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AN ACCOUNT OF INDIAN ASTRONOMICAL HERITAGE FROM THE 5th CE to 12th CE

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ABSTRACT

Astronomical observation is the beginning of scientific attitudes in the history of mankind. According to Indian tradition, there existed 18 early astronomical texts (siddhantas) composed by Surya, Pitamaha and many others. Varahamihira compiled five astronomical texts in a book named panchasiddhantika, which is now the link between early and later siddhantas. Indian scholars had no practice of writing their own names in their works, so, it is very difficult to identify them. Aryabhata is the first name noticed, in the book Aryabhatiya. After this point most astronomers and astro-writers wrote their names in their works.

In this paper I have tried to analyze the works of astronomers like Aryabhata, Varahamihira, Brahmagupta, Bhaskara I, Vateswara, Sripati and Bhaskaracharya in a modern context and to obtain an account of Indian astronomical knowledge.

Aryabhata is the first Indian astronomer who stated that the rising and setting of the Sun, the Moon and other heavenly bodies was due to the relative motion of the Earth caused by the rotation of the Earth about its own axis. He also estabished the 'yuga' theory (one Mahayuga = 432000 years). Varahamihira compiled panchasiddhantika and wrote Brihatsamhita. Brahmagupta is the most distinguished astronomer known to us. His two major works are i) Brahmasphutasiddhanta and ii) Khandkhadaka. Bhaskara I was the follower of Aryabhata. His three known works are Mahabhaskariya, Laghubhaskariya and Aryabhatiyabhasya. Vateswara follows Aryapaksha and Saurapaksha. His master work is Vateswarasiddhanta. Sripati, in his siddhantasekhara, gives the rules for determining the Moon's second inequality. Bhaskara II wrote the most comprehensive astronomical work in Indian astronomy. The result of these works is the account of the Indian astronomical heritage. These works are written in the Sanskrit language. A very few of these manuscripts have been translated in English but many are yet to be done. So, it is necessary to translate these astronomical texts into English with proper commentary for modern scholars. This paper will be helpful in this work.

Key words: proper commentary, relative motion of earth, siddhanta, yuga

1. INTRODUCTION

Vedic texts are the oldest literature of astronomy, divided by contents and chronology into four; the Samhitas, Brahmanas, Aranyakas-Upanisads and Vedangas. The Rigveda is the oldest and most important of the samhitas. The Yajurveda is of two types; Sukla (white) and Krisna (black); both contain a large number of verses interpreting contemporary knowledge including astronomy. Samveda and Atharvaveda are another two samhitas containing similar content to Rigveda, as well as medicine. The important Brahmana texts are the Aittiriya, Satpatha, and Taittiriya; containing astronomical knowledge belonging to the Vedic age. According to D. Pingree, Brahmasiddhanta, an astronomical text is included in Vishnudharmottarapurana. The Vedic people recognized two types of knowledge; inferior knowledge (aparavidya) and superior knowledge (paravidya). To find the right time for religious, agricultural and other social festivals, for recording of recurrence of repeated events from movement of planets, Moon, seasons, etc. paravidya was applied. Many religious festivals in India are still found to be associated with the phases of the Moon (tithi). India, like Egypt and Mesopotemia, originally had a lunar calendar in the time of the Indus civilization. In Vedic times, rectification started, and the Sun gradually assumed greater importance. Consequently, the attempt in the Vedic period to associate the lunar months in a more or less fixed fashion with the agricultural seasons led to the development of a luni-solar calendar. Various mathematical and trigonometrical tables were formulated for better results, but it took a long span starting from remote antiquity up to the advent of the siddhantic texts.

Vedanga Jyotisha is the first complete astronomical

text in Indian astronomical tradition. At the time of composition of this text, the winter solstice was at the beginning of the constellation Beta-Delphini and the summer solstice was in the middle of the Hydrae constellation. According to Varahamihira's statements, Vedanga Jyotisha was composed between the 12th and 14th century B.C.E.; specifically 1350 B.C.E. It consists of a 5 year yuga system containing 67 lunar sideral years, 1830 civil days, 1835 sideral days, 62 synodyc months, 1860 tithis, 135 solar naksatras, 1809 lunar naksatras and 1768 risings of the Moon. Sulbasutras are the manuals for the construction of altars, which are important for religious rituals. The Indian name for geometry was Sulba. The term Sulba has four meanings: 1) mensuration, 2) line of surface, 3) a measure–the instrument of measuring, and 4) geometry–the art of measuring. The Sulbasutras were compiled in the 5th to 4th B.C.E. The astronomical computations described in the Vedanga Jyotisha were in practical use for a very long time. Around the beginning of the Christian era, a new type of astronomical literature, called Siddhantas (decisions), emerged. These texts contain much more material and topics than the previous, Vedanga Jyotisha.

The characteristics of early siddhantic texts are: i) Along with nakstra system, the twelve sign of the zodiac were introduced. ii) A precise value for the length of the solar year was adopted.

Computations of the motions of the planets, the solar and lunar eclipses, ideas of parallax, determination of mean and true positions of planets and a few more topics formed the common contents of Siddhantic texts.

These siddhantic texts adopted more sophisticated mathematics, incorporated the planets into the system, devised a system of coordinates for the determination of the periods of the planetary revolutions, etc. According to tradition, there existed 18 early siddhantas composed by Surya, Pitamaha, etc. Most of these have been lost, but five are available in summarized form in the Panchasiddhantika, compiled by Varahamihira. The latter siddhantas followed the general pattern of earlier siddhantas but in developed form. These siddhantic schools came to be popular in different parts of the country, due to different practical manuals, astronomical tables, and description of instruments.

