Sāyaṇa's Astronomy

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Abstract

In his commentary on the Rigveda, the fourteenth century scholar Sāyaṇa mentions a specific speed for the sun which can be used to determine the distance to the sun. Vartak has interpreted this statement to stand for the speed of light but we cannot place that in any reasonable historical context. The distance to the sun implied by Sāyaṇa's statement suggests that there was another astronomical tradition in India which is now lost.

KEYWORDS: Medieval astronomy, solar system, Siddhāntas

1   Introduction

Sāyaṇa (c. 1315-1387) was a minister in the court of King Bukka I of the Vijayanagar Empire in South India; he was also a great Vedic scholar who wrote extensive commentaries on several ancient texts. In his commentary on the fourth verse of the hymn 1.50 of the Rigveda on the sun, he says[1]

> *tathā ca smaryate yojanānāṃ sahasre dve dve śate dve ca yojane*
> *ekena nimiṣārdhena kramamāṇa namo 'stu ta iti*

Thus it is remembered: [O Sun,] bow to you, you who traverse 2,202 *yojanas* in half a *nimeṣa*.

We have no knowledge that Sāyaṇa was an astronomer and he acknowledges that he is only quoting from an old tradition, so we label this note as "Sāyaṇa's astronomy" only in the sense of what was known by his time in the fourteenth century.

Padmakar Vishnu Vartak in a recent book[2]has argued that this statement refers to the speed of light. He says, "One Yojana is equal to 9 miles, 110 yards = 9 1/16 miles = 9.0625, ...and according to Mahābhārata,[3]Śānti Parva, 231, half a nimeṣa equals 8/75 seconds. If calculated on this data the velocity of light comes to 187,084.1 miles per second... Sir Monier Williams gives one Yojana equal to 4 Krosha = 9 miles. Taking 1 Yojana = 9 miles, the velocity comes to 186,413.22 miles per second. The well accepted popular scientific figure is 186,300 miles per second."

This is astounding because it is in remarkable agreement with our current knowledge about the speed of light! Vartak's reference on the nimeṣa from the *Mahābhārata*, which is usually assigned to 400 B.C. to 400 A.D., is correct.[4]The specific definition of a nimeṣa is there given by 450×30.1 nimeṣa = 1 muhūrta (48 minutes), which means that one nimeṣa is $\frac{16}{75.3}$ seconds. The yojana is a well known unit of distance and the value ascribed by Vartak is the usual one.[5]Even if one argues that there was no standardization of measures in the ancient world and the specific values assigned by Vartak for yojana and nimeṣa were not used by all the ancient authorities, just the fact that there could be mention of a finite speed of light three centuries before that discovery by Roemer is not believable. Furthermore, we cannot place such knowledge in context.

So should we take the statement of Sāyaṇa as an amazing coincidence? From all accounts, the passage is not an interpolation. There are those who would suggest that consciousness reflecting on itself can obtain such quantitative information. But if one discounted that possibility then, wanting evidence of instrumentation that would have allowed an actual measurement of the speed of light to have been made in medieval India of Sāyaṇa's time, the only way Vartak's interpretation can be justified is to assume that the speed was a lucky guess.

We do know that in the Indian tradition a finite speed was associated with the astronomical processes. Thus in the *Sūrya Siddhānta* 2.1-3, the

motion of the planets is described in terms of the action of cords of "air":

> Forms of Time, of invisible shape, stationed in the zodiac (*bhagaṇa*), called the conjunction (*śīghrocca*), apsis (*mandocca*), and node (*pāta*), are causes of the motion of the planets.
>
> The planets, attached to these beings by cords of air, are drawn away by them, with the right and left hand, forward or backward, according to nearness, toward their own place.
>
> A wind, moreover, called provector (*pravaha*) impels them toward their own apices (*ucca*); being drawn away forward and backward, they proceed by a varying motion.[6]

The important point here is that gravitation is expressed in terms of a force which is compared to a wind. One would assume, then, that light must have also been compared to a wind and thus taken to have a finite speed.

It is possible that the speed of 2,202 yojana to half a nimeṣa was chosen just to make the time spent by light on its journey from the sun to the earth equal a round number in some convenient units. Again, this would make this choice just an astonishing coincidence.

On the other hand, if Vartak's interpretation—that the statement refers to the rays of the sun—is wrong, then should we take it to be the speed of the sun? That this is likely is because the luminaries were taken to move at speeds that were more or less fixed. For the other planets this speed was considered to be 11,858.75 yojanas,[7] and there was a corresponding tradition regarding the speed of the sun. In this note we explore the implications of this interpretation that Sāyaṇa's remarks referred to the speed of the sun in its orbit.

2   On nimeṣa and yojana

Can one consider the possibility that nimeṣa in Sāyaṇa's statement only means the "twinkling of an eyelid"– the usual non-technical meaning of the term? This possibility is not credible because then Sāyaṇa would have had no need to give a precise figure of 2,202 yojanas in relation to a figure of speech. In such a situation, a "thousand (for 'a large number') yojanas in a

nimeṣa (for 'a twinkling of an eyelid')" might have been used. So it seems quite certain that a specific meaning of the term nimeṣa is meant here.

The definition of nimeṣa in the Purāṇas generally agrees with that given in the *Mahābhārata.* Yojana is an ancient measure which we come across in the Rigveda. This is how the two units are defined in the chapter 2.20 of the *Arthaśāstra*,[8]which is attributed to Kauṭilya (320 B.C.):

Yojana. 8,000 *dhanus* (dhanus means bow, taken to be about 6 feet). A dhanus is also taken to be equal to one pauruṣa, the height of a person, so assigning about 6 feet to it is reasonable. One dhanus is considered equal to 108 aṅgulas (fingers). It is a stage, 9.1 miles approximately, and according to Kangle it has "reference to the 'yoking' of bullocks, i.e., distance covered before the yoke is taken off."

