as both a number and a symbol in mathematical operations. Bhaskara II used zero extensively in solving algebraic equations and problems in his works, *Līlāvatī* and *Bījagaṇita*. His contributions helped cement the zero's role in Indian mathematics, especially in algebra and trigonometry. The Indian numeral system, which included the concept of zero, was transmitted to the Islamic world through translations of Indian mathematical works. The Arabs were instrumental in spreading Indian mathematical ideas, including zero, to the West. In the 9th century, the Persian mathematician Al-Khwarizmi, wrote influential texts in Arabic that used Indian numerals, including the concept of zero. Al-Khwarizmi's work on arithmetic known as *Kitāb al-Ḥisāb al-Hindī* (The Book of Indian Calculation) was translated into Latin as *Algoritmi de numero Indorum* (Al-Khwarizmi on the Hindu Art of Reckoning). This book played an important role in popularizing the decimal positional number system and Hindu-Arabic numerals to the Western world. The Italian mathematician Fibonacci (Leonardo of Pisa) played a pivotal role in introducing the Hindu-Arabic numeral system, including zero, to Europe. His *Liber Abaci* demonstrated how the Hindu-Arabic numeral system (including zero) was more efficient than the Roman numeral system. This is how the Indian numerals, the zero and the decimal place value system revolutionized science and trade all over the world. (Joseph, G. G., 2000).

It is important to remember that the evolution of zero was not just a mathematical breakthrough but also a profound philosophical concept in Indian thought, representing both the void and the infinite.

**Mystical power of the powers of ten and other magical numbers.**

Mathematicians like Dutta opine that it is not just the zero but also the use of the powers of ten and base ten have deep mystical significance:

In the Vedic culture, a special mystic significance had been attached to the powers hundred, thousand and ten thousand. The number hundred represents a general fullness… The word *sahasra* is derived from the root *sahas* which stands for "mighty", "powerful", "victorious", "strength", "force", etc.; thus, *sahasra* is mighty, a huge number… One may then surmise that the choice of base ten and the coining of number-names for certain powers of ten might have a mystic genesis (Dutta, A. K., 2022).

The eighth *anuvāka* of the *Brahmānandavallī* of *Taittirīya Upaniṣad* (6th century BCE) is a beautiful example of the use of the multiples of ten. The hymn describes the intensity of *ānanda* experienced by the beings in each of these *lokās*:

*sa eko manuṣyagandharvāṇāmānandaḥ |*
*śrotriyasya cākāmaha-tasyāḥ |*
*te ye śataṃ manuṣyagandharvāṇāmānandāḥ |*
(*Taittirīya Upaniṣad, Brahmānanda Vallī*, 8.1)

Swami Krishnananda explains the hierarchy of happiness, also known as Ānanda Mīmāṃsā thus:

These are the levels through which we have to ascend. As we go higher and higher, the greater is the happiness; and the Upanishad tells us that each higher realm is constituted of an experience which is tantamount to one hundred times greater happiness than the earlier one. One hundred times the happiness of this imaginary king of this world is the happiness of the Gandharva. One hundred times the happiness of the Gandharva is the happiness of the Pitru. One hundred times the happiness of the Pitru is the happiness of the celestial. One hundred times the happiness of the celestial is the happiness of Indra. One hundred times the happiness of Indra is the happiness of Brihaspati. One hundred times the happiness of Brihaspati is the happiness of Prajapati, the Creator. One hundred times the happiness of Prajapati is Absolute Happiness. (Krishnananda Sw., 1982).

