Chintamani Ragoonathachari and contemporary Indian astronomy

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Chintamani Ragoonathachari[1] (1840–80) served the Madras Observatory under various cadres. His meticulous contributions fetched him the honour of membership of the Royal Astronomical Society. He conducted two solar eclipse expeditions in 1868 and 1871, and was the first Indian to be credited with the discovery of two variable stars, R Ret and V Cep.

The transit of Venus which occurred in 1874, was a great astronomical event observed by many Indian and European teams on the Indian soil. Ragoonathachari prepared a treatise on this subject sometime in the early part of 1874. The English and Kannada versions are available at the archives of the Indian Institute of Astrophysics, Bangalore. Here a comparative study of the two texts is done to demonstrate the new light it throws on the status of contemporary Indian astronomy.

The two texts

It is widely publicized that Ragoonathachari[1] authored a book on the Transit of Venus in English and Indian languages. The archival collection has the cover page of the Persian version. The entire texts of the English and Kannada versions are available[2,3]. A couple of pages are missing in the Kannada version. They correspond to the diagrams at the end of the text. Since these diagrams are identical with the English version according to the figure captions, the text may be considered as complete.

At the outset the two versions appear to be one and the same; however, a careful study shows that there is a variation. It is interesting to note that the same content has been presented differently to suit different readers. The English version has the text in the form of a dialogue, where a Siddhanti (scientist, astronomer aware of modern/European astronomy) answers and convinces the Indian pundit on the importance of the event.

The Kannada version

The mode of presentation in the Kannada version is different. It is not in the form of a dialogue, but a smooth reading text. Some astrological aspects are also discussed, citing from older scriptures. The language is simple and reads through without much complication. However, it is interesting to note that mathematical symbols and formulae have been avoided and the same is expressed as long sentences. This tries the patience of a reader, since every word has to be written down as a unit and the mathematical symbols introduced. At the same time, it provides an opportunity to use technical words and some have been coined for this purpose. For example, the word 'riputpashika' (caused because of the enemy) was used by astrologers to mean the conjunction of two planets. It would have been the same with transits, since the sun is also considered a 'planet' in the sense of a moving object. A new word 'shukra grastha surya grahana' has been coined to indicate the eclipse of the sun by Venus. Two new words for the maximum and minimum distances of a planet from the earth are coined as 'paramakarshana' and 'sannikarshana'.

The book addresses local astronomers who were perhaps well versed in Sanskrit as well as mathematics. The explanations offered for the transit are simple and can be easily understood.

The first few sections are devoted to the explanation of the phenomenon like inferior and superior conjunctions. The event of transit is explained in terms of the conical shadows caused by Venus. A person close to the planet will see total, annular or partial eclipse depending on his distance within the cone or outside. As he moves farther and farther from the planet, the same event will be termed a transit. This is explained with the help of a diagram and extended as a general expression for a shadow either from the moon or Venus. To clarify the point that a total eclipse of the sun will not be visible from the earth (in the context of the shadow of Venus) the expression used is: 'All these varieties of eclipses will be visible only to those celestial beings like Yakshas, Gandharvas and Kinnaras, since we cannot reach those heights . . . .'

Subsequent sections explain the importance of the event in the determination of the precise value of the astronomical unit (AU). The derivation of parallax from transit observations is relatively simple compared to the description of Halley[4]. (See appendix for the complete derivation which is not available in the English version too. Moreover, there is a typographical error in the equation.) The pros and cons of an approximate value for this unit for AU are explained in detail. The derivation is explained using circular orbits; but it is mentioned that the corrections according to the elliptic orbits are necessary.

Kepler's law is explained as a mere statement. It reads:

> 'The square of the orbital period should be multiplied by a number called Beeja to get the cube of the semi-diameter of the orbit by the square of orbital period of any planet.'

Beeja is a constant defined as the ratio (T^2/a^3) of the earth. Using the accurate value of AU, the deduction of the distances to the planets, their diameters and volumes is also explained. There is an unusual way of defining the volume of a sphere – as the product of the circumference and square of diameter divided by 6.

Parallax is introduced to the reader in a simple way. The corresponding drawings also are clear and precise.

Later sections are devoted to the details of the event of 1874. The timings for various locations are listed. The need for observations from different latitudes is highlighted and examples of planned locations are given. The method of determination of parallax also is described in simple terms. The notation of Jya which is equivalent of product of R, a constant, with sine of an angle is used and the formula is modified to suit this notation (see appendix). But the most interesting are the last three sections which are completely missing in the English version.