Nimeṣa. 150 nimeṣas equal 1 kalā and 80 kalās equal one muhūrta (48 minutes). This means that one nimeṣa equals $\frac{6}{25}$ or about one-fourth of a second.

We see the same definition of yojana in most astronomical texts over several centuries, including in one commentary by Yallaya, who lived just a century later than Sāyaṇa in South India.[9]On the other hand, the definition of yojana by Āryabhaṭa (c. 499) is different. He takes nṛ (man) to be equal to 96 aṅgulas and then he considers a yojana to equal 8,000 nṛ. This amounts to his yojana being equal to approximately $7\frac{1}{2}$ miles.[10]Āryabhaṭa takes the earth's diameter to be 1,050 yojanas, whereas his commentator Bhāskara I, writing a century later, uses another definition of yojana so that the earth's diameter is 1,600 yojanas.

Burgess provides the following commentary on the unit of yojana:[11]

> The usual reckoning makes the yojana equal 32,000 cubits ["cubit" is *hasta*, hand, which ought to be close to 18 inches], but it is also sometimes regarded as composed of 16,000 cubits; and it is accordingly estimated by different authorities at from four and a half to rather more than ten miles English.

Nevertheless, one can speak of what should be the "standard" unit of yojana and nimeṣa by considering astronomical texts.[12]According to these sources, a yojana is 8,000 dhanus or 32,000 hastas, which is approximately 9 miles, and a nimeṣa is given by the equation that

18 nimeṣas = 1 kāṣṭhā

30 kāṣṭhās = 1 kalā

30 kalās= 1 muhūrta (48 minutes).

This amounts to one nimeṣa being equal to $\frac{8}{45}$ seconds. In the various definitions, nimeṣa is approximately one-fifth to one-fourth seconds: the four variants being $\frac{1}{5}$, $\frac{16}{75.3}$, $\frac{6}{25}$, and $\frac{8}{45}$.

3   The Distance to the Sun

We first note that there exist many traditions regarding the distance to the sun. The earliest of these is the statement in the *Pañcaviṃśa Brāhmaṇa* 16.8.6 that the heavens are 1,000 earth diameters away from the earth. Since the sun was taken to be half-way to the heavens this indicates a distance of 500 earth diameters. There are other references in the Brāhmaṇas that indicate that the Indians knew that the orbit of the sun was not perfectly symmetrical.[13]Here we are interested in reviewing the tradition about the distance to the sun during the Siddhāntic period.

Āryabhaṭa, in his *Āryabhaṭīya* 1.6, gives the distance of the sun, R_s, to be 459,585 yojanas. But remember that Āryabhaṭa uses a measure of yojana which is $\frac{96}{108}$ of the standard yojana.[14]

Sāyaṇa's statement can be used to determine the distance R_s to the sun. We have

$$\pi \times R_s = speed/hour \times 12 \ hours.$$

This amounts to the distance to the sun being equal to

$$R_s = \frac{2202 \times 90 \times 60 \times 60 \times 12}{8 \times \pi} \approx 340.6 \times 10^6 \ yojanas.$$

This is approximately 740 times larger than the estimate during Āryabhaṭa's time, assuming the same yojanas were used.

The correct value for the distance is 93 million miles. If Sāyaṇa was using a short measure of yojana then his estimate was only 10 times greater than the modern value. On the other hand, Āryabhaṭa's estimate—and a similar estimate by Ptolemy,—which was typical for the ancient and the medieval world until the time of Copernicus and Brahe,[15]was about $\frac{1}{27}$ of the correct value.

If we use the standard yojana, the distance of the sun by Sāyaṇa's statement becomes approximately 3,000 million miles which is almost as far as the far reaches of the solar system.

4   Concluding Remarks

Even considering the "standard" measures of yojana and nimeṣa, Sāyaṇa's statement, if interpreted as the speed of light, comes pretty close to the true value. If we take this to be no more than a coincidence and interpret Sāyaṇa to mean the speed of the sun, then we get a distance to the sun which is much greater than anyone could have imagined before the speed of light was actually computed by Roemer. This second interpretation also leaves us with an unresolved puzzle.

Perhaps, the resolution of this puzzle lies in the recognition that there existed astronomical ideas in India other than those which have survived as the extant Siddhāntas. The Indian books also speak of lost Siddhāntas. Sāyaṇa appears to quote from one such lost tradition. This tradition may have considered the solar system to be enormously large trying to reconcile this size to the huge numbers related to the cycle of 8.64 billion years in the Purāṇic theory of the kalpa.

Collecting astronomical references in the various Indian texts that do not fit into the standard Siddhāntic models may lead to the recovery of some of the lost traditions. The referee of this paper notes that Sāyaṇa's brother Mādhava wrote two books on astronomy, the *Kālanirṇaya* (also called the *Kāla-Mādhava*) and a commentary on the Parāśara-Smṛti known as the *Parāśara-Mādhavīya*; these may be two sources to begin looking for non-Siddhāntic and "non-standard" astronomical notions current in the fourteenth century.

References and Notes

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10. Shukla, 1976, page 19.

11. Burgess, 1989 (1860), page 43.

12. Basham, 1967, pp. 505-506.

13. This whole question will be discussed in a separate paper.

14. In the *Āryabhaṭa-siddhānta*, Āryabhaṭa uses another measure of yojana which is two-thirds the one in the Āryabhaṭīya.

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