INDIA'S CONTRIBUTION TO ASTRONOMY – RELIGIOUS AND HISTORICAL BACKGROUND

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In the dawn of civilisation people must have had a rudimentary knowledge of time and space, and all the ancient scriptures regarded the universe as consisting of a flat circular earth below and a heaven above through which the sun, the moon, and the stars move. Between them was the middle air, the abode of clouds and demigods. This cosmological picture was considerably changed by later religious thought, but the heavenly bodies were still worshipped as gods. In India the Rig Veda mentions that observatories were erected for astronomical purposes, as the practice of sacrificial rituals demanded the setting up of altars for religious performances, and therefore some astronomical knowledge was necessary for determining the propitious times and dates for periodic sacrifice. Thus some astronomical knowledge became necessary. Like the Babylonians and the Greeks, the Indian priests also kept detailed records of the rising and the setting of various celestial bodies, and thus established a kind of calendar; but without a clear idea of cause and effect. It was but natural that Divine Will was recognised, and the heavenly bodies were regarded as gods. A general belief in astrology was the natural consequence.

During the Upanishadic period, the Brahmana, and the Aranakya periods even those philosophers like Kanada, Gautama and Charvaka whose motives were scientific rather than religious were hardly in a position to drive their speculations home to the point of proof against their scriptures. They tried to get their ideas stated in a consistent and plausible form and had to see how far the results tallied with the experiments of common experience. Considerable progress was made in their observations of the heavens and the inexorable mathematical laws and rational science gave greater prominence to astronomy than astrology. Heaven was, however, still regarded by most people as a place where gods had their abode; and without a systematic layout of planets and stars there could not be any great progress in astronomy and the original rational impulse behind enquires into Nature began to evaporate and disappear. If the planetary system had been properly worked out, and scientific reasoning and the worship of natural laws given preference against the semi-human divinities of the sky, the universe would have been regarded as a vast organism cemented into a coherent unity by sympathetic forces, with Nature as the guiding principle, and the celestial bodies as its purest expression. Instead, the astral religion,

specially of Greece and Babylonia, kept its hold; and a proud and long tradition of astrology was maintained intact. Astronomy was made more subservient to it than to physics.

As time rolled on, the system of astrology in India reached its scientific maturity and began to be regarded as a social science, and astronomy a natural one. It has been argued that since astrology deals with material things, it is bound to
be imperfect owing to human frailty; but astronomy gives clear-cut results and hence is reliable.

Foreign Contribution

In the domain of astronomy the Egyptians claim to be first people who divided days and night into twelve hours and invented water-clocks which they used specially in the night for knowing the time. They used sun-clocks during the day, but in astronomical observations they hardly made any progress. The Babylonians, however, went much further. They invented an improved form of clock known as the water-clock by collecting water from one sunrise to another and by dividing the water into equal parts. It is not clear why a day and night of twelve hours each and not of eight or ten hours were taken. Apparently a compromise was made and the sexagesimal division of the Babylonian units was combined with the Egyptian twenty-four system. They made more progress, observed and recorded the apparent motions of sun, moon and the planets, but hardly formulated any theory to account for their movements. It is here where the Greeks and the Indians showed their geniuses.

Anaxagoras, who was born about 500 B.C. near Smyrna, left his possessions in order to study science and went to live at Athens. It was he who first discovered* that the moon has no light of its own, but shines by reflecting sun's light. With Anaximines he correctly accounted for the eclipses of the sun and the moon. He also gave some fruitful ideas about the nebular hypothesis on which our present cosmological theories are based. He, at the same time, conceived that there are other worlds like ours; but apart from these ideas he hardly made any advance upon the crude astronomy of his time. Both Leucippus and Democritus, who formulated the atomic theory followed the views formulated the atomic theory followed the views of Anaxagoras and made in advance in the astronomy of their time.

About half a century later, Aristotle supported Eudoxus and Callippus and regarded the universe as spherical in shape and finite. It was about 200 B.C. when Aristarchus (310-230 B.C.) first gave the heliocentric idea of the astronomy of his time.+ The historian Plutarch says that for giving a pagan's hypothesis of our universe he should have been indicted for impiety; but since the leading mathematicians of his time like Archimedes and Seleucus did not preach against him, no action was taken. Perhaps nobody cared to know his impious declaration.

