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Aryabhata: The first Astronomer-Mathematician of India

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ABSTRACT :- Aryabhata is a renowned astronomer and mathematician of India. He is often hailed as of greatest minds of ancient India His ground breaking work in mathematics and astronomy has had profound impact on the development of these fields through out history. He born in the 5th century AD. His contributions to the understanding of the universe and the numerical world continue to be celebrated and studied in the Modern mathematical age.

Keywords :- Astronomy, Mathematics, Ancient, Century.

Introduction :- Aryabhatta name is properly spelled Aryabhata. He Mentions in the Aryabhaiya that it was composed 3600 years in the Kali yuga When he was 23 years old. This corresponds to 499CE, and implies that he was born in 476 AD. Provides no information about the place. The information comes from Bhaskara I, who describes Aryabhatta as Asmakiya i.e. Asmaka country. During the Budha's time, a branch of the Asmaka's people settled in the region between the Narmada and Godavari rivers in central India. People believed that he hailed from the region of Kusumapura, which is modern day Patliputra ie, Patna, India.

There is a limited historical record available about his early life offer few clues to his personal life. However it is evident that he received a rigorous education in mathematics, astronomy and possibly other subjects. The depth and sophistication of his work suggest that he had access to a rich intellectual tradition and a supportive environment for scholarly pursuits.

The details of Aryabhata's work are known only from the "Aryabhatiya. The name Aryabhatta is due to later commentators. Aryabhata himself may not have given it a name. His disciple Bhaskara I Called it Asmakatantra. It is also occasionally referred to as Arya-Shu-tas-ash-Ta, becase there are 108 verses in the text. It is written in the very terse style typical of Sutra literature, in which each line is an aid to memory for a complex system. Thus, the explication of meaning, is due to commentators. The text consists of the 108 verses and 13 introductory verses, and is divided into four Padas or chapters.

1. GitikaPadas (13 verses): It covers large units of time - Kalpa, man- vantra, and yuga-which present a Cosmology different from earlier texts Such as Lagadha's vedanga Jyotisha. There is also a table of sines (Jya), given in a single verse. The duration of the planetary revolutions, during a Mahayuga is given as 4.32 million years.

2. GanitaPada (33 verses): It covering Converring mensuration ie ksetra Vyavahara arithmetic and geometric progression, gnomon/shadows ie Shanku-ChhAYA, Simple, quadratic simultaneous and indeterminate equation is kuttaka.

3. Kalakriyapada (25 Verses): It covers different units of time and a method for determining the position of planets for a given day, Calculations concerning the intercalary month and a seven-day week with names for the days of week .

4. GolaPada (50 verses): It covers Geometric/trigonometric aspects of the Celestial sphere, features of the ecliptic, Celestial equater, node, shope of the earth, Cause of day and night, rising of Zodiacal signs on horizon, ete. In addition, some versions Cite a few Colophons added at the end, extolling the Virtues of the work etc.

The Aryabhatiya presented a number of innovations in mathematics and astronomy in verse from, which were influential for many centuries. The extreme brevity of the text was claborated in Commentaries by his disciple Bhaskara I in 600 CE and by Nilakantha Somaya ji in his Aryabhatiya Bhasya in 1465 CE .

Place value system and Zero: - The place value system, first seen in the 3rd- century Bakhshali Manuscript, was clearly in place in his work. While he did not use a symbol for zero, the French mathematician Georges Ifrah argus that knowledge of zero was implicit in Aryabhata's place - Value system as a place holder for the powers of ten with null coefficients.

But, Aryabhata never use the Brahmi numerals. Continuing the Sanskritic tradition from vedic mathematics , he use letters of the alphabet to denote numbers, expressing quantities such as the table of sines in a mnemonic form.

Approximation of π

Aryabhata worked on the approximation for π and may have come to the Conclusion that π is irrational number. In the second part of the Aryabhatiya ie ganitapada 10, he writes .

"Caturadhikam Satamastagunam drasastistatha Sahasranam ayulad vayavistrambhasyasanno vrttaparinahah"

ie Add four to 100, multiply by Eight, and then add 62,000. By this rule the circumference of a circle with a diameter of 20,000 Can be approched."

It means that the ratio of the Circumferrence to the diameter is $(4+100)\times8+62000)/20000 = 62832/20000 = 3.1416$ Which is accurate value of π.

Trigonometry :- In Ganitapada, Aryabhata gives the area of a triangle ''tribhuijasya phalaskariram Samadalakoti bhujardhasamvarga''. ie For a triangle, the result of a perpendicular with the half- side is the area of the triangle.

Aryabhata discussed the Concept of sine in his works by the name of ardha-jya, which literally means "half-Chord". Latter on people called it jya.

Indeterminate equations: A problem of great interest to Indian mathematicians since ancient times has been to find integer solutions to Diophantine equations that have the form $ax + by = c$

This problem was also studied in ancient Chinese mathematics, and its solutions is known as the Chinese remainder theorem. This is an example from Bhaskara's commentary on Aryabhatiya. Find the number which gives 5 as remainder divided by 8,4 as remainder when divided by 9 and 1 as the remainder when divided by 7.

ie, $N = 8x + 5 = 9y + 4 = 7z + 1$

It turns out that the smellest value of N is 85. In general Diophantine question such as this can be notoriously different . They were discussed extensively in ancient vedic text sulabh sutras. In 800 BCE Aryabhattias method of solving such problems elaboratet by Bhaskara I in 621 CE is called kuttaka.

