

PARILEKHANA: THE GEOMETRY OF CELESTIAL EVENTS IN CLASSICAL INDIAN ASTRONOMY

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Abstract: The discussion relevant for explaining any celestial event, was a crucial aspect of all Classical Indian astronomical texts. Each text contained a chapter titled *Parilekhana*, provided instructions for creating these diagrams.

This paper presents examples from different manuscripts, to illustrate the techniques used. The diagrams vividly demonstrate the perceptual differences between the East–West directions. *Śṛṅgonnati*, the section for depicting the orientation of the cusps of the Moon, also features pertinent diagrams.

Keywords: *Parilekhana*; astronomical drawings; eclipses; *valanāśraya vṛtta*; *ayanavalana*; *akṣavalana*.

1 INTRODUCTION

पूर्वापरायतां तद्विस्तारपाश्वके।
दर्शयेच्छिष्य बोधार्थं लिखित्वा छेद्यकं सुधीः।

pūrvāparāyatām
tadbhitāvuttarapāśvake
darśayecchīṣya bodhārthaṃ likhitvā
chedyakaṃ sudhīḥ: |

Astronomical phenomena are demonstrated to students by drawing them on the northern wall, with the illustrations extending from east to west.

The importance of drawings in understanding the concepts involved in astronomical events is quite apparent in the above verse from the twelfth century text *Siddhāntaśiromaṇi* by Bhāskarācārya II. See, also, [Dīkshīt \(1981\)](#).

Parilekhana (परिलेखन) literally means 'drawing' or 'tracing', and refers to the geometrical procedures used to depict celestial events such as eclipses. Texts such as the *Siddhānta śiromaṇi*, *Sūryasiddhānta* and *Āryabhaṭṭya* devote an exclusive chapter to the drawings, as visual representations of calculations.

The dearth of drawings in mathematics and astronomy manuscripts, in India, as compared to the contemporary European texts has been a subject of criticism. In this study we show that the depiction of celestial events as drawings was an important aspect and was dealt with in great detail.

We find diagrams on eclipses in some of the manuscripts and commentaries with or without procedural details and drawings. We scrutinized the following manuscripts: the *Ekanātha Karaṇa* (by Ekanātha, twelfth century), *Brahmatulya Udāharaṇam* (Viśvanātha, sixteenth century), and *Brahmatulya Tippanī* (Ratneshwara,

seventeenth century). The visual data for this study were sourced from two specific manuscripts, both belonging to the tradition of Bhāskarācārya II as per the *Karaṇakutūhala*.

To complement these, we included the texts *Gaṇitagannaḍi* ([Shylaja and Javagal, 2021a](#)) and *Grahaṇamukura* ([Shylaja et al., 2024](#)) by Shankaranārāyaṇa Jois. These seventeenth century contemporary texts were selected for their methodological alignment with Bhāskarācārya's eclipse timing calculations (cf. [Montelle and Plofker, 2014](#)). Notably, both titles, the *Kannaḍi* and the *Mukura* translate as 'mirror', reflecting the detailed textual treatment of *parilekhana*, where diagrams are explicitly described as mirrored projections. Apart from these key sources, a significant corpus of manuscripts remains to be surveyed, edited, and analyzed for further astronomical illustrations. Our search for previous studies on *Parilekhana* revealed two references ([Jambugahapitiye et al., 2025](#); and [Rao and Uma, 2008](#)). One of these is based on the *Karaṇakutūhala*, and the other on a manuscript from Nepal that lacks relevant details on the calculations.

It is worth mentioning that the *Grahaṇa Darpaṇa* is a text devoted to descriptions of *parilekhana* covering all the eclipses for the period 1867 to 1900 CE ([Arasu, 1972](#)).

2 FOUNDATIONS FOR THE DRAWINGS

In order to bridge the gap between theory and observation, we provide a step-by-step explanation of the procedure, supplemented by the reconstruction of diagrams as per current convention, and also a comparison with online resources.

2.1 Fixing Cardinal Points

The first step as given in the *Gaṇitagannaḍi* describes the setting up of the ground.

