

A GLIMPSE OF
ĀRYABHAṬA'S THEORY OF ROTATION OF EARTH

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Āryabhaṭa, the famous Indian scientific astronomer of the fifth century A.D., talks of rotation of earth in his only extant work *Āryabhaṭīyam*. But he was criticized by his successors, such as Varāhamihira, Brahmagupta, Lalla, Śrīpati and Bhāskara-cārya II. His commentators also did not interpret the relevant verses in the way meant by Āryabhaṭa. Nevertheless, there were other commentators like Prthūdaka, etc. who acknowledged that Āryabhaṭa spoke about the rotation of earth.

Āryabhaṭa (fifth century A.D.) is the first Indian astronomer, whose work *Āryabhaṭīyam* is the earliest extant scientific treatise on Indian astronomy. In the first chapter of this work he writes, 'ku nīśibunīrkḥṣṛ prāk,' or, '(In a yuga of 4320000 solar years, the revolutions) of the earth eastward are 1582237500'.¹

Later on he says, 'prāṇenaiti kalāṃ bhūḥ', or, 'The earth turns through 1' in 1 *prāṇa* or in 1/6 *vināḍī*'.²

Again Āryabhaṭa writes,

*'anulmagatirnausthaḥ
paśyatyacalaṃ vilomagaṃ yadvat |
acalāni bhūni tadvat
samapaścimagāni Laṅkāyam ||*

Or, 'Just as a man in a boat going in one direction sees the stationary things on the bank as if moving in the opposite direction, in the same way to a man at Laṅkā the fixed stars appear to be going westward'.³

All these three quotations are sufficient—(there are some more examples)—to show that Āryabhaṭa knew about the daily rotation of the earth; the earth made 1582237500 revolutions in 4320000 solar years; or in other words, 4320000 years consisted of 1582237500 sidereal days or 1577917500 civil days; the constellations were fixed.

Then what makes him say the following verse?

*udayāstamayanimittam nityam —
pravahena vāyunā kṣiptaḥ |
Laṅkāsamapaścimago —
bhapañjaraḥ sagraho bhramati ||*

Or, 'The circle of constellations together with the planets moves westward at Lañkā being thrown by the wind called *Pravaha*, thus causing the daily rising and setting of planets'.⁴

In this verse he is apparently contradicting his own statement that the circle of constellations is fixed and that the earth rotates. Is this verse an interpolation or it reads like this because of some changes made by the commentators. Or, Āryabhaṭa is stating the current theory, but the appropriate words introducing it are missing. This is, however, definite, that in the face of the three previous statements, it cannot and should not be denied that Āryabhaṭa was conversant with the rotation of the earth. It cannot be said whether this was a result of his own observations or was based on previous ones. His own verses 48-50 in *Golapāda* are clear evidence that he made use of previous records of observations and made his own observations as well.

This important astronomical theory, however, was not only ignored by other astronomers, who succeeded Āryabhaṭa, but was strongly refuted. Thus says Varāhamihira (sixth century) in *Pañcasiddhāntikā*, 'Others say that the earth, as if on a potter's wheel, rotates and not the constellations. If that were so, how could hawks, etc., come back to their nests. Moreover, if the earth rotated once a day, bees, geese, etc., would be driven to the west. If the earth moved slowly, how could it complete a revolution in one day'.⁵

Even an astronomer of Brahmagupta's calibre (seventh century) quotes Āryabhaṭa's statement *prāṇenaiti kalāṃ bhūh*, in *Brāhmasphuṭasiddhānta* and refutes it by saying that if the earth rotated, nobody could come back to his own abode; things standing would fall down.⁶

Lalla (eighth century) says in *Śiṣyadhīvrddhida*, 'If the earth rotated, how could the birds come back to their nests. In that case, the arrows thrown towards the sky, would fall towards the west, the clouds would be moving towards the west. If it is said that the earth moves slowly, then how can it go round the universe in one day'.⁷

Śrīpati (eleventh century) in *Siddhāntasekhara* quotes the example of the man in the boat as given by Āryabhaṭa and forwards similar arguments as those given by others to refute the rotation of the earth.⁸

Now what does Bhāskaraçārya II (twelfth century) have to say in this respect. He does not mention about the rotation of the earth in *Siddhāntasīromāṇi* but speaks about the daily revolution of the sphere of constellations towards the west.⁹

These are the views of some of the outstanding astronomers after Āryabhaṭa, who do not agree with him about the rotation of the earth.