Ancient Indian seers and mathematicians were able to observe the number patterns which seemed to repeat in cosmic phenomena. A well-known example of this is the sacred number 108 and its significance in religious disciplines such as *japa* (repetition of a mantra). According to yogic traditions, the human body has 108 *nāḍīs* (energy channels) that converge at the heart chakra. Practicing yoga or meditation is believed to balance these *nāḍīs* and bring spiritual awakening. In Ayurveda, there are 108 *marma* points (vital nerve centres) on the human body. There are traditionally 108 Upanishads, which are sacred texts in Hinduism that explore philosophical concepts of *Brahman* (absolute truth) and *Ātman* (Self). Many Hindu gods and goddesses, such as Shiva, Vishnu, and Durga, have 108 names (*Aṣṭōttara Nāmāvalī*). Chanting these 108 names is a well-known discipline that is practiced by millions of Hindus every day. Pilgrims often perform 108 circumambulations (*pradakṣiṇa*) around sacred sites or temples as a form of devotion. (Stewart-Brown, C., 2024).

For instance, the distance from the Earth to the Sun is roughly 108 times the Sun's diameter (107.55 to be precise), the distance from the Earth to the Moon is about 108 times the Moon's diameter (110.63) and the diameter of the Sun is about 108 times (109.17) the diameter of the Earth. 108 is considered a Harshad

number, which means it is divisible by the sum of its digits (1 + 0 + 8 = 9). No wonder then that the number 108 has been considered of great religious and spiritual significance in Indic traditions.

**Mathematics for Monks and Meditation**

Scholars of the history of Indian mathematics have pointed out that many Jain monks exhibited a keen interest and passion for mathematics as mathematical analysis and speculation aligned well with Jain cosmology and also for sharpening the mind for scriptural debates and in-depth study:

Like the Vedic mathematicians, the Jains had an interest in the enumeration of very large numbers, which was intimately tied up with their philosophy… It was as a part of this inquiry that the Jains developed their interest in the concepts of infinity (very large numbers) and the infinitesimal (very small numbers)... The contemplation of such large numbers led the Jains to an early concept of infinity, which, if not mathematically precise, was by no means simple-minded. (Joseph, G. G., 2000).

The story of the Buddha in the *Lalitavistāra*, enumerating the powers of ten from *koṭi* ($10^7$) to *tallakṣaṇa* ($10^{53}$) to a mathematician called Arjuna is well known.

One hundred times ten million is called a billion (*ayuta*). One hundred times one billion is called one hundred billion (*niyuta*). One hundred times one hundred billion is called one quadrillion (*kañkara*). One hundred quadrillion is called one sextillion (*vivara*). One hundred sextillions is called a nonillion (*akṣobhya*). One hundred nonillions is called a *vivāha*. One hundred *vivāhas* is called an *utsañga*. One hundred *utsañgas* is called a *bahula*. One hundred *bahulas* is called a *nāgabala*. One hundred *nāgabalas* is called a *tiṭilambha*. [F.76.b] One hundred *tiṭilambhas* is called a *vyavasthānaprajñapti*. One hundred *vyavasthānaprajñaptis* is called a *hetuhila*. One hundred *hetuhilas* is called a *karaphū*. One hundred *karaphūs* is called a *hetvindriya*. One hundred *hetvindriyas* is called a *samāptalambha*. One hundred *samāptalambhas* is called a *gaṇanāgati*. One hundred *gaṇanāgatis* is called a *niravadya*. One hundred *niravadyas* is called a *mudrābala*. One hundred *mudrābalas* is called a *sarvabala*. One hundred *sarvabalas* is called a *visaṁjñāgati*. One hundred *visaṁjñāgatis* is called a *sarvasaṁjña*. One hundred *sarvasaṁjñas* is called a *vibhūtaṁgamā*. One hundred *vibhūtaṁgamās* is called a *tallakṣaṇa*. (Dharmachakra Translation Committee., 2013).