शिलातले वा समभूतले वा सुसाधितांशे फलके फटे वा ।
 मानैक्यखण्डप्रमितेन कुर्यात्सूत्रेण वृत्तं वलनाश्रयाख्यम् ॥
 śilātale vā samabhūtale vā susādhitāṁṣe
 phalake phaṭe vā |
 mānaikyakhaṇḍapramitena kuryātsūtreṇa
 vṛttaṃ valanāśrayākhyam ॥

The board or the ground intended for drawing should be horizontal as tested by a water level mechanism. This method of using water for levelling the platform was well known. It is described in a stone inscription that praises Singhaya Bhatta, a *Jalasuṭra*, the mechanic or engineer involved in managing this instrument (see Appendix 10.1).

Fixing the cardinal points is a general procedure. A circle is drawn with a radius of 12 *Āṅgula* (i.e. about 21.16 cm) and a *Saṅku* (a stick, wooden or metallic) of the same height, serving as a gnomon, is located at the center. The points of intersection of the shadow of the tip of the gnomon on the circle are marked in the forenoon and in the afternoon. The line joining the points of intersection is bisected (bisection of a line is referred to by the phrase *Matsya-Utpādyā*). The bisector represents the North–South direction. The entire procedure of fixing cardinal points is called *Pracī Sādhana*.

2.2 Description of the *Ayanavalana* and the *Akṣavalana*

The parameters for the drawing were calculated in advance. These included, the instant of eclipse (*Parvānta*), the half duration of the partial eclipse (*Sthiti*), the duration of the total eclipse (*Vimarda*), and the instantaneous speeds (*Sphuṭa Gati*) of the Sun and the Moon.¹ The procedure also demanded a set of additional parameters, specifically for diagrams drawn with a standard radius of 6 *Āṅgula* for the Sun or Moon. They were

Instantaneous values of the diameters of the eclipsing body (*Chādyā*), eclipsed body (*Chādaka*) namely the Sun, Moon, and shadow, calculated and expressed in units of *Āṅgula*.

Vikṣepa or *Śara* (at three points *Sparśa*, *Mokṣa* and *Madhya*) – ecliptic latitude at the first contact, the midpoint and the last contact.

The *Ayanavalana* a_v is the deflection due to the declination, and is the angle between the diurnal circle and the ecliptic. In Figure 1, EQ is the Equator; CA is the ecliptic; γM is the lon-

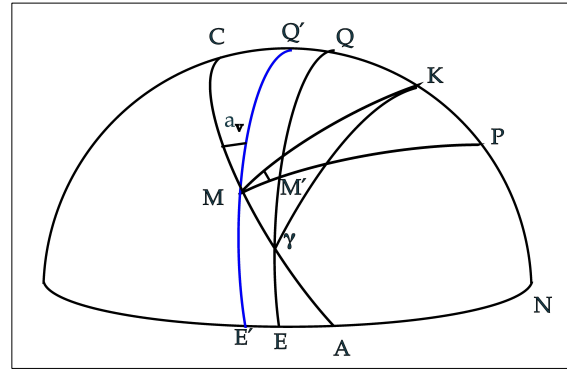


Figure 1: The angle between the ecliptic (CA) and the diurnal circle of the Moon (E'MQ') is the *Ayanavalana*. It is same as the angle KMP, K is the pole of the ecliptic.

gitude of the Moon (λ). MM' is the declination of the Moon (δ). K is the pole of the ecliptic and P the pole of the diurnal circle E'Q'. Because of the declination the deflection is given by CMQ' which can be shown to be equal to KMP (a_v) and given by

$$\sin a_v = \sin \varepsilon \times \cos \lambda / \cos \delta \quad (1)$$

where $\varepsilon = 23.5^\circ$ = the obliquity of the ecliptic.

