Research paper

# **ASTRONOMY AND MATHEMATICS IN ANCIENT INDIA**

**Geo Jolly Cheeramvelil**

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**Abstract**:

Ancient India was well advanced in the fields of mathematics and astronomy. It was highly developed at that period. Ancient Indians contributed immensely to knowledge in maths as well as astronomy. It is clear that most of the modern theories were well known to Indians. But why didn’t they achieve a position they deserved? Is our knowledge on Indian contribution to astronomy and mathematics limited ? This study is a descriptive type of research based on secondary data gathered from Indian ancient books, epics, articles, websites, and web-based journals.

**Keyword :** Astronomy, mathematics, India, Astronomers.

1. **INTRODUCTION**

Indian mathematics and astronomy had a long history which originated from the prehistoric era. Indian mathematics had its classic period during 400 AD to 1200 AD when Aryabhata, Brahmagupta, Bhaskara II, and Varāhamihira. Made valuable contributions. The decimal system we use today was first recorded in Indian mathematics. They made early contributions to many concepts like zero, number theory, arithmetics, algebra and so on. Most of the mathematical concepts we developed were spread to different parts of the world and subjected to further developments and formed the foundations of many areas of mathematics, physics and so on.

Indian Astronomy was developed during 1500 BCE associated with the studies of Vedas. One of the oldest astronomy texts, Vedagana Jyotisha, dates back to 1400-1200 BCE. Indian astronomy was influenced by Greek astronomy during the beginning of 4th century BCE. Yavanajataka and Romaka Siddhanta can be considered as examples as they are Sanskrit translations of greek text.

There was active development in astronomy and mathematics during those periods especially within Kerala school of astronomy and mathematics.

**Time Period :** Astronomy was developed during the period of Indus valley Civilization. Mathematics was highly developed during the 400 AD to 1200 AD.

1. **RESEARCH QUESTION**

How did Indian society influence modern mathematics and astronomy?

This research mainly aims to find the influence of Ancient Indian Society in the fields of modern mathematics and astronomy. Though we were able to find many valuable theorems and inventions, due to lack of proper documentation skills and invasion of the west made it slip from our hands. This research looks into main theorems and inventions that Indians developed and lost credits and how those findings influenced the present world.

1. **METHODOLOGY**

The study is based on secondary sources.

**Source of Data :** Data’s are based on certain books, articles, websites and journals published on the web.

**Analysis :** Different materials collected are analysed, verified and systematically came under an appropriate conclusion.

1. **ASTRONOMY AND MATHEMATICS IN INDIA**

We have discussed and invented many things which are not known to most of the people in the world including Indians. We had a deep knowledge in mathematics and astronomy.

**Mathematics**

Mathematics in ancient India during its early stages, developed mainly along two broad geometric and the arithmetical and algebraic.The remarkable progress made by Indians in mathematics is now well known, and it is widely acknowledged that the roots of modern arithmetic and algebra were formed in India many years ago. Excavations of Harappa and other sites of Indus valley civilization showed evidence for use of practical mathematics in India. Numerous texts and works were produced in India. Ancient and medieval Indian mathematics were mostly composed in Sanskrit. They were able to develop many important theories and also worked in development in series expansion of trigonometric functions.The religious texts that belong to vedic period provide the evidence for the usage of large numbers by Indians. By the period of Yajurvedasamhita around 1200–900 BCE, numbers as high as 1012 were being included in the texts and works. For example, the mantra or sacred recitation recited at the end of the annahoma aka "food-oblation rite" performed during the asvamedha, and uttered just during-, before-, and just after sunrise, invokes powers of ten from a hundred to a trillion. The Arabs gave Europe its early arithmetic and algebra—hence the term "Arabic numerals"—but the Arabs had taken them from India. Even before the official embassy transported books to Baghdad, it appears that some knowledge of Indian mathematics, particularly the place-value system of numbers, had made its way into Western Asia. In India, the introduction of zero and the decimal place-value system opened the door to fast development in arithmetic and algebra.

**Vedic Mathematics**

## **Jain mathematics (400 BCE – 200 CE)**

Although Jainism is a religion and philosophy, the great Mahavir Swami predates its most famous exponent, (6th century BCE), most Jain Texts which are related to mathematical work were composed after the 6th century BCE. Jain mathematicians are important historically as they are the crucial links connecting the mathematics of the Vedic period and the modern / classic period. The significant and most important historical contribution of the Jain mathematicians lies in the freedom of Indian mathematics from the constraints like religion and ritualism .

