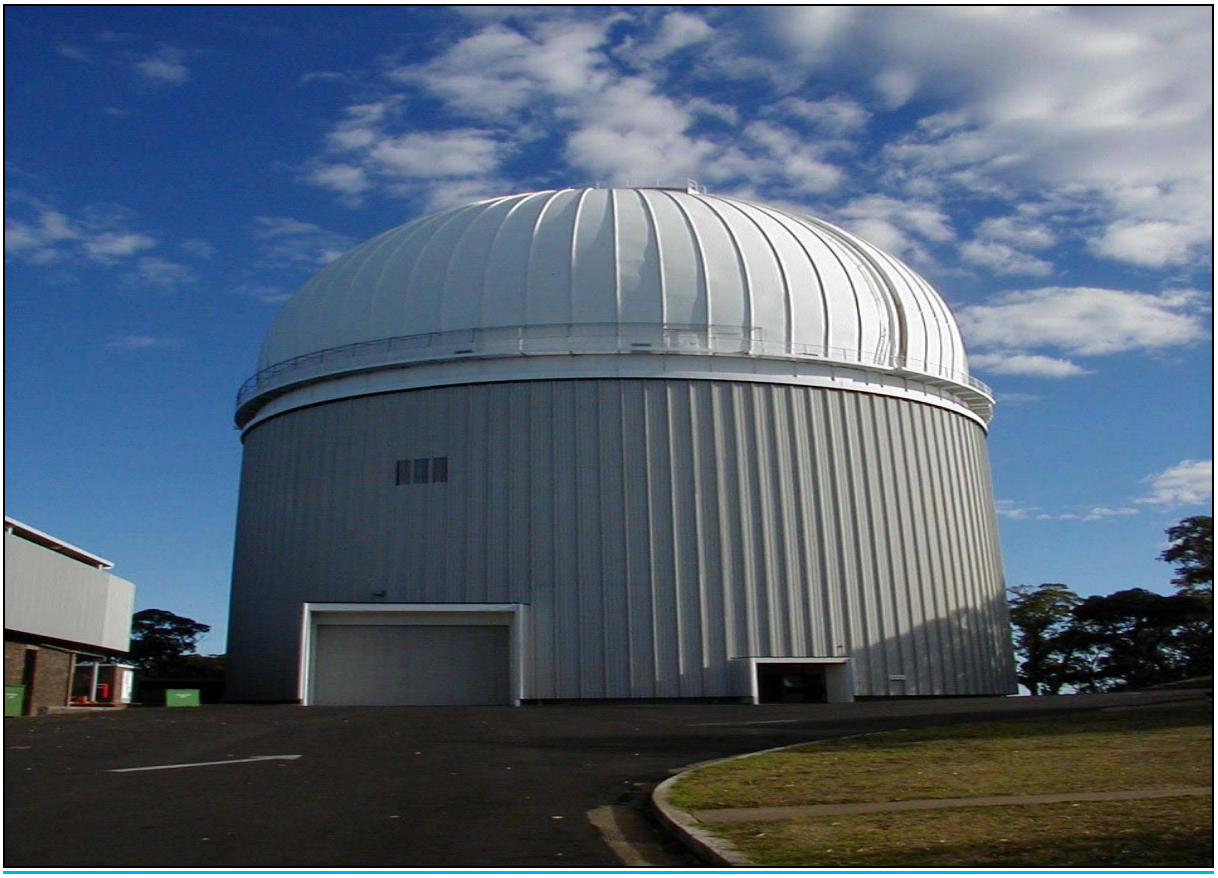
THE GOLDEN AGE OF INDIAN ASTRONOMY



Anglo-Australian Telescope

Aryabhata was born in the year 476 AD in Kusumapura, which is identified with Patna of today. Very little is known about his life, since there are no documented records relating to him. It is fortunate that we are able to work out the year of his birth because in one of the Shlokas of his book 'Aryabhateeya', he explicitly states it: "when 60 time 60 years & three quarter Yugas (eras) had elapsed, 23 years had then passed since my birth". The Christian year began in the Kaliyuga year 3101, thus making 60 times 60, that is 3600 as the year 499 AD. Taking off 23 from this we get the year of birth as 476 AD.

Although Aryabhata was a respected figure of his time & his book carrying detailed calculations of positions of Stars & Planets in the Sky using Trigonometry, was considered the last word on the subject, his one conclusion brought embarrassment to his admirers & detractors alike – he belived that the stars in the sky form a frame fixed in Space & it is the Earth that Spins round its Polar Axis.

This belief was contrary to the widely held conviction that the Earth is fixed in Space & it is the Stars that go round the sky in Circles. We can appreciate why people thought so. If we look at the Daytime sky, we see the sun move in a Circular Trajectory, rising in the East & setting in the West. At Night we see the stars doing the same. A Spectacular way of demonstrating it is to take

a Photograph of the night sky wherein the shutter is kept open for several Hours. One then sees circular Trajectories in the sky as shown in the Photograph by David Malin from the Anglo Australian Observatory. The circular star Trajectories are shown very clearly. Had there been a Pole Star in the South, we would have seen it as a fixed point at the centre of all these circles.