The rationale for the *Akṣa Valana* is explained as that correction which arises because the diurnal path of the Moon is inclined to the prime vertical. In Figure 2, M is the position of Moon in its orbit marked and $MM'P$ is the hour circle. MXN is the secondary to the prime vertical. The diurnal circle of the Moon (not marked in the diagram) will be parallel to the Equator EQ. The angle between that and the prime vertical EXZ is the *Valana Ak* (that is not marked in the figure) but it can be shown that it is the same as that between the circles NXM and $PM'M$. It is given by

$$\sin a_k = \sin \varphi \times \sin z / \cos \delta \quad (2)$$

where φ = latitude of the place = PN (Shylaja et al., 2024).

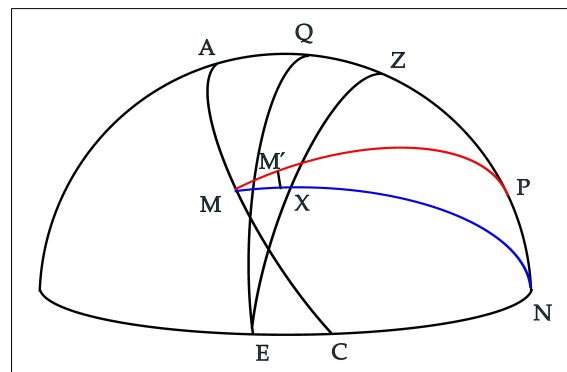


Figure 2: As in Figure 1, EQ is the Equator, and EZ the prime vertical but CA the orbit of Moon. The *Akṣa Valana* is the angle between the diurnal circle of the Moon and the prime vertical which is same as PMN .

We have attempted to explain the two *Valana* with separate diagrams for better clarity. *Ayanavalana* and *Akṣavalana* values need to be calculated at the First Point of Contact and also the Last point of Contact. The two quantities are added as per the sign convention. The vector sums are called *Sparśa Valana* and *Mokṣa Valana* respectively. Almost all texts describe the vectorial addition of the two quantities in great detail; this is because the commencement of *Sparśa* and *Mokṣa* need not be in the same hemisphere.

2.3 The Procedure of Parilekhana

In the examined manuscripts the values for diameters, *Valana* (deflection) and *Śara* (celestial latitude) are expressed in *Aṅgula*, using the conversion of 1 *Aṅgula* = 3 arc minutes. The *Aṅgula* is a pervasive linear measure in Indian history that evolved from the *Sindhu-Saraswati* period through to the seventeenth century (Balasubramaniam, 2009); its physical length is 1.763 cm. Epigraphical evidence suggests its primary use was in land measures for revenue and civil engineering, such as determining brick dimensions and architectural proportions and taxation (Jagadish, 2005; Shylaja and Ganesh, 2016). However, for the purpose of *Parilekhana*, the high-precision standardization of these linear values is not a prerequisite, as the primary concern is the relative angular proportions:

- (1) After fixing the cardinal points draw a circle with radius equal to half the sum of the diameters of the *Chādyā* (one getting covered) and the *Chādaka* (one that is covered). In the case of lunar eclipse, they are the shadow and the Moon. This circle is called *Mānaikyārdha Vṛtta* or *Valanāśraya Vṛtta*.
- (2) The calculated *Śara* at mid-point, *Sparśa* and *Mokṣa* are marked on the perpendiculars to the East–West line along the *Valanāśraya Vṛtta*. The Moon is drawn as a circle at the tip of the *Madhya Śara*. At the tip of these markers the *Sparśa Valana* and *Mokṣa Valana* are marked along the *Val-Anāśraya Vṛtta*. All the texts emphasize on the sign convention here.
- (3) These define the *Sparśa Marga* (path of the *Chadaka* to the midpoint) and *Mokṣa*

Marga (path from the midpoint). The circles with radius of the shadow are drawn on these lines; the points of contact of the shadow circles with the disc of Moon at midpoint are the points of contact.

- (4) To mark the total eclipse, the shadow circles are drawn along the paths so that they are on the inner side of the Moon's edge.

This completes the procedure. It should be noted that the Moon is stationary and the shadow is considered to be moving across it. This is different from the current convention where the shadow is stationary.