## **Oral tradition**

Mathematicians of ancient India were mostly comprised of Sanskrit Pandits (Pandit means learned man) who were trained and excelled in Sanskrit language and literature, and had common knowledge in grammar like vyakaranam, exegesis (mimamsa) and logic (nyaya).Memorisation of sruti / what is heard through the mean recitation played a major role in the transmission and spreading of sacred texts in the ancient India. Memorisation and recitation played a major role in transmitting the philosophical and literary works, and also the treatises on ritual and grammar. Modern scholars of ancient India have noted the "truly remarkable achievements of the Indian pandits who have preserved enormously bulky texts orally for millennia.”

**Important Works**

* Trigonometric functions.
* Chhedi Calendar.
* Quadratic equations
* Value of pi (accurate to 4 decimal places).
* Spherical trigonometry.
* Continued Fraction.
* Accurate astronomical constants.
* General solutions for linear equations.

**Famous Mathematicians**

These are the main contributors and contributions to the world by Indians.

1. **Baudhayana**

He was one among the most brilliant mathematician who lived in the Indian. Several Concepts he invented were later rediscovered by Europeans. He was able to calculate the value of pi by himself. The Pythagorean theorem is considered as one of the most important theories and is placed in the top 10 theories ever. But Baudhyan found the theorem several years before pythagoras found it and it was found in Baudhyan’s Sulva Sutra.

1. **Aryabhatta**

He was a fifth century mathematician, astronomer,astrologer and physicist. At the age of 23 he wrote Aryabhattiya which had 4 sections which describes methods of denoting numbers by alphabets, second one contains number theory, geometry, trigonometry and algebra.Rest were on astronomy.

He showed zero was not only a numeral but also a concept.

1. **Brahmagupta**

He was able to take mathematics to new heights during the 7th century. He introduced negative numbers and operations on zero into mathematics. He wrote Brahma Sputa Siddantika. This book helped Arabs to know our mathematics system.

1. **Bhaskaracharya**

He was born in Karnataka. He wrote Siddhanta Shiromani which contains four sections. It contains Algebra, Arithmetic , Goladhyaya and Grahaganit. He introduced a cyclic method to solve algebraic equations. This was rediscovered by Europeans and renamed into ‘inverse cycle’.His work was translated by James Taylor and made his work well known.

1. **Mahaviracharya**

A Jain guru during (500 BC-100BC). Jain gurus know how to solve quadratic equations. They have also described fractions, algebraic equations and so on. He founded the current LCM solving method. Thus long before John Napier introduced the method was known to Indians.

Ancient Indians made significant developments in several frontline areas of mathematics . The indian contributions in arithmetic trigonometry and algebra were transmitted by Arabs and Persians to Europe.

**Astronomy**

The main aim behind Indian astronomy was to have an accurate calendar, a better understanding of climate and rainfall patterns for farming, fixing seasons and festivals, navigation and so on. Knowledge in astronomy helped in trade as it requires crossing oceans and deserts. At a period when the Greeks were still utilising celestial crystal spheres to explain the universe, Indian astronomers suggested that the stars were precisely like the sun but considerably further away in the first century CE. They also recognised that the globe was round, and Indian astronomers sought to determine the planet's circumference.

1. **Aryabhatta**

Aryabhatta is one of the greatest mathematicians and astronomers of all time. He studied at Khagol, the famous astronomical observatory at Nalanda. Disregarding the view that planet earth is immovable he stated it rounds and rotates on its own axis. He correctly explained why the moon and other planets shine by stating it is due to the reflection by the sun. He gave a scientific explanation for solar and lunar eclipse and explained it was not caused by rahu/ketu or some other demons.

1. **Bhaskaracharya**

Authored Karaṇakutūhala and Siddanta Shiromani. He observed planetary positions, conjunctions, eclipses, cosmography and so on.

1. **Lagadha**

He wrote Vedanga Jyotisa which describes a number of astronomic attributes.The Vedanga Jyotiṣa also details astronomical calculations, calendrical studies, and establishes rules for empirical observation.

1. **Nilakantha Somayaji**

He was an astronomer from kerala. In his Tantrasangraha, published in 1500, Nilakantha Somayaji of the Kerala school of astronomy and mathematics revised Aryabhata's model for the planets Mercury and Venus. Until Johannes Kepler in the 17th century, his equation for the centre of these planets was the most accurate. He also Jyotir Mimamsa based on the importance of astronomical observations to obtain correct parameters for computations.

