

THE IMPACT OF MODERN EUROPEAN ASTRONOMY ON RAJA JAI SINGH

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(Received 30 May 1978; after revision 30 September 1978)

The paper has been dealt in three parts. The first part gives (i) a brief life sketch of Jai Singh, his interest and proficiency in Mathematics and Astronomy; (ii) his study of astronomical works of his predecessors; and the (iii) building of observatories, the first attempt of its kind in India.

The second part is devoted to his quest for modern astronomical knowledge; (i) before; (ii) during and (iii) after the observatory was built. This includes his mission of Portugal under Pedre Figueredo; Jesuit Missionaries from Chandernagore; and request to the Portuguese Governor of Goa to arrange the visit of Jesuit scholars from Bavaria.

In the last part, an analysis of Jai Singh's Tables has been made. It is found that Kepler's second law was applied to, in the explanation of Planetary Motion, explained by a combination of circular motions. Effort was made to acquaint with telescope and its construction by Court artisans. The instruments were used to observe the phases of Venus and Mercury, the satellites of Jupiter, the ellipsoidal shape of Saturn, the sun-spots and their rotation, and the stationary nature of fixed stars.

"Lamp is lighted from lamp" is the invariable law of the history of civilization and Jai Singh was no exception. For his achievements in the fields of mathematics and astronomy, he was to a very great extent, indebted to the labours of his predecessors. Three scientific traditions contributed to Jai Singh's achievements : the ancient Hindu *Jyotiṣa Vidyā*, the mediaeval Greco-Arabic *Ilmul-Haiat*, and modern European astronomy. But whereas writers on Jai Singh have noticed the influence of the first two traditions, little note seems to have been taken of the extent to which modern European astronomy exercised its influence upon him.

Jai Singh was born in 1686 A. D. and was hardly a boy of thirteen, when he was called upon to shoulder the responsibilities attached to the Raj Gaddi of Amber. Thus the period of regular schooling he received was extraordinarily short. But as he had a natural aptitude for the sciences of mathematics and astronomy, he

*Paper presented at National Seminar on "Technology and Science in India during 1400-1800 A.D." held at Indian National Science Academy, New Delhi; April 20-21, 1978.

obtained a thorough knowledge of their rules and principles and solved a number of obscure problems that had baffled his predecessors¹. One of these problems was the determination of the sine of one minute. Ullugh Beg had only been able to find out the sine of one degree².

But Jai Singh went one step further. He solved the problem of finding the sine of an arc, one fifth of another one whose sine is known. With the help of this discovery, he was able to determine the sine of a minute as well³.

But more important were his astronomical contributions. He built the first observatory in India, and as the traditional instruments of brass could not satisfy his exacting standard, he replaced them with new ones of far bigger size, and constructed in lime and stone⁴. And therein lies his originality.

Still his inquisitive mind could not remain content with the knowledge he acquired from texts on Hindu *Jyotiṣa* and Greco-Arabic astronomy. He had learnt that in the West too, astronomical researches were being pursued with utmost vigour⁵. So he would not miss to avail himself of the new discoveries and would verify them with his own observations.

Jai Singh's contact with modern astronomy began much before 1724 A. D. when he commenced building the observatory at Delhi and lasted till his death in 1743. This period of more than nineteen years may be divided into three stages : before the construction of the observatory, during the construction and working of the observatory, and after it was completed.

1. *Before the building of the Observatory :*

Jai Singh says that he had studied some European astronomical tables (*Zij-i-Firangi*)⁶ along with those compiled by Hindu and Muslim astronomers in his early years and it was when his exacting standard could not be satisfied with them, that he referred the matter to the Emperor. The latter commanded him to build an observatory which was commenced in 1724⁷. It is not clear exactly which European 'Tables' were consulted by him in his earlier period.

2. *During the building and working of the Observatory :*

Jai Singh says that while ordering him to build the Observatory, the Emperor asked him to utilise the services of European Scholars (*Danayan-i-Firang*) as well along with these of Brahmans and Muslim geometers and astronomers⁸.

Naturally the Raja must have had frequent discussions and exchanges of scientific ideas with these European scholars; but their names and identities remain obscure.

3. After the Observatory was completed :

This is by far the most important stage in the contact of the Raja with European astronomical literature and scholars thereof.

The Raja says in the Preface to his "*Mohammad Shahi Tables*" :—

"After seven years had been spent in this work, information was received that about this time observatories had been constructed in Europe and that the learned scholars there were busy in prosecuting this important work, that the work of observation was still continuing there and that they were constantly making researches into the subtleties of this science. Hence a number of reliable persons well versed in this science were sent to Europe along with Padre Manuel.

They procured (and returned with) the new tables constructed there under the title '*Hir*' (de L '*Hire*') of which revised edition was published thirty years ago"⁹.