It was however Hipparchus who totally discarded Aristarchus's heliocentric hypothesis and adhered to the prevalent geocentric system. He

In India Aryabhatta conceived that same idea of the planetary system, but he did not dare go against the general belief of his time.

+ The present writer does not think that either Aristarchus or Copernicus got the heliocentric idea from India; but Heracliedus of Pontus was certainly foreshadowed.

made accurate observations of the heavens, his greatest achievement being the discovery of the Precession of the Equinoxes. He also calculated the length of the year as 365- days. Based on his extensive observations Ptolemy, who wrote his famous Almagest in about 150 A.D. held the field till the time of Copernicus who later supported by Galileo, Kepler and Newton, changed the entire conception of the universe.

Later Development

Aryabhatta I was perhaps the first mathematician who, having based his ideas on the teachings of the sage, Parasara, propounded his astronomical system but the author of the extant Aryabhatta that deals specially with mathematics and astronomy, is likely to be another Aryabhatta whose astro-mathematical works, known as Arya-Siddhanta, lived at the end of the fifth century A.D. He was a great inventor who boldly discarded all astrological predictions and sought to reform astronomy on scientific principles.

It may be mentioned here that Aryabhatta, like Aristarchus of Samos who had boldly rejected Eudox's vortex idea, maintained the idea of the rotation of the earth round its axis and gave the idea that a similar phenomenon would happen if the sun was regarded stationary at the centre, and the earth and other planets were to revolve round the sun. His estimate of the earth's circumference was not very wide of the mark. For the purpose of calculations, however, the planetary system was taken as geocentric and the later astronomers accepted this idea.

The younger Aryabhatta was followed by Varahamihira who was probably born in the beginning of the sixth century A.D. He was an all-round scientist who wrote several well known works of which the Pancha Siddhanta treats both astrology and astronomy that include the computation necessary for finding the position of a planet. He discussed the sphericity of the earth and subsequent astronomers followed him. Alberuni translated two of his works into Arabic in 1000 A.D.

It is said that while summarising his astronomical theses, he was helped by some Scythian Brahmans who were well versed in Babylonian and Greek astronomy. It is very speculative on our part to say how far the great Indian astro-mathematician received his astronomical information from the Middle East countries. It is also possible that the same type of ideas has originated in different countries much at the same time, as we find in the case of the independent discovery of oxygen in different Western
countries – France, England and Sweden.

Another prominent Indian astronomer was Brahmagupta (born 628 A.D.) who lived at Ujjain, then a great astronomical centre of India. It is said that unlike his great predecessor of encyclopaedic knowledge, he was a more original thinker who separated astronomy from astrological speculations although he had made various astrological charts and reformed astronomy on scientific lines. It is recently said that he invented the quadrant (Turya Yantra) for astronomical observations and applied algebra to astronomical calculations. In a few decades the Caliphs of Bagdbad made use of this scientific invention in their astronomical

observatories.

A few centuries later, although the Medieval Age had set in India, there was born in 1114 A.D., a world-renowned astro-mathematician of prodigious scholarship, popularly known as Bhaskaracharya, who also worked at Ujjain. His treatise, known as Siddhanta-Siromani, contains: (i) astronomy, (ii) arithmetic and mensuration known as lilavati and (iii) bijaganit (algebra). In his studies on the earth he gave its diameter as 7905 miles and mentioned its attractive power, thus forestalling Newton by several centuries. He also determined with considerable accuracy the positions of the sun, the moon, and the planets in terms of their positions on March, 19 1520.

Like the Buddhist monks there was a host of Indian astronomers who did missionary work in Middle East countries. For instance, patronizing the Persian school of astronomy, the Second Caliph, Al-mansur, in 723 A.D., invited to his court the renowned Indian astronomer, popularly known as Manaka, who gave various tables of equitations of planets according to their motions with observations relative to both solar and lunar eclipses, as well as the ascension of the signs. It is also said that the illustrious astrologer, Abu Mashar of Balkh, depended much on another Indian astronomer well-versed in the science, learnt from him the great cycle of 'kalpa' and applied it for his astrological calculation. Besides, Brahmagupta's two well known astronomical works, Brahmanasphuti Siddhanta and Khandakhadyaka, were translated into Arabic and named as Sirhind and Arkand. They exercised great influence in imparting scientific knowledge of astronomy in the country, and the great mathematician, al-Kanaurizi, further developed the Indian astronomical system in his country. A few years later another Saraconic mathematician, al-Kindi, laid stress on the used of Indian numerals and astronomical tables. The Third Caliph, Harun-al-Rashid, set up a House of Wisdom for the translation of Greek and Indian works the chief translator being the Nestorian Hunaya-ibn-Ishaq (809-877 A.D.) and also founded an astronomical observatory at Baghdad with the help of Indian astronomers.