**Major Institution : Kerala Mathematics (1300-1600)**

Kerala school of astronomy and mathematics South India, Kerala was founded by Madhava of Sangamagrama.It flourished during the 14th and sixteenth centuries and the authentic discoveries of the college appears to have ended with Narayana Bhattathiri (1559–1632). In trying to resolve astronomical problems, the Kerala college astronomers independently created some critical arithmetic concepts.The works of the faculty have been first written up for the means of Englishman C.M. Whish in 1835. According to Whish, the Kerala mathematicians had "laid the inspiration for an entire machine of fluxions" and those works abounded "with fluxional paperwork and collection to be determined in no paintings of overseas countries.". However, Whish's outcomes have been nearly absolutely neglected, till over a century later, while the discoveries of the Kerala college have been investigated once more via the means of C. Rajagopal and his associates. Their paintings consists of commentaries at the proofs of the arctan collection in Yuktibhāṣā given in papers,a observation at the Yuktibhāṣā's evidence of the sine and cosine collection and papers that offer the Sanskrit verses of the Tantrasangrahavakhya for the collection for arctan, sin, and cosine (with English translation and observation)

Most relevant Works:

* The infinite geometric series.
* Intuitive use of mathematical induction.
* Use of rectification.
* Use of series expansion.
* A semi-rigorous method of differentiation of some trigonometric functions.
* Using the improved series to derive a rational expression.

**Indian and foreign astronomy.**

The Indian Astronomy withinside the Middle Ages appears very one of a kind from astronomy in prehistoric times. Before Aryabhata, we knew approximately astronomy normally as a listing of observations recorded or information listed. However, for almost a thousand years since Aryabhata, Indian astronomers wrote specialized books about arithmetic at the back of the movement of planets and stars. We know this era as the Siddhantic Astronomy era (500 CE to 1400 CE).

* In the Indian context, this section starts around 500 AD with the appearance of Siddhantic Astronomy and excellent astronomers like Aryabhatta.
* Pre-career of Indian astronomers for the following millennium turned into the calculation of geocentric planetary orbits.
* They developed processes and algorithms for solving mathematical equations.
* This included and developed concepts of trigonometry and the limiting value of functions – the first step towards differential calculus.

India's Siddhantic Astronomers were on the verge of splitting into two branches. Many eminent astronomers devoted their lives to Aryabhata and worked on developing the Aryabhatiya.

At this stage, the exact mathematical equations for covering the movement of celestial bodies like the Sun, Moon and Planets were parameterised. Important functions like sine functions are developed and used. Eclipses are calculated on the basis of angular movements of the Sun and the Moon per day and also based on their relative vertical and horizontal displacements.Planetary locations were calculated and Astral Charts were created for the astrological purposes.

By analyzing the facts we can see that Indian astronomy was influenced on greek astronomy. Many Sanskrit words related to astronomy, calendar were borrowed from greek language. There is a similarity between Indian and pre-ptolemaic greek astronomy.Hellenstic astronomy had great influence on the local astronomic traditions on eastern India.

Indian astronomy reached China during the expansion of Buddhism . Many Indian works were translated during the Three Kingdom era which dated from 220-265 CE.

Arabs adopted sine functions from Indian work instead of chords of arc used in Hellenistic mathematics. Through Islamic astronomy Indian astronomy had a great influence on european astronomy.

Kerala School of astronomy and mathematics had a great influence in astronomy of Europe since Kerala established a connection with Europe by trades and Jesuit missionaries. However there is no direct evidence for idea transmission by manuscript and writings.

Astronomy as a probe shows and provides the map of intellectual growth of our culture. The development of astronomy takes place in stages that are vastly different from one another. These stages are similar to the transitions that occur in the evolution of cultures. These significant shifts are not always visible in archaeological evidence. As a result, astronomy is a wonderful window into the past. The Indian astronomers' impact did not end there; their work would be utilised by Islamic academics and would become one of the pillars of Islamic astronomy. Hindu mathematical skills combined with Islamic observational techniques led to tremendous breakthroughs in astronomy during India's famous Mughal Era (1526–1725). These techniques formed a key element of contemporary astronomy as a result of the British Colonial conquest of India.

1. **CONCLUSION**

Indian development in mathematics and astronomy has influenced modern science and mathematics. Many machines, laws that we see now were developed by us Indians. But due to lack of proper documentation the inventions and theories were stolen by foreigners. Our ancient science has played a vital role in the development of the current world and will be playing a role in shaping the future world as well. When the scientists of the rest of the world were trying to invent laws and theorems Indian mathematicians and astronomers were able to find it.

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