Looking at such a Photograph, we get the first Impression that the earth is fixed in space & the Celestial Bodies move around it in Circular Trajectories. This was the impression prevalent in the days of Aryabhateeya; prevalent not only in India but in Arabia, Europe etc. it require a great deal of courage to take a stand differing from this view.

But this is exactly what Aryabhata did. In his volume Aryabhateeya there is a verse that translates thus: just as person going in boat sees fixed things going in opposite direction, so do the shining objects in the sky, though fixed seem to be going towards the west.

In short Aryabhata is saying that the Stars are fixed & it is the Earth which Spins around its Polar Axis from the West to the East; & that this relative motion makes us see the stars moving from the East to the West.

How did Aryabhata's Contemporaries & Followers react to this statement? We have ample written evidence that a Millennium Later Copernicus had to face considerable opposition to his theory that the earth is not fixed but goes round the sun. Later Galileo had to face the Inquisition for defending Copernicus & he ended by recanting. Both Copernicus & Galileo were in trouble because the establishment was motivated by religious Dogma. To say that the earth is not fixed at the centre of the universe was considered Anti-religious.

ARYABHATA

In India there was no Religious factor in this Situation. Aryabhata was however the victim of social Dogma. It may have been because of the Greek influence that the Geocentric Theory had gained Adherence in India. It was belived that the earth was fixed in space? & did not spin about an Axis. Rather the firmament of stars, the sun & the moon rotated around the earth.Aryabhata was alone raising the Counter-issue that the stars are fixed in space & the earth spins about an axis.

Whatever literature we have on Astronomical Developments in India during the Golden age shows that Aryabhata was criticized, derided or ignored where this fundamental issue was concerned. Obviously influential in Scholastic circles for his erudite working of positions of stars on the Celestial sphere, Aryabhata in general commanded respect; it was therefore embarrassing for his followers when he came out with the above statement. It is interesting to see how they reacted to it.

Bhaskara I, who followed him as the Principle disciple, Writer in his Commentary of Aryabhateeya that the normal meaning of the verse above was as given: but that cannot be right! If the earth moved that is if it was spinning about an Axis, the Oceans would be disturbed & would cause havoc. So, he concludes that what the learned Aryabhata must have meant was that the stars actually move & if one observed the earth from a moving star we would find it spinning in the opposite direction! Sanskrit being a very flexible language one can extract convoluted meaning from any sentence.

It is believed that the Bhaskara I, had carried out this Whitewashing Exercise because leading Astronomers of his time like Varahamihira came down very heavily against his Mentor Aryabhata for his above statement & some damage control was clearly necessary. It is interesting that around 1540 when Copernicus' book was published, its preference was apparently changed. His claim for a Heliocentric Theory was watered down by calling it a 'Hypothesis'.

And, so later, astronomers refused to accept Aryabhata's statement that the Earth spins. The 7TH Century astronomer Brahmagupta was very scornful of Aryabhata. He said:" since Aryabhata knows nothing of Mathematics, Celestial Sphere or time, I have not separately mentioned his Demerits."

This criticism is unfair considering what Aryabhata achieved in his lifetime. Here are a few Examples:

He gave a good Approximation to the Ratio of the Circumference to the Diameter of circle, which we write as Symbol Л. In school texts the approximation is given as 22/7... Aryabhata gave a better Approximation as 3.1416, quoting a value for it as 62832 / 2000. This value is better approximation then the value 3.141666 give by Ptolemy. It is significant that Aryabhata called the ratio above as "Approximate" value. Today mathematicians call a 'Transcendental Irrational' thus recognizing that it cannot be represented by a ratio of whole numbers exactly.

Aryabhata did not stop at starting that the Earth Spins about its Axis....we went on to determine its rate of Rotation. He came up with a time of one rotation as 23 hours, 56 minutes & 4.1 seconds, a value remarkably close to the Modern value of 23 hours 56 minutes & 4.091 seconds.

He seems to have been the first Astronomer & Mathematician to have given Trigonometric Tables for different angles. Western Scholars have compared the Indian tables with Greek ones & have found that the former, though based on Pragmatic Interpolation rather then Elaborate Geometric constructions, are more accurate.

The Old Indian system of expressing numbers in terms of letter which is found in many old sourced for Mathematical results was modified by Aryabhata & made much more effective.

Brahmagupta, as stated before, started off as a Critic of Aryabhata. However he too realized the merits of Aryabhata's work & based several of his result on it. His book simplifying Aryabhata's technique was named by him Khanda – Khadyaka, that is, "Food prepared with Sugar Candy". It becomes very popular but had the unfortunate effect that the original work of Aryabhata on which it was based was lost.

Though, the golden age of Indian astronomy has passed, its significant has not & the far-reaching impact of the thought & vision of those times is very much part of the bedrock of our scientific tradition.