For a few centuries however, Baghdad remained the great centre of mathematical and astronomical studies. Religious tolerance and official patronage keep alive an active interest in Nature; but her golden days did not last long, for the Mongols soon overran the Middle East, and in the twelfth century sacked Baghdad. From the thirteenth century onwards, Mohammedan power began to decline, and rational enquires in science and philosophy were condemned as corrupting the truths of Islam. The scientific tradition in the Sarcacentic countries began to dwindle and their knowledge was taken to Europe.

Like her renowned neighbour, India's days of glory were also numbered, and although, for some centuries, great mathematician, and astronomers like Bhaskara made valuable contributions, their outlook was, like Newtons, chiefly theological. In the thirteenth century practically the whole of northern Indian was overrun by the bigoted Pathans, and the educational institutions like Nalanda and Vikramashila were razed to the ground. Like the Islamic world India also sank into oblivion.

Generalisation

The Early cosmology in India, like that of Greece in her golden age (500-300 B.C), took the form of dramatic historical fables known as Puranas. In the beginning, the heavenly bodies were regarded as gods, but during the later period attempts were made to explain the structure and behaviour of the heavenly bodies in scientific terms. The Upanishads put forward theories of natural happenings and have thus laid the foundations of philosophical science. As a result the different schools which started in with vague ideas of creations gradually brought general scientific theories into precision; but unfortunately, scientists like Patanjali gradually lost faith in themselves, and their methods of thought changed direction. They began to doubt more and more if scientific enquiries along could unfathom the workings of the universe, and gradually the centre of gravity shifted from natural philosophy to unaccounted Divinity. The heavenly bodies thus again came into prominence and because objects of worship, as they had been before in Egypt and Babylonia. Astronomy thus became more subservient to astrology than to physics and dynamics. As a result, a sophisticated kind of heaven-worship began to replace the rational speculations about Nature, and a faith in divination began to revive; but in India the spirit of rational investigation soon returned a few centuries after the Chritistian era, and her astronomers showed definite superiority over her celebrated rival (Greece) in calculating the solar year and in recording the progress of the moon through the sky with an accuracy which was not surpassed until the seventeenth century A.D. In 1787, J.S. Bailley* published his treaties about the great antiquity of the Hindu astronomical system. He believed that their calculations, made from time immemorial, were infinitely more exact and natural than those of Ptolemy: and that the Greeks of Alexandria had profited by the Indian thoughts, but had mutilated their results. Bentley, on the other hand, holds a different view.

For the purpose of astronomical calculations the planetary system was taken as geocentric, although it was suggested in India long before Aristarchus that the earth revolved round the sun and also rotated round its axis. The true cause of solar and lunar eclipses were also properly explained, and the occurrence of both the eclipses were forecast with great accuracy. The later astronomers like Varahamihira, Samudragupta, and Bhaskar also accepted the heliocentric idea, but did not bother to preach it to the public. In short, the Indian astronomical formulations were more reliable than those of the Graeo-Roman world for all practical purposes.

Conclusion

In summarising it may be stated that unlike the Babylonians and the Egyptians who only cared for the continuity of their astronomical records for the maintenance of a reliable calendar, the Indians of antiquity went deep into the matter and tried to theorise all the natural phenomena which they had come across. Their astronomy has three definite phases: (a) Vedic Astronomy, which is unscientific, (b) Vedanga, Jyotisha which is formal but crude;

*Jean Sylvain Bailley was the first mayor of Paris and President of National Assembly in 1789. He was born in 1736 and guillotined in 1793.

(c) Siddhanta Astronomy, which is highly intellectual. No doubt, some of the astronomical problems of the present time were not clear in those days; but the Indian astronomers did lay the foundation, the generalisation on which during the sixteenth and seventeenth centuries became the main feature of the rapid development of astronomy in the West. To be brief, astronomy and mathematics led the way and physics followed it in the seventeenth century. Chemistry moved forward in the eighteenth century, biological sciences in the nineteenth, and atomics science in the twentieth century.

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