SPEED OF LIGHT IN THE VEDIC LITERATURE

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Speed of light is a universal constant. In the western world, its value was first determined by Roemer in 1676. Prior to that, it was believed that light travels with infinite speed. However, its value was known to Indians since Vedic period (c. 1500 and 1200 BC). Sayana a Vedic scholar (c. 1315–1387) and a minister in the court of King Bukka I of the Vijayanagar Empire in South India, wrote commentaries on *Rigveda*. In a hymn addressed to the Sun, he says that "it is remembered that the Sun traverses 2,202 *Yojan* in half a Nimesh". This value is quite close to the presently measured value of the speed of light in vacuum, i.e., 300 million metre per second or 186,000 mile per second (Vartak, 1995; Kak, 2000). The paper examines Sayana's *shloka* that he has decoded from *Rigveda* hymn 1.50.4 to reveal how speed of light was calculated using unit of time as *Nimesh* and unit of distance as *Yojana*. It is argued that the value of speed of light mentioned in Sayana's *shloka* was not just a coincidence, it is calculated based on some rational approach.

Keywords: Sayana shloka, Speed of light

Introduction

Speed of light is a universal constant. Knowledge of its numerical value helps us to understand and predict many natural phenomena. Much before the west calculated the speed of light, it was known to the Indians. In the western world, its value was first determined by Roemer (1644–1710) in 1676. Prior to that, it was believed that light travels with infinite speed. However, Its value was known to Indians since Vedic period (c. 1500 and 1200 BC). The paper examines Sayana's shloka that he has decoded from *Rigveda* hymn 1.50.4 to reveal how speed of light was calculated using unit of time as *Nimesh* and unit of distance as *Yojan*. It is argued that the value of speed of light mentioned in Sayana's Shloka was not just a coincidence, it is calculated based on some rational approach.

Sayana shloka on speed of light

Sayana a vedic scholar (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 (Kak, 1998). More than a hundred works are attributed to him. In his commentary on the fourth verse of the hymn 1.50.4 of the *Rigveda* on the Sun, he says (Mullar, 1890):

"तरणिर्विश्वदर्शतोज्योतिष्कृदसिसूर्य।विश्वमाभासिरोचनम्।
तथाचस्मर्यतेयोजनानांसहस्रम्द्वेद्वेशतेद्वेचयोजने।एकेननिमिषार्धेनक्
रममाणनमोऽस्तुते॥-

Taranirvishvadarshatojyotishkrridasisurya |
vishvamabhasirochanam |
Thhaca smaryateyojananam. Sahasredvedvesate
dveca yojaneekena nimisardhenakramamaa."

Oh Sun! (You) overwhelm all in speed, visible

to all, source of light. (You) shine pervading the Universe. Thus, it is remembered: [O Sun] Bow to you; you who traverse 2,202 Yojan in half a Nimesh.

हे सूर्य, तुम तीव्रगामी एवं सर्वसुन्दर तथा प्रकाश के दाता और जगत को प्रकाशित करने वाले हो। आधे निमेष में 2202 योजन का मार्ग क्रमण करने वाले प्रकाश तुम्हे नमस्कार है।

Bhatta Bhaskara (10th century) has written the same statement in his commentary on the Taittirıya Brahman (Kak, 1999 and Kak, 2000). A copy of Sayana commentary dated 1395 CE is preserved in the central library, Baroda (Shrava, 1977).

How was speed of light calculated?

In the Vedic literature, unit of distance was taken as *Yojan* and unit of time used was *Nimesh*. The measure of these units was well defined. Fifteen *Nimesh* is one *Kastha* and thirty *kastha* makes one *Kala*. Thirty *kala* is equal to one *Muhurta* and thirty *Muhurta* i.e.,

30 ×30 ×30 ×15 *Nimesh* makes one day and night (Gupta, 2010).

15 *Nimesh* = 1 *Kastha*

30 Kastha = 1 *Kala*

30 Kala = 1 *Muhurt*a

30 *Muhurta* = 1 day and night

Number of second in one day and night,i.e., in 24 hour = 24×60×60= 86400.

Hence 1 *Nimesh*

= 86400/ 30×30×30×15 second

=0.21333 second.

According to one publication of Government of India, the value of one *Yojan* is 9 miles 110 yards, i.e equal to 9.0625 miles (Vartak, 1995).

It means that 2202 *Yojan* makes

2202 *Yojan* × 9.0625 mile = 19955.625 mile.

Distance travelled by light in one *Nimesh* is 2202 Yojan × 2

=4404 *Yojan*

= 4404×9.0625

= 39911.25 mile.

Now the speed of light

= Distance/ Time = 39911.25 mile/0.21333 second

=187086.908 mile/second

= 187086.908×1.609 km/s

= 301022.835 km/s.

When this value is compared with the presently measured value of speed of light in vacuum is 299792.458 km/s, error in the value of speed of light as stated by Sayana is found to be 4.1 per cent.

Kak (1999) and Goel (2013), also find the value precisely equal to the speed of light as per modern measurements. Kakh as used the unit of length given in the Arthshastra while Goel has used the unit of length that was prevalent in Indus-Sarswati Civilisation to calculate speed of light represented in the form of the above shloka. Kolhe and Kumar (2006), mention that the speed of light as given in Sayana Bhashya matches with 20th century measurement.

Western ideas about speed of light during ancient and medieval period

In the west, it was believed that light can travel any distance in no time at all. During the ancient and medieval period light was generally believed to travel with infinite speed (Salmon, 1977).