2. MAIN CONTRIBUTORS TO INDIAN ASTRONOMY DURING THE 5th to 12th CE

2.1. Aryabhata I (b 476 CE)

Aryabhata was the pioneer of modern mathematical astronomy in India. The Aryabhateeyam (Aryabhatiya) was a popular work and was studied throughout India. It was mentioned by Varahamihira of Kapitthaka (near Ujjain) in the sixth century, by Bhaskara I of Valabhi (near Kathiawar) and Brahmagupta of Vinmal (in Rajasthan) in the seventh century and by Govindasvami of Kerala in the ninth century. The Aryabhatiya measured the day from one sunrise to the next, where in his other work Aryabhata siddhanta measured the day from one midnight to the next. The astronomical parameters obviously differed because Aryabhata I, as observed by a few scholars, wanted to improve them on the basis of his observations. Aryabhata I's rules are very short and cryptic in style. The knowledge is codified systematically in this text for the first time into two major sections, ganitapada (mathematical section including geometry) and golapada (celestial sphere section dealing with astronomy). The elementary results of course are given in two other sections, gitikapada (elementary data on astronomy and sine table) and kalakriyapada (section on reckoning time). Aryabhata I's fundamental operations in arithmetic, like square, squaring, cube, cubing, square root and cube root are unique in the ganitapada. In the astronomy part, Aryabhata I says that he does not believe in the theory of creation and annihilation of the world. For him, time is a continuous process without beginning or end. In modern time the basic of steady state theory of cosmology makes such a statement. Aryabhata I's theory on the helical rising and setting of the planets is like so: "when the Moon has no latitude, it is visible when situated at a distance of 12 degrees (of time) from the Sun. Venus is visible when 9 degrees (of time) distance from the Sun. The other planets, taken in the order of decreasing sizes, are visible when they are 9 deg. (of time) increased by two".

2.2. Varahamihira

Three major works of Varahamihira are the following;

a) Panchasiddhantika, b) Brihatsamhita, c) Brihat Jataka.

In the Panchasiddhantika, five siddhantas are included – Paulisa, Romaka, Vashishta, Surya and Paitamaha. The rule of computing eclipses is very vividly explained.

2.3. Brhamagupta

Two well-known works are:

a) Brahmasphutasiddhanta, b) Khanda Khadyaka.

Brahmagupta is respected for his remarkable boldness and insistence on observational verification and accuracy of results. Parallax in modern astronomy is known as lambana in Indian astronomy. Brahmagupta's method of computing lambana is based on evaluating five Rsines. In eclipse calculations, the difference lambanas of the Sun and the Moon are required and as such sometimes this difference is called lambana. Al Biruni recognizes Brahmagupata's contribution to astronomy especially in respect to eclipses.

2.4. Bhaskara I

He composed mainly three works;

a) Mahabhaskariya, b) Laghubhaskariya and c) Aryabhatiya bhashya.

In addition to these, another part exists containing a general introduction including the life and works of Bhaskara I. He is the follower of Aryabhata I and his works provide us with a detail exposition of the astronomical methods taught by Aryabhata I.

2.5. Vateswara

As a follower of Aryabhata, Vateswara compiled Vateswara Siddhanta, composed of all contemporary knowledge of astronomy. He became famous as a critic of Brahmagupta. Vateswara consulted the works of earlier writers and utilized their contents but it should not be inferred that everything that Vateswara gives in the Vateswarasiddhanta is derived from the anterior works. There is plenty of material in this text which is original. The other characteristic of this book is the sequence of the contents. It is mostly Vateswara's own contribution.

2.6. Bhaskaracharya

He is the last astronomer and mathematician of the classical age of Indian astronomy. His masterpiece Siddhantshiromoni consists of four parts; Lilavati (arithmetic), Bijaganita (algebra), Grahaganitadhyaya (mathematical treatment of planets), Goladhyaya (celestial knowledge). In addition to the Siddhantsiromoni he wrote another four books; Karankutuhal, Srvatobhadrayantra, Vasishthatulya and Vivahapatal. The three books are not found today. All the books are written in verses. In Siddhantsiromoni, 1500 Sanskrit verses explain contemporary astronomical knowledge. In the mathematics part the author has not given any direct proof of any theorem. These are included in the problems. Lilavati was the most famous book on mathematics at that time. Lilavati and Bijganita were used as standard text books for next 600 years throughout India. Many scholars wrote commentaries on these books. Lilavati was translated into other languages such as Persian and English. Bhaskaracharya has given the names of all the numbers in multiples of 10. These books can be understood by students of twelfth standard but in siddantsiromoni, grahaganitadhyay or goladhyay chapters cannot be understood without basic knowledge of astronomy. Bhaskara had a special interest in astronomy as these two chapters (books) together have 1000 verses. He was not only a theoretical astronomer but expert sky-observer. For smooth sky observing he developed astronomical instruments included in goladhyay. The names of the instruments are Gola, Nadivalaya, Yasti, shanku, Ghatica, chapa etc.

3. CONCLUSIONS

This period 5th CE to 12th CE was the golden age of Indian astronomy and mathematics, starting in the year 500 with Aryabhata and ending with Bhaskaracharyain in the year 1200 CE. Therefore, this account may be helpful to further knowledge of this period. After this period Indian knowledge started to decline rapidly; Nalanda University was destroyed and there was not a single university in India over next 600 years. The history of Indian astronomy is not suffering for lack of sufficient literature. We have a huge number of documents in the Sanskrit language. These are being translated into English, but a lot is needed to be done. The classical period is the golden era for Indian astronomy. This account is not sufficient but a hint only.

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