Appeal to Indian astronomers to take up observations

The last three sections deal with an emphasis on the need for observations. The astrological predictions also are mentioned, but the emphasis is on revival of observational techniques. It states:

> 'Many astronomers in this country have been doing calculation of celestial events like eclipses, conjunction of planets following texts which were written several centuries ago. Thus there is always a difference of five galige in eclipses, for others it is about 12 galiges and for planetary positions it is almost two months. The main reason for this is not updating the calculations from time to time'.

Galige and Vigalige are measures of time. In order to initiate the local astronomers into actual observations, he gives details of an occultation and eclipses of the same year. He calls them interesting and enjoyable experiences. One of them is the daytime occultation of Venus by the moon. It is said that this should be observable in the northeast at noon. Perhaps this has been suggested as an attraction to observe the event during broad daylight. It also raises doubts on the visibility, whether the skies were good enough for the daytime visibility or whether the use of a telescope or binoculars was implied.

The text also gives a clue on the contemporary method of computations. All calculations that are provided in the table have Chennapuri (Madras/Chennai) as the reference and for the different places the correction for longitude is offered in minutes. Further, the actual timings of the event are given in terms of Shankuchchaya, which is the length of the shadow of a gnomon of 12 in. There is a subunit indicated with the abbreviation as vyam, which may mean a fraction of an inch, now forgotten. One may infer that a person interested in observing the event had to set up a gnomon and monitor the shadow length. Simultaneously, he had to watch the sun for catching a glimpse of the dark spot of Venus on the disc. How the two things had to be achieved practically remains a mystery. The daily observation of the meridian transit of the sun as a ritual is hinted at as an essential technique for fixing the thithis.

The last section also deals with citations from various texts, old and new, which emphasize the need for observations. Some of the texts like *Brihat Samhita* and *Griha Laghava* are well known. However, there is a mention of some authors whose works were perhaps used as reference books. They are Mallari Bhatta, Papu Devashstri of Kashi Vedhashala, Srinivasa Dikshit, Vaidyanatha Dikshita and Raja Tolappa, whose works have not been documnented anywhere. He further refers to correspondence with Papu Devashastri. It may be worth searching the books of these scholars.

The Indian context

Although Ragoonathachari served the colonial government, he was aware of the local expertise and drawbacks in this field. He has put forward a suggestion for setting up not one but several observatories in India, arguing that a small continent like Europe has several observatories.

Ragoonathachari expresses concern about the valuable Sanskrit texts and offers to render them into English. This request appears in the English version of the text available in the archives[3]. (It appears that he was not well versed in Sanskrit, according to the statement. This is also reflected in the fact that there were several typos and grammatical errors in the Sanskrit verses written in Kannada script; these were corrected with the help of the original texts)[5]. He has put forward a request for a sum of Rs 6000 for printing the copies to be distributed to a selected list of people. He also mentions that the proposed title is *Jyotishya Chintamani*. There is a mention of the financial help from the Nizam of Hyderabad of Rs 1600; this may be the reason for offering to bring out the book in Telugu also. (He does not specify the third language planned for translation.)

This text may be used to infer some personal details about the author; for example, his mother tongue. According to language specialists[6], the Kannada text is authored by him and is not a translation. This is inferred from the clarity in the language and the flow. Mastery over the content also is immediately apparent. The figures are identical in the English and Kannada versions, with numbers and legends. However, in the Kannada text, reference to figure 3 appears before figures 1 and 2, indicating that it was written after the English version was prepared and planned independently. There is a reference to Madhwacharya, which may hint at the author's affiliation to the Vaishnava community, established in Udupi, Karnataka. The manuscript appears to be handwritten and printed perhaps using a technique like lithography. This may be partly responsible for the many spelling mistakes which could not be corrected.

It appears that there was a strong opposition from traditional astronomers for the adoption of correction based on the European system of calculation. Each school continued making calendars according to the texts prescribed by their religious leaders. As a consequence the errors added up to large values, although by different amounts. Ragoonathachari specifically refers to *Thithi Nirnaya* by Madhwacharya. After several citations in his defence, he argues that correction by actual observations is the only solution. It is interesting to note that he cites some verses whose sources are unknown[5]. It is worth searching those references, which are likely to throw light on the development of Indian astronomy during the colonial period. He concludes with the following statement which is valid even today:

> 'There is an objection raised by many people that these observed timings are unsuitable for religious ceremonies because several timings which need to be observed with great difficulty show lot of discrepancy although the timings are exactly agreeable in case of eclipses. This book gives the opportunity to absolve these objections and I appeal to all the experts and religious authorities to view this book without bias and publish their opinions supported by sacred scriptures.'

Appendix

The method of estimation of the parallax of sun

The text describes a simple explanation of this procedure. The diagram (Figure 1) is redrawn here with more legends for the sake of clarity.

