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Jai Singh: A Tribute to Indian Astronomy

- Gimmi Akkatt[1]

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Introduction

Virendra Nath Sharma's scholarly work *Sawai Jai Singh and His Astronomy* sheds light on the scientific quest and accomplishments of an Indian mind in an age far behind the modern technological wisdom and scientific developments. Nath attempts brilliantly to bring to light the long-forgotten inventions and contributions of an Indian emperor and astronomer to the world of astronomy. This authentic work based on many scattered resource materials in many languages like Rajasthani, Hindi, English, French, German, Latin, Portuguese, Persian and Sanskrit is the outcome of the author's quest to know why Jai Singh built instruments of stone and masonry in an age of telescope.

Jai Singh: The Ruler-Astronomer

Sawai Jai Singh was born on the 3rd November, 1688, in a royal family in the town of Amber in the state of Rajasthan, India. He learned many languages, mathematics, science, astronomy, fine arts and marital arts. When his father died, though he had to cut short his formal education and ascend the throne of Amber on January 25, 1700, he acquired mastery over the subjects of astronomy and mathematics along with the administration of his empire. As a powerful ruler, he used the great wealth and resources available to him for the revival of astronomy

in his country. Within the 20 years of his scientific endeavors, he worked out diverse instruments, constructed observatories, compiled an outstanding library, organized competent astronomers of different scientific background and sent a fact-finding scientific mission to Europe.

The Hindu and Islamic Astronomical Traditions in India

When Jai Singh embarked on the task of reviving Indian astronomy, there were two prominent traditions of astronomy prevalent in India, namely, the Hindu and the Islamic. *Vedanga Jyotisa*, written by Lagadha around 500 B.C., the only text and canon on Hindu astronomy, gives us a glimpse into the Hindu astronomical tradition. The composition of a series of astronomical texts or *Siddhantas* from around 400 A.D., made rapid growth in the astronomy. Varahamihira who summarized five *siddhantas* in his *Pancasiddhantika*, Aryabhatta, Bhaskaracarya I, Brahmagupta, Lalla, Vatesvara, Sripati, and Bhaskaracarya II are some of the prominent figures in the history of the Hindu astronomical tradition. Despite the reluctance of the Indian astronomers to accept the astronomical insight of the West, there were noteworthy astronomers between the period of Bhaskaracarya II and Sawai Jai Singh.

Mahadeva compiled planetary tables (*Mahadevi Sarani*) in 1316 to calculate the apparent and mean positions of the planets. Makaranda wrote a text for preparing a *Pancanga* or almanac and Kesava II made a good contribution to astronomy through his work *Grahakautuka*. Ganesa Daivajna's *Grahalaghava* and Nityananda's *Siddhantasindhu* on the subjects of astronomy were very popular. Many texts and treatises on instrumentation were written during the period between Bhaskaracarya II and Jai Singh. *Yantraratnavali*, a treatise on instruments written by Padmanabha, *Yantracintamani*, a treatise describing the quadrant by Cakradhara, *Jyotimimamsa* of Nilakantha are only a few of them. Though the early instruments of Hindu astronomy were rather simple, the dawn of the 18th century witnessed the construction of a large variety of complex instruments. A variety of time measuring instruments portable and small in size show that the main concern of Hindu astronomers was with the measuring of time than measuring the coordinates of stars and planets.

The invasion of India around 1000 A.D., from the Northwest marked the advent of Islamic art and science. Many Muslim scholars migrated to India with the ascendancy of the Mughals and brought with them astronomical literature such as *Zijes*, which consist of numerical tables to measure time and to compute planetary and stellar positions, and the appearance of the moon and eclipses. Jai Singh's primary source of inspiration was the Islamic school of astronomy. Though most of the contributors of this school were followers of Islam, major contributions were also made by Zoroastrians, Sabians, Jews and Christians.

By the time Jai Singh began his scientific career, European astronomy had made remarkable advances in the theoretical and the observational aspects of this branch of science. Copernicus (1473-1543) in his *De Revolutionibus Orbium Coelestium* revived the Greek idea of heliocentric cosmos. In 1609, Kepler (1571-1630) expounded the first two laws of planetary motion in *The New Astronomy* and the third law of planetary motion was published in 1619. Newton, in *Principia* depicted the laws of mechanics and those of universal gravitation.

A Designer of Astronomical Instruments

Jai Singh built *Dhat al-Thuqbatayn* or dioptra, an instrument to determine the diameter of the orbit of the planets. In the *Yantraprakara*, we find a description about *Dhat al-Shuhatayn*, the instrument Jai Singh designed to measure the zenith distance of an object such as moon. Another instrument Jai Singh designed was *Dhat al-Halaq* or armillary sphere to determine the longitude of the rising point of the eclipse and the time elapsed since sunrise in the afternoon or remaining till sunset in the afternoon. The *Suryasiddhanta*, written around 400 A.D., has already mentioned about a rudimentary armillary sphere.