How do Āryabhaṭa's commentators interpret the above verses. Bhāskara I, probably in the beginning of the seventh century, is separated from Āryabhaṭa by a century or so. His is the earliest commentary (incomplete) on *Āryabhaṭīyam* so far available. He does not think that Āryabhaṭa meant rotation of the earth. The asterisms move westward by the *Pravaha* wind and it appears as if the earth is moving. He reads *bhūḥ* (earth) as *bham* or asterisms and that simplifies the matter for him.¹⁰

The next commentary is by the Kerala astronomer Sūryadeva Yajvan of the thirteenth century. While commenting on the verse giving the revolutions of the earth, he says that the earth is fixed. So there can be no question of its revolution. But since the circle of constellations is moving to the west, the earth situated below appears to move towards the east. He supports his argument by quoting Āryabhaṭa's example of a man in a boat. Just as to him the immovable things appear moving in the opposite direction, so does the stationary earth appear moving, to the stars. Like Bhāskara I, he reads *bham* instead of *bhūḥ*. Thus the question of earth's rotation does not arise. Again in the verse about the boat, instead of using *acalāni* (fixed) as the adjective of *bhāni* (stars), Yajvan brings in '*bhāni bhūsthānyacalāni vastūni prānmukhaṃ gacchanīva paśyanti*', or, 'the stars see the fixed things on the earth as if moving to the east'. He, of course, takes the help of the next verse which does say that the circle of constellations is moving to the west.¹¹

Parameśvara of the fourteenth century, another commentator of Āryabhaṭa and a Kerala astronomer of great reputation, also does not think that Āryabhaṭa believed in the rotation of the earth. In his commentary on *Daśagītikā 1*, he says '*bhūmirhyacaleti prasiddhā. Tasyāḥ kathamatra bhramaṇakathanam. Ucyate. Pravahākṣepāt paścimābhimukhaṃ bhramato nakṣatramanḍalasya mithyājñānavasād bhūmerbhramaṇam praṭīyate. Tadaṅgīkṛtyeḥa bhūmerbhramaṇamuktam*'. Or, 'It is well known that the earth is stationary; so how can one talk about its rotation. In reality the circle of constellations is moving to the west because of the wind *Pravaha*, and owing to ignorance it appears that the earth is rotating. So *Āryabhaṭa* talks of the rotation of the earth'. According to him, Āryabhaṭa's example of the man on the boat is to dispel the ignorance of those, who would like to believe that the circle of constellations is stationary, but the earth moves. Parameśvara also gets support from the next verse that says that the asterisms move.¹² It is a pity that this kind of twisted explanation would come from Parameśvara, who himself was an observer of the heavens for over fifty years.

Then comes Nīlakaṇṭha's commentary. Nīlakaṇṭha is another Kerala astronomer of the fifteenth century. His commentary on *Daśagītikā* is not available. But in his commentary on the example of the man on the boat he quotes Āryabhaṭa's verse, '*ku ni.prāk*', giving the number of rotations of the earth in a *yuga* and says that this number relates to the rotations of the circle of constellations to which it would appear that the earth was moving. He continues

that Āryabhaṭa could not have believed in the earth's rotation because he himself is saying in the next verse that the rising and setting of the planets is caused by the motion of the circle of constellations.¹³

Another commentator, Yallaya, gives similar explanations.

Thus it appears that all these outstanding commentators of Āryabhaṭa either did not genuinely agree with him that the earth rotated or did not like to go against the traditional belief about the earth being stationary and did not wish that their respected teacher should go against it. Hence their far-fetched explanation.