The procedure for solar eclipses is similar to that of lunar eclipses. Here the *Valanāśraya Vṛtta* will have a smaller radius as the sum of the radii of the Sun and the Moon. The values of the two *Valana* and *Śara* are marked; the *Sparśa marga* and *Mokṣa Marga* need to be drawn as in the case of a lunar eclipse.

The objective of *Parilekhana* is to depict the eclipse as a drawing with the first and last contact points marked on the disc of the Moon. This procedure is described in detail in the example of a lunar eclipse.

When representing the total eclipse, the difference between the radii of the shadow and the Moon is marked on the same *Sparśa Marga* and *Mukti Marga*. These points represent the onset of totality, which is called *Vimarda*. These correspond to the onset and closure of totality and are marked as *Sammīlana* and *Unmīlana*.

Thus, the two (four, in case of total eclipses) points of contact are marked on the disc of the Moon. As per the descriptions in all of the texts, this completes the *Parilekhana*.

Once the calculations were done, astronomers used to make a list of all the values before doing the *Parilekhana*. For example, in the manuscript *Brahmatulya Tippanī*, all the values are listed separately (Figure 3).

2.4 Presenting Diagrams Specific to the Location

The procedure for verification requires preparation of a drawing depicting how the eclipse appears from the observer's location with the

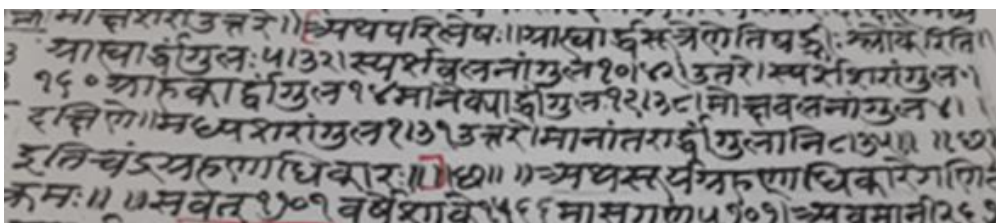
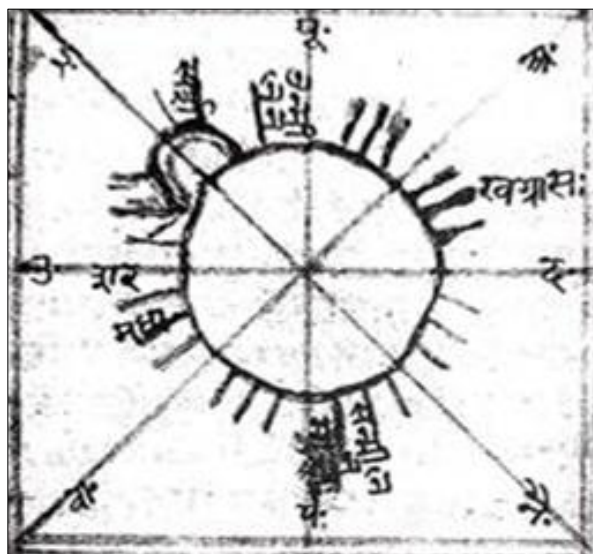
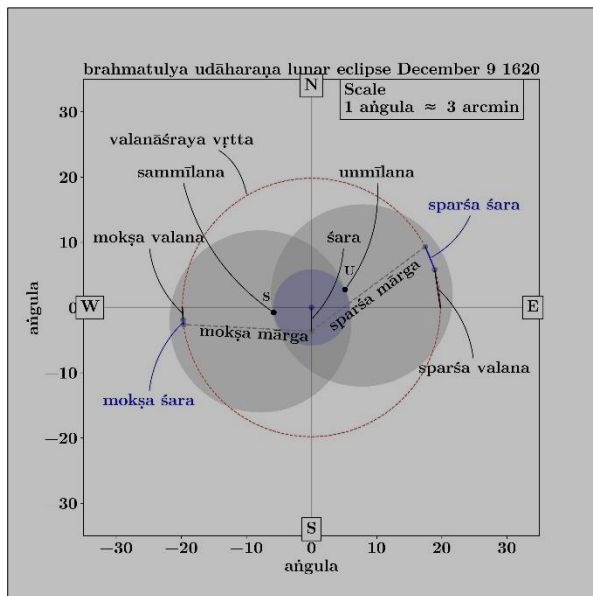
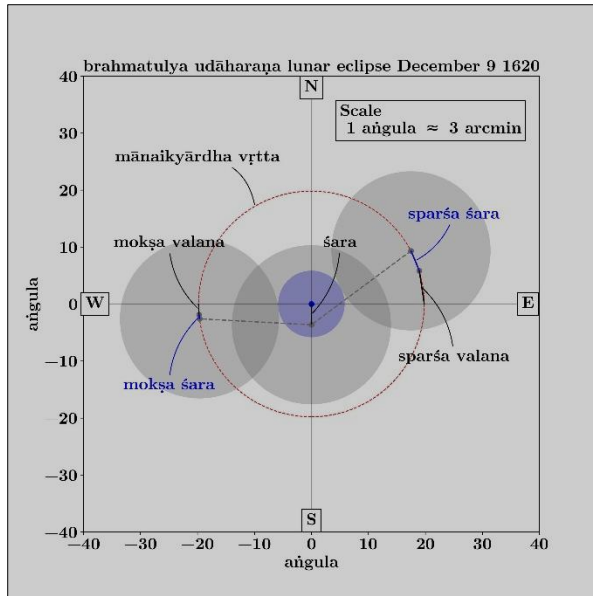