Algebra:- In Aryabhatiya, Aryabhata provided elegant results for the summation of series of square and cubes as follows

$$1^2+2^2+3^2+\ldots\ldots\ldots\ldots n^2= \frac{n(n-1)(2n-1)}{6}$$

and $1^2+2^2+3^2+\ldots\ldots\ldots\ldots n^2 = (1+2+3+\ldots\ldots\ldots+n)^2$

$$= \{\frac{n(n-1)}{2}\}^2$$

Astronomy: - Aryabhata's system of astronomy was called the audAyuka system, in which days are reckoned from Uday, dawn at Lanka or equator". Some of his later writings on astronomy, Which apparently proposed a second model are lost but Can be partly reconstructed from the discussion in Brahmagupta's Khandakhadyako. In some text, he seems to ascribe the apparent motions of the heavens to the earth's rotation. He may have belived that the planet's orbits is . elliptical rather then circular.

Motions of the solar System :-

Aryabhata Correctly insisted that the earth rotates, about its axis daily, and that the apparent movement of the Stars is a relative motion caused by the rotation of the Earth, Contrary to the then- prevailing view, that the sky rotated. This is Indicated in the first chapter of the Aryabhatiya, where he gives the number of rotations of the earth in a Yuga and made more explicit in his gola chapter.

Aryabhata described a geocentric model of the Solar system, in which the Sun and Moon are each, Carried by epicycles. They in turn revolve around the Earth. In this model which is also found in the paitamahasiddhanta in CE 425, the motion of the planets are each governed by two epicycles, a smaller Manda (slow)and a larger Sighra(fast). The order of the planets in terms of distance from earth is taken as the moon, mercury, venus, the sun, Mars, Jupiter, Saturn and the asterisms.

The positions and periods of the planets was calculated relative to uniformly moving points. In the case of mercury and Venus, they move around the earth at the same mean speed as the sun.

In other case of mars , Jupiter and Saturn, they move around the earth . specific speeds, representing each planet's motion through the zodiac. Most historians of astronomy consider that this two-epicycle model reflects elements of Pre-Ptolemaic Greek astronomy. Another element in Aryabhatta's model, the sighrocca, the basic planetary period in relation to the sun is seen by some historians as a sign of an underlying hellocentric model.

Eclipsess :- Solar and Lunar eclipses were scientifically explained by Aryabhata. He states that the Moon and Plants shine by reflected sunlight Instead of the prevailing cosmogony in which eclipses were caused by Rahu and Ketu, he explains eclipese in terms of shadows cast and falling on Earth. Thus the Lunar eclipse occurs when the moon enters into the Earth shadow. He discusses at length the size and extent of the earth's shadow and the provides the computation and the size of the eclipsed part during an eclipse. Later Indian astronomers improved on the calculation, but Aryabhata's methods provided the core. His computation paradigm was so accurate that 18th century scientist Guillaume Le Gentil, during a visit to Pondicherry, India, found the Indian computations of the duration of the Lunar eclipse of 30 August 1765 to be short by 41 seconds, where as his charts were long by 68 seconds.

Sidereal Periods :- Considered in modern English units of time, Aryabhatta calculated the sidereal rotation as 23 houts, 56 minutes and 4.1 seconds; the modern value is 23:56:4.091. Similarly his value for the length of the sidereal year at 365 days 6 hours 12 minutes and 30 seconds is an error of 3 minutes and 20 seconds over the length of a year

Heiocentrism :- As mentioned, Aryabhata Supported an astronomical model in which the Earth turns on its own axis. His model also gave corrections for the speeds of the planets in the sky in terms of the mean speed of the sun. Thus it has been suggested that Aryabhata's calculations were based on an underlying heliocentric model in which the planets orbit the sun though this has been rebutted. It has also been suggested that aspects of Aryabhata system may have been derived from an earlier, likely Pre-Ptolemaic Greek heliocentric model of which Indian astronomers were aware though the evidence is scant.

The general consensus is that a synodic anomaly does not imply a physically heliocentric orbit and that Aryabhatta system was not explicitly helicentric.

Conclusion :- Aryabhatta's introduced several mathematical concepts that were ground breaking for their time. He developed a system of place value system for numbers, which was a significant advancement over the numeral systems used in ancient India. He also introduced the concept of Zero and developed rules for arithmetic operations involving Zero. Additionally, Aryabhata work on algebra included the solution of linear and quadratic equations as well as the concept of indeterminate equations

Aryabhata's astronomical theories were revolutionary for the their time. He proposed a heliocentric model of the solar system suggesting that the planets orbit the sun. Although this model was not widely accepted unit centaries later it was significant departure from the prevailing geocentric view that placed the earth at the center of the universe. Aryabhata also accuratey calculated the length of the sidereal year the obliquity of the elliptic and the Positions of the planets.

Aryabhata work had a profound influence on later generations of mathematician and astronomers. His Aryabhatiya was translated into Arabic and Persions and his ideas were further developed and dissemminated through out the Islamic Countries.

Aryabhata is a testment to his brilliance and ingnenaity. His ground breaking work in mathematics and astronomy has had a lasting impact on the development of these fields As we continue to explore the mysteries of the universe and the intricacies of numbers we can appreciate the contributions of this ancient Indian scholar who paved the way for coming generations of mathematicians and astronomers of the world.

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