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SĀYAṆA'S ASTRONOMY

SUBHASH C. KAK*

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In his commentary on the *Ṛgveda*, 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.

Key-words: Medieval astronomy, Siddhāntas, Solar system

INTRODUCTION

Sāyaṇa (c. 1315-1387) was a minister in the Court of King Bukka 1 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 hymn 1.50 of the *Ṛgveda* 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 = 91/16 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 *Krośa* = 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."

* Department of Electrical & Computer Engineering Louisiana State University, Baton Rouge, LA 70803-5901, USA

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 BC to 400 AD, 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.

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 *Ṛgveda.* This is how the two units are defined in the chapter 2.20 of the *Arthaśāstra,*[8] which is attributed to Kauṭilya (320 BC) :

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 *nimeṣa* 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 7½ 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 to 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

$$\frac{1}{5}, \frac{16}{75.3}, \frac{6}{25}, \text{ and } \frac{8}{45}.$$

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

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

This amounts to the distance to the sun being equal to

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

This is approximately 740 times large 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.

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

1. Müller, Max (ed), 1890. *Ṛgveda-Saṃhitā together with the Commentary of Sāyaṇa.* Oxford University Press, London.
2. Vartak, P.V., 1995. *Scientific Knowledge in the Vedas.* Nag Publishers, Delhi.
3. *Mahābhārata* (Gītā Press Edition), Śānti Parvan, chapter 231, verse 12.
4. Ganguli, K.M., 1970. *The Mahābhārata.* Munshiram Manoharlal, Delhi, vol. 9, p. 155.
5. Basham, A.L., 1967. *The Wonder that Was India.* Sidgwick and Jackson, London, p. 594.
6. Burgess, E., 1989. *The Sūrya Siddhānta.* Motilal Banarsidass, Delhi, p. 53.
7. Dīkṣit, Ś. B., 1896, *Bhāratīya Jyotiṣa.* Translated from Marathi into Hindi by Ś. Jhārkhandī. Hindi Samity, Lakhanau, 1963, p. 422.
8. Kangle, R.P., 1986 (1972). *The Kauṭilīya Arthaśāstra.* Motilal Banarsidass, Delhi.
9. Shukla, K.S., 1976. *Āryabhaṭīya opf Āryabhaṭa.* Indian National Science Academy, New Delhi, p. xliii.
10. Shukla, 1976, p. 19.
11. Burgess, 1989 (1860), p. 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.
15. Neugebauer, O., 1975. *A History of Ancient Mathematical Astronomy.* Springer-Verlag, Berlin.