Consider the view from above the orbital plane, i.e. the ecliptic. S is the sun, circle A B C D denotes the equator of the earth. Let us assume that four observers are located at these points. The orbit of Venus is marked and the position of Venus is given by V and V' at two different instants, which will be defined now. The observer at A sees the western edge of

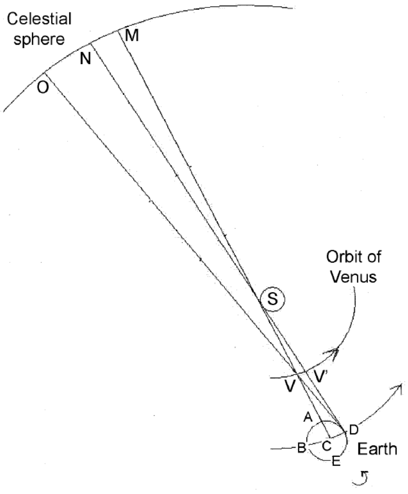

Figure 1. The geometry of transit of Venus as described in the text.

Venus touching the eastern edge of the sun at an instant *T*, such that the sun (and Venus) is on his meridian. As seen by the observer at *D*, the sun is rising at his eastern horizon and Venus is far away from the sun. He cannot see Venus owing to the brightness of the sky. The parallax of Venus is defined as the angle subtended by Venus at the earth's radius. This angle *CVD* is difficult to measure. Now we may extend the lines *CV* and *DV* to the celestial sphere to *M* and *O*. Thus *MVO* will be same as *CVD*.

Horizontal parallax of Venus = angle *CVD* = *OM*.

The parallax of the sun also is defined with the radius of earth as the base. Angle *CSD* is the parallax of the sun. Extending *CS* and *DS* to the celestial sphere we notice that *CSD* is the same as *MSN*.

Horizontal parallax of sun = angle *CSD* = *NM*.

It can be shown that

$$\frac{\sin CVD}{\sin CSD} = \frac{CS}{CV}, \tag{1}$$

since the angles involved are small.

The advantage of this explanation over the method given by Halley is clear from the following equation.

$$OM = ON + MN, \tag{2}$$

where *OM* is the parallax of Venus, *MN* = parallax of sun and *ON* = Relative parallax of Venus with reference to the sun = parallax of Venus – parallax of sun.

Let *V′* be position of Venus seen by the observer at *D* at the instant *T′*. *VV′* = Relative parallax of Venus with reference to the sun = *ON*.

At the instant *T′*,

$$\frac{\text{Parallax of Venus}}{\text{Parallas of sun}} = \frac{1000}{277}. \tag{3}$$

Here we assume that if 1000 units correspond to the distance of the sun, 723 is the distance to Venus. This ratio was accurately known.

Equations (2) and (3) are written in the Kannada version as long, complicated sentences. Equation (2) may be rewritten as:

$$\frac{\text{Parallax of Venus} - \text{Parallax of sun}}{\text{Parallax of sun}}$$

$$= \frac{1000 - 277}{277} = 2.61. \tag{4}$$

The numerator in eq. (4) is the relative parallax corresponding to *VV′* or *ON*. The transit of Venus gives an opportunity to measure this precisely. As mentioned earlier, the observer at *D* can, in principle, measure this angle. However, in reality this is not possible. Therefore, he waits for Venus to reach *V′*, which corresponds to the first point of contact as seen by him. This implies that the time difference between sunrise and the first contact is a measure of *VV′*. Thus, it is important that the observations be made at places separated by 90 degrees of longitude.

Equation (4) is written in the English version (p. 14) as

$$\frac{\text{Relative horizontal parallax}}{\text{Sun's horizontal parallax}} = \frac{723}{277}. \tag{5}$$

Here the equality symbol '=' appears as '–', causing confusion.

Thus the parallax of the sun is obtained precisely. The ratio 2.61 can also be calculated precisely knowing the relative positions of Venus and the earth in their respective orbits. The text further describes the estimate of the distance to sun as

Sine of the horizontal parallax of the sun

$$= \frac{\text{Earth's radius in miles}}{\text{Sun's distance from the earth}}. \tag{6}$$

This is a simplified version of the method described by Halley, who generalizes it to any two longitudes.

The convention of the Indian method namely writing the sine as Jya, is followed in the Kannada version. The tables of Jya were available with mathematicians in this format. Therefore, the result has to be divided by *R*, which is called Trijya.

1. Archives of IIA; http://hdl.handle.net/2,248/1329
2. Archives of IIA; http://hdl.handle.net/2248/1326
3. Archives of IIA; http://hdl.handle.net/2248/1321
4. Woolf, H., *The Transit of Venus*, A Study of Eighteenth Century Science, Princeton University Press, 1959.
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6. Venkatasubbaiah, G., 2008, pers. commun.

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