Just as the Vedic seers seamlessly used geometry for Vedic rituals, we also see the Buddhist and Jain monks making new mathematical discoveries in their quest for *Nirvāṇa, Siddhi* and *Kaivalya*. Swami Vivekananda, one of the greatest monks that India sent to the West in the early twentieth century with her message of spirituality, would often remark that a man who knows how to cook properly can also meditate with concentration:

'He who knows even how to prepare a smoke properly, knows also how to meditate. And he who cannot cook well cannot be a perfect sannyasin. Unless cooking is performed with a pure mind and concentration, the food is not palatable.' Work cannot produce real fruit without detachment on the part of the worker. "Only a great monk', the Swami said one day, 'can be a great worker; for he is without attachment… No work is secular. All work is adoration and worship. (Nikhilananda, Sw., 1953)

**Āryabhaṭa invokes Brahman**

Āryabhaṭa (476-550 CE) was one of the earliest and most prominent mathematicians and astronomers of the Siddhānta period. His celebrated treatise *Āryabhaṭīya* (499 CE) opens with this invocation to Brahman:

*pranipatyaikamanēkam kaṃ satyāṃ devatāṃ paraṃ brahma |*
*āryabhaṭastrīṇi gadati gaṇitaṃ kālakriyāṃ gōlam ||*

[Having paid reverence to Brahman, who is one (in causality, as the creator of the universe, but) many (in his manifestations), the true deity, the Supreme Spirit, Āryabhaṭa sets forth three things: mathematics [gaṇita], the reckoning of time [kālakriyā], and the sphere [gōla].] (Clark, W. E., 1930).

The commentator Suryadeva (1191 CE) opines that the mysteries of the science of astronomy were revealed to Āryabhaṭa because of his worship of *Svayambhū* (the creator god Brahma). Bhaskara I however opines that Āryabhaṭa is referring to *Nirguṇa Parabrahman*. In verse 8 of *Gōlapada*, Āryabhaṭa makes a metaphorical reference to the day and night of Brahma (similar to the notions of the *mahāyuga, kalpa* and *pralaya* in the puranas):

*brahmadivasena bhūmer upariṣṭād yōjanaṃ bhavati vṛddhiḥ |*
*dinatulyaikarātryā mṛdupacitāyāstadiha hāniḥ || 8 ||*

[During a day of Brahma, the size of the Earth increases externally by one yojana; and during a night of Brahma, which is as long as a day, this growth of the earth is destroyed.] (Clark, W. E., 1930).

In the concluding verses of the *Gōlapada* in *Āryabhaṭīya*, he invokes the grace of Brahman again thus:

*sadasajjñānasamudrāt samuddhṛtaṃ brahmaṇaḥ prasādena |*
*sajjñānottamaratnaṃ mayā nimagnam svamatināvā || 49 ||*

[By the grace of Brahman, the precious sunken jewel of true knowledge has been rescued by me, by means of

the boat of my own knowledge, from the ocean which consists of true and false knowledge]

*Āryābhaṭīyam nāmnā pūrvaṁ Svāyambhuvam sadā nityam |*
*Sukṛtāyuṣoḥ praṇāśaṁ kurute pratikañcukam yo 'sya || (50)*

[He who disparages this universally true science of astronomy, which formerly was revealed by Svayambhu, and is now described by me in this Āryabhaṭīya, loses his good deeds and his long life.] (Clark, W. E., 1930).

While there may be differences of opinion on whether Āryabhaṭa was invoking the creator god *Svayambhū Brahma* or the formless supreme consciousness *Parabrahman*, one cannot ignore the inference that Āryabhaṭa's pursuit of the knowledge of mathematics and astronomy was rooted in a deeper spiritual pursuit of the *parā vidyā*. The above verses make it amply clear that Āryabhaṭa was neither an atheist nor an agnostic. Michel Danino highlights the following comment from *Āryabhaṭīya* as an intriguing expression of his spiritual worldview:

Knowing ... the motion of the Earth and the planets on the celestial sphere, one attains the supreme Brahman after piercing through the orbits of the planets and stars. (Danino, M., 2011).

In fact, this attitude or worldview is not unique to a few individuals like Āryabhaṭa or Varāhamihira but reflects a widely prevalent tradition of synergy between science and spirituality in India.

