

Ancient Indian Astronomy

लोकानामन्तकृत् कालः कालोऽन्यः कलनात्मकः
स द्विधा स्थूलसूक्ष्मत्वान्मूर्तश्चामूर्त उच्यते १०

Kinds of time. 10. Time is of two kinds ; the first (is continuous and endless which) destroys all animate and inanimate things (which is also the cause of creation and preservation), the second is that which can be known. This (latter kind of time) is also of two kinds ; the one is called MŪRTA (measurable) and the other is AMŪRTA (immeasurable, by reason of bulkiness and smallness respectively).

Surya Siddhanta 1.10

India is a land which has been the site of one of the oldest civilizations in the world and one of the few to yet retain elements of this old civilization. A lot has been said of this civilization, that its proponents were mystics , that they were scientists, that they were brutes, that they were philosophers, this document is but an attempt to view the people of this civilization as astronomers. These were a people who understood not only that the motion of planets was affected by the sun but also wrote extensively about it. Indian astronomers have been around since the 2nd millenium BC ,starting with Lagadha, who is credited with compiling of the *Vedanga Jyotisha*, better known as Indian astrology to the works of Achyuta Pissarati who wrote a treatise on eclipse predictions. I intend to present the combined knowledge of all these great minds in different spheres of astronomy. The intent of this work is to arrange the works which were mainly seminal into some sort of modern dialectic so that the world might know the quantum of knowledge in astronomy that India had.

The basis of astronomy in India starts with the association of the stars with celestial beings, who watch over the earth. It is generally assumed that Indians were illiterate and carried on an oral tradition of knowledge for a long time, right till about 4-5th CE . The most extensive works of these Indians is their philosophy of what is known as the *Vedas*. The *Vedas* seem to be a work which mostly deals with knowledge of nature and its relation to man, moving from archaic mountain gods to sophisticated rites involving sacrificial pits covering football fields. The *Vedas* with over 70,000 verses cover a range of topics from occult to spirituality and from astronomy to astrology. There are 4 primary *Vedas* a) The *Rg Veda* b) *Yajur Veda* c) *Sama Veda* and d) The *Atharva* or *Atharvana Veda*. These are estimated to be, at their earliest at least as old as 1500 BCE. The *Vedas* were written in the ancient Sanskrit language. All words which are not english in this treatise are from the sanskrit language. Typical references in *Rg veda* talk of the stars manifesting themselves on earth and interfering with the life of human beings. Later on, as we observe the literature, we notice the stars taking a less and less prominent position and observation and documentation of the planetary movements becoming dominant. We also notice the meticulous care taken in trying to make accurate observations.

The text of *Surya Siddhanta* written around 4 BCE is my primary reference, however I will refer to the *Rg veda* as and when the opportunity comes up. The *Surya Siddhanta* is a dialogue between the sage *Maya* and the representative of the Sun God. *Maya* desires the knowledge of astronomy and astrology. The sun in response deutes his representative to instruct *Maya* in such knowledge. The *Surya Siddhanta* talks of many topics starting with

The nature of Time (Siddhanta, 4 BC(1858 translation), pp. 1-13), **the motions of Planets** (Siddhanta, 4 BC(1858 translation), pp. 13-26), **eclipses and cosmogony of the hindu system.**

Indian astronomy starts with the fundamental idea in Indian thought, that of the connection between man and all creatures around him. Indian astronomy, like Indian philosophy, gives a form to all gross matter including stars and planets. It will be seen throughout the text that planets and stars are constantly referred to as *Devas* or the demi gods. This, however, does not necessarily imply that the texts are either mere mythologies or fanciful stories. Many times we find that there are precise mathematical concepts embedded very deeply in these stories. Most of these are relative symbols; for instance, the tripartite division of the cosmos into earth sky and space is similar to the tripartite division of psychology (Kak, 2000). The papers of Dr. Subhash Kak have been of extensive use to me in this work and I will be referring to his work as Kak.

Mostly the knowledge derived can be divided into 2 states, the pre *Siddantic* and post *Siddantic*.