The mission was well received by the King of Portugal, as it was suggested to him that friendly relations with the Raja would be highly useful not only for the protection of Portuguese territories in India, but also for the propagation of Christian religion¹⁰. So he sent a Portuguese Scholar Xavier de Silva with a number of astronomical tables, chief among them being that by L Hire¹¹. But more important from our point of view was the telescope, which we are told by the author of '*Asaral-Sanadid*', Padre Manuel's mission brought with itself to India¹². The mission was back in India by the end of 1730¹³.

But L '*Hires*' Tables could not prove helpful because the timings of different celestial phenomena as calculated according to this "*Tables*" were found widely differing from those obtained by actual observation¹⁴. But what proved a still more difficult problem was that even de Silva could not solve these anomalies.

Hence the Raja was obliged to refer to French Fathers Pons and Boudier. He sent five questions to them and finally requested the French authorities of Chandernagore to send them to Jaipur. His request was granted and the Fathers started in January 1734¹⁵. They reached Jaipur, but an unfortunate quarrel arose between the visitors and local Pandits as to the extent to which Indian *Jyotiṣa* was indebted to Greek astronomy¹⁶.

Moreover the climate of Jaipur did not suit the visitors and they were obliged to return by the end of the same year¹⁷.

Now the Raja wrote to the Portuguese Governor of Goa to arrange for the visit of some European mathematicians. The Governor secured for him the help of two Bavarian Jesuits Gabellaberger and Strobel. Though there were some hurdles in their reaching Jaipur, they reached there in March 1740¹⁸, and the Raja received

them with utmost honour and provided every facility¹⁹. But then Gabelsberger fell ill and died in 1741. Two years later the Raja also breathed his last. Strobel, who survived him, remained for sometimes more in Jaipur²⁰.

TRACES OF MODERN ASTRONOMICAL DISCOVERIES IN JAI SINGH'S TABLES

The basic idea of modern astronomy, i.e. its helio-centric concept of the Universe as prevailing during that period did not appeal to Jai Singh to whom "*Almagest*" was not only "*Megalia Syntaxis*" but also the "*Samrāt Siddhānt*" in the literal sense of the word, and a loyal devotee can not think of ever revolting against the *Samrāt*. Hence it is not surprising that Jai Singh refused to follow the lines of research indicated by the European astronomy²¹. Neither could it appeal to his Chief Assistant Mirza Khairullah Muhandis, who had such a high regard for the *Almagest* that he transcribed his copy of this work with his own hand²² and then wrote a detailed commentary upon it²³. Nor could it appeal to other investigators of the Observatory, who had been brought up in the traditions of Aristotilian physics. The change-over from geo-centric to helio-centric principle could hardly be palatable to them.

However, the stories of seventeenth century discoveries of European astronomers trickling in the Delhi Observatory through European Scholars and the invitees from Portugal and Bavaria could not leave the Raja and other investigators impervious to them. Clinging to the basic principle of Ptolemaic system that the earth is stationary and occupies the central position in the universe, they yet appreciated some of the new discoveries. These may be considered in two categories; theoretical and practical.

- (1) *Theoretical : Kepler's "First law" applied to explain planetary motion hitherto explained by a combination of uniform circular motions.*

The European scholars with whom the Raja and his assistants came in contact must have narrated how Copernicus and his successors had arrived at their epoch making theories. Of these the "First Law of Planetary Motion" which Kepler took some eighteen years to formulate was of special interest to them. Like their counterparts in the West, astronomers in the East, had become concerned at the Plethora of epicycles and the ever increasing number of deferents, which the existing theory necessitated. Mulla Mahmud Jaunpuri alludes to this insoluble problem in his "*Shams-Bazigha*" as follows :

"Though the number of spheres proposed by Ptolemy may suffice for resolving the anomalies with regard to acceleration and retardation, but the following problem still remains unsolved, namely how is it that the centres of epicycles in the case of planets revolving round the centre of an imaginary sphere called "Equant" with uniform velocity, and in the case of the moon round the centre of its deferent, which

coincides with the centre of the universe; and how is it that they do not revolve with uniform velocity round the centres of their deferents, as is evident from the principles. For this reason, later astronomers have increased the number of component spheres, but hold conflicting views regarding the demonstration. One who desires to acquaint himself with details thereof must consult commentaries on *Tazkira*²⁴."

So to Jai Singh and his Chief Assistant Mirza Khairullah Muhandis, Kepler's first law of planetary motion was a God-sent blessing. They discarded the principle of circular motion that had kept astronomical computation in its iron grip ever since the times of Plato and Eudoxus to that of Khairullah's elder brother Imamuddin Riazi, the author of *at-Tasrih* and substituted in its place Kepler's first law after divesting it of its helio-centric content.

Raja Jai Singh declares his acceptance of the principle of "Elliptic Orbit". But before making this declaration, he describes the methods of approach adopted by the ancient and modern (European) astronomers.

He says : "The ancients (Hipparchus and Ptolemy) remained attached to the curve they supposed the planet to describe and it has always been a circle.

(As against this) the European astronomers always emphasize the observed positions of the star and give no importance to the form of the curve, it is supposed to describe²⁵."