**Varāhamihira, worshipper of the Sun**

Varāhamihira (505- 587 CE), a renowned astronomer who lived in Ujjain is known for his definitive works on Indian astronomy and astrology such as *Pañcasiddhāntikā* and *Bṛhat Jātaka*. Varāhamihira frequently alludes to his religious and spiritual inclination towards sun worship, as indicated in this verse from the *Bṛhat Jātaka*:

*Ādityadāsa-tanayas tadavāptabodhaḥ kāpitakaḥ savitṛlabdha-varaprasādaḥ |*
*Avantiko munimatāny avalokya samyag Horām Varāhamihiro ruciram cakāra ||*
(Kuppanna Sastry, T. S., & Sarma, K. V. (Eds.)., 1993, p. XXVIII).

The renowned Indian historian, epigraphist, and numismatist Ajay Mitra Shastri (1934–2002) explains the significance of the above verse thus:

That Varāhamihira was a devotee of the Sun admits of no doubt. His father's name was Adityadāsa, his own name-ending 'Mihira', derived from 'Mithra', the Iranian Sun-god, his obtaining a boon from the Sun, his obeisance to the Sun in all his works except the *Vivāhapaṭala*, (which, appropriately enough, opens with an invocation to Kāma, the Indian god of love), and his devoting a comparatively larger number of verses to the description of Siirya icons, all indicate that the sun was his family deity. His son Pṛthuyaśas also invokes the Sun in the opening verse of his. As we have seen, Varāhamihira was regarded as an incarnation of the Sun. (as cited by Kuppanna Sastry, T. S., & Sarma, K. V. (Eds.)., 1993, p. XXVIII).

**The Manifest and the Unmanifest in Algebra**

Bhaskara II (1114–1185 CE), the renowned author of mathematical works like the *Lilavati* and *Bījagaṇita*, invokes Ganesha and Saraswati in his works, demonstrating the integration of spiritual reverence with intellectual pursuits. This practice signifies that knowledge is viewed as sacred, a gift of the divine. The *Bījagaṇita* opens with the following invocation which presents a profound play of words between algebra and Vedanta:

*utpādakaṁ yat pravadanti buddher*
*adhiṣṭhitaṁ satpuruṣeṇa sāṅkhyāḥ*
*vyaktasya kṛtsnasya tadeka bījaṁ*
*avyaktamīśaṁ gaṇitaṁ ca vande*

[I bow with reverence to that unmanifested which the wise (and mathematicians) regard as the substratum of the Being and the source of intelligence. It is the root cause of this entire world. I bow to the unmanifested i.e. to God and to Mathematics (which has similar attributes).] (Abhyankar, S. K., 1980).

The word *avyakta* is used to denote an unknown variable in algebra but it also refers to the Unmanifest Nature or Prakriti in Sankhya philosophy. *Buddhi* refers to both the logical intelligence of a mathematician and the viveka buddhi of a mumukshu seeker of truth. Sankhya refers to both a knower of mathematics as well as a knower of the Purusha (Self) in Sankhya philosophy. Bija refers to the cause of the world as well as the unknown variable in algebra. (Dutta, A. K., 2023).

**Astronomy and auspicious times**

The Kerala school of mathematics and astronomy (c. 14$^{th}$ -16$^{th}$ CE), was centered in Kerala and led by mathematicians like Mādhava of Saṅgamagrāma, Parameśvara, Nīlakaṇṭha Somayājī, and Jyeṣṭhadeva. This school made pioneering contributions to calculus, trigonometry, and mathematical series, centuries before similar developments in Europe. Mādhava of Saṅgamagrāma is considered as the pioneer of the Kerala school and one of the greatest mathematicians and astronomers of his times, going by the ingenuity and accuracy of his methods. Based on the autobiographical details provided by Mādhava in his work Veṇvāroham, his place of origin has been identified as the place called Irinjarappally in Kerala. Mādhava is credited with discovering infinite series expansions for trigonometric functions such as sine, cosine, and tangent, laying the groundwork for what would later become calculus. There are three infinite series named after him: 'Madhava-Newton', 'Madhava-Leibniz', and 'Madhava-Gregory' series. We may consider Madhava to be the founder of

mathematical analysis. Some of his discoveries in this field show him to have possessed extraordinary intuition, making him almost the equal of a more recent intuitive genius, Ramanujan (1887–1920), who spent his childhood and youth at Kumbakonam, not very far from Madhava's birthplace. (Joseph, G. G., 2000)