The pre *Siddantic* era is mostly referenced from the *Vedanga Jyotisa* or Indian Astrology and references from the *Naksatra Vidya* of the *Chandogya Upanisad*. The *Upanishads* are philosophical extensions of the *Vedas*. The basic knowledge of Indian Astronomy is broken down in the pre *Siddantic* era as follows

1. *Rg Vedic* astronomy (c. 4000? - 2000 BCE)

Motion of the sun and the moon, *Naksatras*, planet periods. The start of this stage is a matter of surmise but we have clues such as Vedic myths which have been interpreted to indicate astronomical events of the fourth millennium BCE.

2. Astronomy of the *Brahmanas* (2000 - 1000 BCE)

Astronomy represented by means of geometric altars; non-uniform motion of the sun and the moon; intercalation for the lunar year; “strings of wind joined to the sun.” The *Vedanga Jyotisha* of *Lagadha* must be seen as belonging to the latter part of this stage. The text that has come

down to us appears to be of a later era. Being the standard manual for determination of the Vedic rites, *Lagadha's* work must have served as a “living” text where the language got modified to a later form.

3. Early *Siddhantic* and early *Puranic* (1000 BCE - 500 CE)

Here our main sources are the *Sulbasutras*, the *Mahabharata*, the early *Puranas*, the *Surya Siddhanta* and other texts. Further development of the *Sighrocca* and *mandocca* cycles, the concepts of *Kalpa*. According to tradition, there existed 18 early *Siddhantas* composed by *Surya*, *Pitamaha*, *Vyasa*, *Vasistha*, *Atri*, *Parasara*, *Kasyapa*, *Narada*, *Garga*, *Marici*, *Manu*, *Angiras*, *Lomasa (Romaka)*, *Paulisa*, *Cyavana*, *Yavana*, *Bhrigu* and *Saunaka*. Of these, summaries of five are now available in the book *Pancasiddhantika* by *Varahamihira*, and the *Surya siddhanta* has come down in a later, modified form.

The *Upanishads* and the *Vedangas* form an appendix to the Vedas, said to be compiled around the early part of 8th century BC. The *Siddhanta* period is the period after the work of *Aryabhatia*, the seminal work of the great Indian mathematician *Aryabhata*(476–550 CE). The interest in astronomy seems to have been generated with the widespread cultivation on the *Sindhu-Saraswathi* basin. The river *Sindhu* corresponds to the modern river Indus flowing through the region of modern Pakistan. This area is today identified as North-West Pakistan, the area of the excavation of the monoliths belonging to the civilization known as the Harappan civilization. It is speculated that this is indigenous *Sindhu-Saraswathi* basin peoples who moved out due to the sudden drying of the *Saraswathi* River. The importance to agriculture rests with the predictions of seasons and the planning of planting and sowing. Different motions of the moon marked different festivals and the related celebrations. For instance the year, beginning with the full

moon in the month Phalgunā (or Caitra or August), was divided into three four-monthly, *caturmasya*, sacrifices. Another way of marking the year is by a year-long *Diksha* (Learning period). The year was closed with rites to celebrate *Indra Sunasira* (Indra with the plough) to “obtain the thirteenth month;” this thirteenth month was interposed twice in five years to bring the lunar year in harmony with the solar year (Kak, 2000). This is also known as an *adhika masa* (Intercalary month).

The planets and stars

The ancient Indians seem to have developed a sense of matching the physical attributes of the celestial body with the motion of the body. For instance a slow object like Saturn was known as Sanischara or the slow one and even had attributes of general filth and even a popular color attributed to wickedness, black. The fastest bodies, the sun and the moon were given primary importance right from sacrifices, where the moon was the primary sacrificial agent in the form of the plant soma, to the central God in the Hindu pantheon as *Surya Narayana* or the sun God. The stationary stars were known as *Nakshatras* and the 27 principal *Nakshatras* were taken to be consorts of the moon. The point why 27 was taken is an interesting one, primarily this is taken to be the time in which the moon takes to make one complete rotation around the earth, but since the path of the moon follows the ecliptic, it was necessary that these “consorts” of the moon lie in the path assuming he spends a night with each one of them. This path was the ecliptic and the ecliptic has 12 distinct regions each on an average occupying 30 degrees, so when 27 is divided by 12 it breaks down into 2 and a quarter days which is then approximated as 2 per zodiacal constellation and a quarter of the next *Nakshatra* being in between. So the cusps were also accommodated in the Indian system.