Then he gives his own method of approach, which is to reconcile between the two. He says :—

"What I understand is that the form of planetary orbit be declared in accordance with the findings obtained after minute observations, so that both of these methods of approach be taken into consideration. Hence after utmost efforts and deep thinking, such forms were determined as when calculation is made in accordance with their perquisites, calculated positions be as approximately near the observed ones, as possible²⁶."

After this preliminary remark, he specifies the curve that best suited the purpose of bringing the calculated and observed results close to one another. He says :

"Before anything else it must be known that the orbit of the Sun's eccentric sphere (ecliptic) has been proved to be of the form of the surface of an ellipse²⁷."

Likewise he speaks of the elliptical orbit of the moon—

"It may not remain unknown that for determining the four equations of the moon from the centre of the earth, let the ellipse TLXM be the orbit of the centre of the moon"²⁸.

But more clear and lucid is the exposition of the same subject given by Mirza Khairullah Muhandis. Maulvi Ghulam Husain quotes in his *Jame Bahadur Khani* from Khairullah's Commentary on *Zij-i-Mohammad Shahi* as follows :—

“Mirza Khairullah Muhandis declares in his commentary on *Mohammad Shahi Tables* : We have found the orbit of the Sun as well as those of all deferents of elliptical form. Our argument is that whenever we calculate the different positions of the Sun and other planets in accordance with equations of the circle, they do not conform with the actually observed ones. On the contrary, when the equations are derived taking the orbit to be elliptical and calculate the position, they generally conform with observations. Hence the orbit must be elliptical²⁹.

(b) *Practical : Acquaintance with telescope and verification of modern discoveries.*

The telescope which had revolutionised astronomy in the west, was also imported into India and local artisans of Jai Singh's household manufactured their own telescope as powerful and excellent as their European prototypes. The Raja employed this locally constructed telescope for sighting the new moon. Thus the old cumbersome method of determining the time of the visibility became obsolete and discarded. He says :—

“As our artisans have constructed the telescope so excellent that with its aid we can see bright and luminous stars even about midday in the middle of the sky, by employing such powerful telescope, the new moon can be seen even before the time, the astronomers have determined for its rays to begin emanating. And also after it has entered the prescribed limit of its invisibility, it still remains visible (through the telescope)”³⁰.

It (the telescope) provides the same facility in the case of other planets with regard to their appearance and disappearance and also with regard to the rising and setting of lunar mansions.

He says :—“The same is true with regard to the appearance and disappearance of the remaining five planets and also the rising and setting of lunar mansions”³¹

Then he set to verify what was told to him about the discoveries made by Galilei and others and to his great joy, he found them true. They were four in number, namely :—

1. The phases of Mercury and Venus, first discovered by Galilei in 1610.
2. The ellipsoidal form of Saturn, which Graco-Arabic astrophysics believed to be perfectly spherical having all its diameters equal.

3. The satellites of Jupiter which had constituted the first discovery made by Galilei with his telescope in January 1610.

4. The sun-spots and their rotation, the most important discovery made by Galilei, which had cost him his eye-sight.

We quote in his own words :—

“We also found the form and behaviour of some of these planets contrary to what the earlier scholars have recorded in current works. They are as follows :

First : We observed with our own eyes that Venus and Mercury receive light, like the moon, from the Sun, because we found that their light is diminished or increased according to their distance from the Sun.

Second : We have observed Saturn and found that it has the form of an ellipsoid, i.e. of its two diameters intersecting at right angles, one is smaller and the other, longer.

Third : We found four brilliant stars approximately near the equator of Jupiter revolving round it.

Fourth : We saw a number of spots distinct from one another, on the surface of the Solar disc and found them completing their round on the Sun along with the rotation of the Sun itself in about one year”³².

One more deviation that Jai Singh made from the traditional Greco-Arabic astronomy also seems to have been made as a result of Western influence. That was related to the stationary (or otherwise) nature of the so called “Fixed stars”. Ptolemaic astronomy divides the stars into two categories; the wandering stars called “Planets” and the stationary or “Fixed Stars”. The latter were conceived as fixed and immovable. It was conceded by some astronomers that they make a very slow and imperceptible movement taking thousands of years to revolve round the earth. But even these later scholars gave this “motion” to the sphere of the fixed stars as a whole and not to individual stars severally. Whether considered fixed and stationary or moving imperceptibly, they maintain their positions relative to one another intact.

But Jai Singh in the seventh section of the “Khatima” of his *Zij-i-Mohammad Shahi*, while bringing up to date the Star Catalogue of Ulugh Beg, refutes the stationary nature of the so called “Fixed Stars”. He says :—

“Those stars that are termed “Fixed Stars” in the terminology of astronomers are not fixed and stationary in reality. Nor do they move with one rate of velocity, but with different velocities”³³.

This is of course yet another discovery borrowed from modern European astronomy.

Such, in short, was the impact made by modern (European) astronomy on Jai Singh. Perhaps he might have been influenced further had he been able to pay yet greater attention to his favourite field of knowledge, and then "instead of his labours ending with his death when science expired on his funeral pyre, there might have been established a living school of research"⁸⁴.

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