The keen interest in astronomy and the underlying mathematical analysis required for making astronomical calculations were driven by the need to determine the accurate timings for rituals as prescribed by the shastras. For example, many of the festivals and the religious observances associated with them like *Uttarāyaṇa* and *Makara Saṅkrānti* are based on significant astronomical events that occur in the lunar or solar calendar year and the celebration of such festivals presupposes a knowledge of astronomy.

**Ramanujan - the man who knew infinity**

Srinivasa Ramanujan (1887-1920) is regarded as one of the greatest mathematicians of all time, who made pioneering contributions to number theory, continued fractions and infinite series. What puzzled many mathematicians, including his mentor G. H. Hardy, was that Ramanujan had no formal training in pure mathematics and yet made outstanding contributions in his short lifespan of 32 years. What many modern mathematicians refuse to acknowledge or recognize is the mystical and spiritual side of Ramanujan's personality. Ramanujan was known for his interpretation of dreams and was deeply devoted to his *kuladevatā* Nāmagiri Tāyār, consort of Lord Narasimha at the Namakkal temple. Ramanujan attributed his discovery of solutions to many equations to the grace of Nāmagiri Tāyār:

While asleep, I had an unusual experience. There was a red screen formed by flowing blood, as it were. I was observing it. Suddenly a hand began to write on the screen. I became all attention. That hand wrote a number of elliptic integrals. They stuck in my mind. As soon as I woke up, I committed them to writing. (Baaquie, B. E., & Willeboordse, F. H., 2009)

Robert Kanigel mentions in his well-known biography of Ramanujan, *The Man Who Knew Infinity,* that he once told his friend that "An equation for me has no meaning unless it expresses a thought of God." (Kanigel, R., 1992, p.67). Kanigel also corroborates the mystical experiences of Ramanujan:

It was goddess Namagiri, he would tell friends, to whom he owed his mathematical gifts. Namagiri would write the equations on his tongue. Namagiri would bestow mathematical insights in his dreams. So he told his friends. (Kanigel, R., 1992, p. 48).

T. K. Rajagopolan, a former accountant general of Madras, would tell of Ramanujan's insistence that after seeing in dreams the drops of blood that, according to tradition, heralded the presence of the god Narasimha, the male consort of the goddess Namagiri, scrolls containing the most complicated mathematics used to unfold before his eyes. (Kanigel, R., 1992, p. 301). Ramanujan's life and work which continue to be discussed and celebrated today stands as a testimony of a long and unbroken tradition of the happy marriage of science and religion in India.

**Conclusion**

We have only touched the tip of the iceberg here and covered only a sampling of the wide spectrum of mathematicians and astronomers who illuminated the firmament of Indian science. The more we dig into the past, the more we find that the evolution of science in India is deeply interwoven with spirituality. Many scientists born in the Judeo-Christian traditions often rebel and breakaway from their religious roots as they find it impossible to reconcile religious dogma with their scientific pursuit. In contrast, we have many shining examples of mathematicians and astronomers like Āryabhaṭa who did not face such a conflict because Indic religions encouraged a spirit of free enquiry and did not draw a '*Lakṣmaṇa rēkhā'* between the secular and the sacred as in the West. From the life and works of these Indian mathematicians, we can safely surmise that the evolution of mathematics and astronomy in India with its unique methods, cannot be comprehended without an understanding and appreciation of the underlying religious, philosophical and spiritual framework of Indian Civilization.

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