The *Samrat Yantra* or the "Supreme Instrument" designed to measure the local time or apparent solar time (not the standard time of a country) is Jai Singh's most important contribution. He designed *Sasthamsa Yantra* to measure the declination, zenith, distance and the diameter of the sun. The *Sasthamsa* of Jaipur observatory is one of the most accurate instruments of Jai Singh that still maintains the precision. The *Daksinottara Bhitti Yantra*, a modified version of the meridian dial

of the ancients, is used to measure the meridian altitude or the zenith distance of an object such as the sun, moon, or a planet. In the opinion of Jagannatha, it was with this instrument that Jai Singh established the obliquity of the eclipse in 1729 (p. 66). The *Kapala* and *Jaya Prakasa Yantras* are designed to indicate the local time and to measure different astronomical parameters, like the coordinates of a celestial body. Jagannatha, in his *Samrat Siddhanta* gives us a detailed description of the construction of the instrument. Though there is a mention of *Kapala* in *Suryasiddhanta*, the canon of Hindu astronomy, there is nothing in common with the *Kapala* constructed by Jai Singh.

Nadivalaya is an equinoctial sundial to indicate the apparent solar time of the place. This is an effective instrument to show the passage of the sun across the celestial equator. Jai Singh built *Digamsa yantra* at Jaipur, Varanasi, and Ujjain to measure the angle of azimuth of a celestial body.

Jai Singh's Observatories

Jai Singh constructed observatories at Delhi, Jaipur, Mathura, Varanasi and Ujjain, which were completed between 1724-1735. The Delhi observatory was constructed around 1724. Many foreign travelers some of whom have given us valuable information about the observatory visited Delhi, being the imperial capital. According to the visitors to the observatories like Tieffenthaler, W. Franklin, William Hunter, William Daniel, Leopold Von Orlich and Garcin de Tassy, the Delhi observatory had seven instruments of high precision. Along with many visitors, Claude Boudier, a French Jesuit who visited the observatory hailed the precision and accuracy of the measurements obtained by the instruments at the observatory.

Tieffenthaler speaks about the instruments that it "is astonishing and striking for the novelty and size of the instruments" (p.125). The great *Samrat Yantra* in this observatory is the "largest sundial in the world." Kapala is the only instrument at the Jaipur observatory to convert graphically the horizon system of coordinates into the equatorial system and vice versa. Robert Barkur who came to India in 1748, was curious about the astronomical wisdom of the Indians (p.193). Many travelers

visited the observatories at Varanasi, Ujjain and Mathura and gave a detailed account and admiration of the observatories.

Jai Singh's Intellectual Pursuits

Jai Singh had an excellent set of books on mathematics, astronomy and astrology for his library. He also wrote a *zij* or a set of astronomical tables, which made the computation of the occurrence of celestial phenomena easier and gave rules and regulations for calendar transformations and trigonometry and spherical astronomy (p. 236). Jai Singh has, to a certain extent, depended upon the *Tabulae Astronomicae* of De La Hire (1640-1718) to complete his work. His earnestness in constructing observatories and the making of an excellent library on astronomy, astrology, and mathematical subjects in different languages give us a glimpse into his interest in astronomy. A large group of scholars with background in different astronomical traditions was participants in his astronomical endeavors.

Because of various reasons, Jai Singh's astronomical endeavors could not usher in a new age of astronomy in India. Under the pathetic condition of communications between Asia and Europe during the 17th-18th centuries, an Eastern scholar like Jai Singh could easily remain ignorant of the contemporary scientific advances in Europe. The inflated view of the biased and tradition-bound scholars of India, especially the Brahmins about their own science and culture made it difficult to be open to anything relevant coming from the West. Their acceptance of S*uryasiddhanta* as the divinely inspired text on the complete astronomical knowledge made them complacent and less curious about the scientific developments in Europe. Brahmin pundits had their religious taboo against "crossing the ocean," the violation of which would lose their caste. Besides, the Europeans especially the Jesuits, had to reject Copernicus and Kepler because of their theological beliefs and allegiance to their superiors.

A Man Ahead of His Times

The primary objective of Jai Singh's endeavors in astronomy was to revive the existing astronomical tables. He constructed observatories

and equipped them with masonry instruments many of which were designed by Jai Singh himself. Though he recommended the future kings to advance the efforts in astronomical observations, the astronomical pursuits at Jai Singh's observatories came to an end with his death. He patronized scholars of Hindu, Persian, Arab and European astronomical traditions.

Jai Singh's European assistants on whom he depended for the information of neo-astronomical advances, primarily the Jesuits, were threatened of inquisition if they "hold or defend the views supported by the discoveries of Kepler or Galileo" (p. 311). Jai Singh was more interested in observing and mathematically predicting the positions of the heavenly bodies. Boudier, after visiting the Jaipur observatory, writes: "he (Jai Singh) is the most capable astronomer in India. Jai Singh was interested in the prediction of solar eclipses, and in calculation of the occultation of stars and planets by the moon" (p. 312).

Jai Singh's major contribution to India was *Zij-I-Muhammad Shahi*, a set of astronomical tables based on his observations. Despite Jai Singh's genuine interest and multifaceted efforts, he could share the concerns and interests of only the medieval astronomers of Islamic period. His various undertakings and astronomical ventures could not mark the beginning of a modern age in science in India. He was modern in his approach and open to novel scientific ideas. Jai Singh realized more than anyone else that fresh ideas and the spirit of Islamic and European traditions are to be infused into the astronomy of the country. Jai Singh was an enlightened scholar, a man far ahead of his times, in his outlook and endeavors. And in presenting Jai Singh and his accomplishments in its comprehensiveness, the book *Jai Singh and His Astronomy* is also a testimony to the painstaking efforts by the author Virendra Nath Sharma.

[1] Gimmi Akkatt did his Masters in Philosophy at Jnana Deepa Vidyapeeth, Pune.