Another interesting aspect is the fact that there is extensive documentation on how planets traversed the ecliptic. Each zodiac in itself was regarded as a "house" the planet visited, spent some time there and then moved to the next house. Also the relation between the "mythology" of planets and their actual observation seems to be related for instance Mercury is viewed as the son of the moon by Tara, the wife of *Brihaspati* Jupiter, or the *Naksatra Rohini* (Aldebaran), Venus as the son of *Bhrgu* and the priest of the demons, Mars as the son of the earth or *Siva*, Jupiter as the son of *Angiras* and the priest of the gods, and Saturn is seen as being born to *Revati* and *Balarama* or to Chaya and the sun. Saturn is described as the lord of the planets, lord of seven lights or satellites, and the slow-goer. Since the Indian calendar was reckoned according to the constellation at the Vernal equinox, one may assume the name son of Aldebaran implies that Mercury was first noted during the era of 3400-2210 BCE when the vernal equinox was in the Pleiades. (Kak, 2000)

Another interesting thing that (Kak, 2000) claims which I find also equally valid is the equation between Saturn and *Yama* the god of Death. The fact that *Yama* is the "dual" God is actually the dual to the lunar cycle of 354 days to the solar cycle of 366 days is 378 days. Thus we see that embedded in the mythology of the moon and the planets seems to be actual observations.

Mercury is also associated with the God *Vishnu* (Rig, 1896, p. 1.154) with another interesting story has *Vishnu* measure the length and breadth of the sky with his three steps each one covering the earth, the heavens and the final step landing on the head of *Bali*, the demon king. This seems to correspond as (Kak, 2000) states with the 3 rotations of a synodic period of 118 days of mercury with the 354 days it takes for a solar year. This also seems to correspond to the 261 sky days, i.e 3 rotations of mercury of 87 days.

Time and the physics of it

The Indian astronomers seem to have had a conception of time which was fairly sophisticated. They seemed to understand that time is but a relative concept subject to the fact that moving bodies exist. As is evident from the quote at the beginning, they speak of the metaphorical time of passing and the actual time which is but a consequence of moving bodies. They also seem to have had a conception of the measurement of time. The Indians measured time with the breaths, with each breath being correlated with half *nimesha* and so on. They managed to reach a *ghatika* which is about 23.5 minutes in today's time. They theorize (Siddhanta, 4 BC(1858 translation)) that the 60 *ghatikas* make a *nakshatra ahoratra*. Thirty such *ahoratras* make what is called a *nakshatra masa* or a month. The Indians distinguished between the lunar and solar month to call the solar month a *savana*. A solar month was calculated on the basis of the time the sun took to move from one zodiac to the next. A completion of movement along 12 such zodiac constellations was said to make a year, a *samvatsara*. There were specific numbers attached to this month of the sun for instance 51,840,000 such months were said to constitute a *yuga*, which were 4 in number. There seems no logic attached to this number itself, nor does it seem to be a priori. The specific nature of the number does raise some interesting questions. Numbers like this also lead to some interesting coincidences. One seems to be the reference to the speed of light made by *Sayana*, a minister in the court of Bukka –I the king of the Vijayanagara Empire (CE 1315-1387). This was a large and prosperous Indian Empire in the modern state of Karnataka. In his commentary on the fourth verse of the hymn of the *Rg Veda*

tatha ca smaryate yojananam.sahasre dve dve 'sate dve ca yojane ekena nimisardhena kramamn. (Rig, 1896)1:150 (Chapter 1 Verse 150)

Thus it is remembered: [O sun] you who traverse 2,202 *yojanas* in half a *nimesa*.