Empedocles (490–430BC), suggested that light from the Sun must take some time to get to earth. Aristotle (384–322 BC), who dominated western science for two millennia disagreed with this assumption and said that light is due to presence of something, but it is not movement. Euclid and Ptolemy built upon Empedocles's ideas and speculated that light was emitted from the eye which enabled sight (Beare, 1984). Francis Bacon (1561–1626), Johannes Kepler (1571–1630) and Rene Descartes (1596-1650) believed the speed of light to be infinite (Mackay and Oldford, 2000). So strongly did Descartes endorse this view that in 1634, he wrote to a friend, "for me this was so certain that if it could be proved false, I should be ready to confess that I know absolutely nothing about philosophy (Holton, 1973)."

Galileo was the first person in the west to measure speed of light. In 1638, he found its value to be ten times greater the speed of sound. Later in 1675, a Danish astronomer Ole Roemer calculated the speed of light to be 220,000 kilometer per second based on his observations of Jupiter's moon as compared to the presently accepted value 299792.458, error in his measurement was 26 per cent.

Sayana commentary is still 300 years older than the first measured value of the speed of light with an error of only 4.1 per cent.

Discussion

Sayana's 2202 *Yojan* in Nimeshadra cannot be just a coincidence, as there are many such accurate astronomical measurement found in the Vedic literatures. It is argued that if prior to 13th century, Indians could find accurate value of many astronomical measurements, is it not possible that Sayana in 13th century can calculate speed of light? Some of such astronomical measurements are mentioned below.

The Indians of the fifth century Common Era calculated the age of the earth as 4.3 billion years, while scientists in 19th century England were convinced it was 100 million years (Teresi, 2002). From the radiometric age dating technique, presently accepted age of the Earth is 4.54 billion years. This value has only 5.28 per cent error.

The period of one sidereal rotation of the earth according to Aryabhata (476–550 CE) is 23 hours 56 minutes 4.1 second (Dutta, 2006). This is remarkably close to the modern value - 23 hours, 56 minute 4.091 second. Error is 0.22 per cent.

Aryabhata has measured mean angular diameter of the Moon as 31'8'' while modern value is 3'8''. (Shukla and Sharma,1976).

Aryabhata in his book *Aryabhatia* (Clark,1930) has written that 1,582,237,500 rotations of the Earth equal 57,753,336 lunar orbits. This is an extremely accurate ratio of a fundamental astronomical ratio (1,582,237,500/57,753,336 = 27.3964693572). This is very accurate astronomical value. Presently, it has been found that the moon orbits the earth once in 27.322 days. Error in Aryabhata measurement is only 0.27 per cent.

Aryabhata accurately calculated the earth's circumference as 24,835 miles, which was only 0.2 per cent smaller than the actual value of 24,902 miles.

In Surya Siddhanta, the rate of precession of the equinox is 54 minute per year, while presently its measured value is 50.3 minute. The error is 7.3 per cent.

Bhaskara II (1114–1185), calculated the time taken for the Earth to orbit the Sun to 9 decimal places (365.258756484). Error is 6.7 per cent when his calculation is compared with the presently accepted value of 365.2563 days.

In his book *Siddhantasiromani* and *Karaakutuhalahe* wrote on his astronomical observations of planetary positions, conjunctions, eclipses, cosmography, geography and the mathematical techniques and astronomical equipment used in the studies.(Sridhar and kumar, 2014).

Not only this, Indian Scholars have always calculated accurately time of sunrise, sunset, eclipse, motion of the planets.

Rajaram (1995), presents quotes of the French astronomer Jean-Sylvain Bailly (1736–93), in his book The Politics of History , "the motion of the stars calculated by the Hindus before 4500 years vary not even a single minute from the tables of Cassine and Meyer (used in the 19th century). The Indian tables give the same annual variation of the moon as the discovered by Tycho Brahe – a variation unknown to the school of Alexandria and also to Arabs who followed the calculations of the school. "The Hindu systems of astronomy are by far the oldest and that from which the Egyptians, Greek, Romans and even the Jews derived from the Hindus their knowledge."

It is obvious that the above value of speed of light was known much earlier,because in his shloka, Sayana says it is remembered (Thus it is remembered: O Sun, Bow to you; you who traverse 2,202 Yojan in half a Nimesh) which implies that the ancient scholars of an even earlier age had calculated the speed of light.

Max Muller, the famous German and Sanskrit scholar published Sayana commentary in the *Rig-Veda Samhita* in 1890. The manuscripts that was used for this publication were dated back three or four hundred years from his times, which means much before the time of Roemer (1644–1710).

Many questions arise here. How could people in ancient India measure the value of speed of light so accurately? What instruments or method was available to them? As during Vedic period, there was a tradition of coding the language and writing in the form of metaphors, complex riddles and mnemonics is the method and instrument descriptions are given in the coded form that are still to be explored?

We know that celestial objects like the Sun, moon and stars appear to move faster when at the top of sky as compared to when at the horizon. This is because light reaches us slightly later when the celestial objects are at the horizon. Did Sayana calculate speed of light based on his keen observations of the celestial bodies in the sky?

Further study is needed to explore all such questions.

Conclusion

This paper presents the facts about the value of speed of light in Vedic literature. Vedic literatures are huge reservoir of knowledge. We can get ideas and hints about numerous concepts in science from these literatures. Schrodinger claims that the Vedic slogan "All in One and One in All" was an idea that led him to the creation of quantum mechanics (Moore, 1989). Kak (2008a) is of the opinion that many ancient ideas of physics available to

us through a variety of sources are generally not known in the Physics world. He (Kak, 2008b) restates that Historians of science are generally unaware of the contributions of Indians to physics.

We need to take a firm step to recognise and acknowledge and preserve contributions of our ancient literature. Our students should be made aware of the contributions of Indian scholars and Vedic literatures to not only the speed of light but other ideas of science also.

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