Āryabhaṭa meant *bhūḥ* and not *bham* — Brahmagupta quotes *bhūḥ*. And if Āryabhaṭa did not speak of the rotation of the earth, what is there for Varāha, Brahmagupta, Lalla and Śrīpati to contradict?

Udayadivākara in his commentary on *Laghubhāskariyam*, i. 32-33 writes, *bhūbhramaṇamapyūcāryeṇūbhhyupagotaṃ naksatrāmāṃ sthiratā ca. Vidyate hi pāḥāntaraṃ prāṇenaiti kalām bhūriti*'. Or, 'Ācārya Āryabhaṭa realised the rotation of the earth and the immobility of the asterisms. There is another reading *prāṇena*, etc.'¹⁴

There is yet another evidence. Pṛthūdaka (ninth century) while commenting on *Golādhyāya* 30 of *Brāhmasphuṭasiddhānta* says, '*ācāryāryabhaṭeṇāpi bhūbhramaṇamabhyupagatam*'. Or, 'Ācārya Āryabhaṭa also knew about the rotation of the earth'. Pṛthūdaka then quotes the line '*prāṇenaiti kalām bhūḥ*' and also the example about the man on the boat. Pṛthūdaka continues, '*lokabhayād bhāskarādibhiranyathā matveyamāryā vyākhyātā* or, 'Bhāskara and others did not want to go against the traditional belief and therefore gave an interpretation other than what was originally meant'.¹⁵ Pṛthūdaka was not afraid to speak the truth. And in *Golādhyāya* at several places in his commentary he talks of the rotation of the earth. Moreover, while commenting on Brahmagupta's repudiation of the earth's rotation, he positively supports Āryabhaṭa's view. The following quotation is from his commentary.

*'bhapañjaraḥ sthiro bhūrevāvṛtyāvṛtya
pratidaivasikau, udayāstamayau sampādayati
nakṣatragrahāṇām'*

Or, 'the circle of constellations is stationary; the earth itself by its rotation causes daily rising and setting of stars'.¹⁶

So was not Makkibhaṭṭa, the commentator of Śrīpati's *Siddhāntasekhara*, afraid of quoting or supporting Āryabhaṭa's theory. While explaining a civil day he says, '*bhūmiḥ prāṇmukhī bhramati*', or, 'the earth rotates towards the east'.¹⁷ It is a great disadvantage that the portion of his commentary from the middle

of the fourth chapter of the *Siddhāntaśekhara* is lost; otherwise it would have been interesting to note his explanations of the verses, where Śrīpati contradicts Āryabhaṭa's theory of rotation.

The above is a very brief account of Āryabhaṭa's theory of rotation of earth and how it was received by his successors and commentators.

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REFERENCES

- ¹ *Daśagītikā*, 1 (Kern's edition)
- ² *Daśagītikā*, 4
- ³ *Golapāda*, 9
- ⁴ *Golapāda*, 10
- ⁵ *Pañcasiddhāntikā*, xiii, 6-7
- ⁶ *Brāhmasphuṭasiddhānta*, xi, 17
- ⁷ *Golādhyāya*, vii, 42-43
- ⁸ *Golavāsanādhyāya*, 15-17
- ⁹ (Sastri's edition) *Madhyamādhikāra*, *Kālamānādhyāya*, 13-14
- ¹⁰ Extracts (from a MS) kindly supplied by Dr. K. S. Shukla, Lucknow University
- ¹¹ Extracts (from MSS) kindly supplied by Curator, Government Oriental Manuscripts Library, Madras
- ¹² *Āryabhaṭīyam* (Kern's edition), p. 5; pp. 75-76
- ¹³ *Āryabhaṭīyam*, Part III, *Golapāda*, (Edited by S. K. Pillai, Trivandrum), pp. 23-24
- ¹⁴ Extracts (from a MS) kindly supplied by Dr. K. S. Shukla
- ¹⁵ *Brāhmasphuṭasiddhānta* (Sharma's edition), Vol. IV, p. 1636
- ¹⁶ Colebrooke's Misc. Essays (new edition, vol. II), p. 344
- ¹⁷ *Siddhāntaśekhara*, i, 39 (p. 25).