A *yojana* is approximately calculated to be 9.1 miles in length. A *nimesha* can be approximately worked out to 16/75 th of a second. Doing further calculations we actually arrive at a figure which is very close to 186,000 miles! Obviously this is but a lucky coincidence as (Kak, 2000) claims but it does seem intriguing that there should have been such an amount of number crunching at so early a time in history.

The constellations

The Vedic peoples seemed to have a system to identify *nakshatras* with constellations by a method of cross reference. There seem to have been lesser importance attached to the constellations by themselves as unrelated to the *nakshatras*, but as we see later they form parts of many a story which seems to connect with the time of occurrence rather than an event by itself. The *Rg Veda* talks of the 34 lights which seem to refer to the sun, the moon and the 27 *nakshatras* and later this number was increased to 28 including *Abhijit* or Vega. Constellations other than the *Naksatras* were also known; these include the *Rksas* (the Bears), the two divine Dogs (Canis Major and Canis Minor), and the Boat (Argo Navis). *Aitareya Brahmana* speaks of *Mrga* (Orion) and *Mrgavyadha* (Sirius). The moon is called *Suryarasmī*, one that shines by sunlight (Kak, 2000). The *Satapatha Brahmana* is one of the addendums to the Vedas. It provided a number of astronomical references. The sixth chapter of this book talks of creation under *Prajapati* (Lord of man) and mentions the emergence of *Asva*, the horse, *Rsabha*, the goat, *Aja*, the unborn, and *Kurma* the tortoise. These seem to be completely unrelated to each other; however (Kak, 2000) argues that these refer to the Sun and the constellations of Gemini, Capricorn and Cassiopeia. This is from the etymological considerations where *Kurma* is

connected to *Kasyapiya* and references in the *Rg Veda* where the *Asva* is identified with the sun. *Rsabha* literally means twin asses, defined as *Asvinau* which later usage points to Castor and Pollux of Gemini. As we have already seen the movement of planets along the ecliptic was marked out as a path along constellations. It may seem reasonable at this stage to say that Western Astronomy seems to influence Indian astronomy. But this will be a very *prima facie* assumption. I will go on to show that this identification seems to have existed long before the formal constellation theories put forth by Plato in 5th -4th BCE. *Aryabhata*, *Varahamihira*, two of the most renowned astronomers from India and others used the *naksatra* references that the *Saptarsi*(The Great Bear) were in *Magha*(Widely accepted to be Regulus in Leo) at the time of the Great *Mahabharata* war to determine its epoch. The Great War in the *Mahabharata* is said to have taken place in the plains of modern day Uttar Pradesh in India costing the lives of over a million people. *Aryabhata* declared the war to have occurred in 3137 BCE (the Kali era begins 35 years after the war), and *Varahamihira* assigned it 2449 BCE. It has been suggested that this discrepancy arose because the change in the number of *naksatras* from the earlier counts of 27 to the later 28 was differently computed by the two astronomers. There are also references of Saturn coming in conjunction with Aldebaran at the start of the Great War which also seem to indicate that the war was fought around the same time

To summarize I would like to suggest that there seems to have been a great amount of work put into the astronomical details mentioned in the text. There also seem to have been measurements made in early Indic tradition of the radius of the earth and the distance of the sun and the radius of the sun. There also have been a number of places where the masses of the planets have been specified in relation to the earth (Kak, 2000). These have been used in sacrificial offerings and even while constructing altars. Houses have been constructed keeping in mind the constellation

at right ascension i.e rising at a specified sun position. Horoscopes accurate for thousands of years were cast which accounts for precessions, which clearly shows the advanced and sophisticated nature of their observations. There also seems to have been distinctions regarding the size of the universe in general and the limits of the planets. The planets and the stars seem to limit only the visible universe, both philosophically and physically, there seems to be a train of thought which tells us that the Indians believed there was more than that meets the eye. In fact the *Puranas* account for nearly 13-16 times the size of the universe relative to the solar system. Concepts of universes swirling in a vortex of *maya* seem to be a common refrain in philosophy. All in all I believe there is a lot more to Indian cosmology than what meets the eye, let alone what I have expounded here. Given proper time and research I am certain we can recover a great body of information

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