Figure 3: Example from the *Brahmatulya Tippanī* manuscript, which lists the calculated values for *Parilekhana* (courtesy: Bhandarkar Oriental Research Institute: Pune).



Figures 4a,b,c (top to bottom): Diagrams for the lunar eclipse of 9 December 1620. For details see the text.

necessary corrections; the *Akṣa Valana* (deflection because of latitude of the observer) and the *Ayanavalana* (deflection because of the declination). At a given instant these are obtained from the hour angle, *Natāmśa*, as

$$Natāmśa = (Nata \text{ at } Saprasakāla * 90) / Ratryardha \quad (3)$$

As discussed previously, Equation (1) gives the *Akṣavalana* = $(120 \sin(Natāmśa) * Akṣāmśa) / 120$ (4)

where the *Akṣāmśa* is the terrestrial latitude. Similarly, the

$$Ayanavalana = \frac{R \cos(bhuja)}{5}, \text{ where } R = 120 \quad (5)$$

where the *Bhuja* is the value of the *Sāyana Candra* at the *Sparśa* and the *Mokṣa Kāla* considered separately. The two components are added as per the specific directions.

These values provide the view from the given location of the observer, which can be depicted as a diagram. In other texts, instead of the angular measure, the directions of the points of contact on the disc of the Moon are specified.

These are relevant for a solar eclipse rather than a lunar eclipse. However, the text does not discuss explicitly the *Valana* or the preparation of a diagram for a solar eclipse. For the sake of completion, we have calculated them following the same procedure as in the *Karaṇakutūhala* of Bhāskarāchārya. An exact procedure for the calculation is available in the paper by Shylaja (2025), and details of the values used for specific parameters are listed in Appendix 10.3.

3 EXAMPLES

Here are examples of drawings from different texts.

3.1 Illustrations From the *Brahmatulya Udāharaṇam*

The *Brahmatulya Udāharaṇam* by Viśvanātha is a practical guide that uses examples to explain the calculation of eclipses and various other astronomical phenomena.

3.1.1 Lunar Eclipses

The examples are for the lunar eclipse of Śaka 1543 *Mārgaśira Masa* (9 December, 1620). The various parameters required for the drawing are calculated and we have verified the calculations (Shubha, 2020). Figure 4a represents the drawing prepared as per the instructions for the partial phase, while Figure 4b is for the total phase. One of the manuscript copies has a drawing, and this is reproduced in Figure 4c.

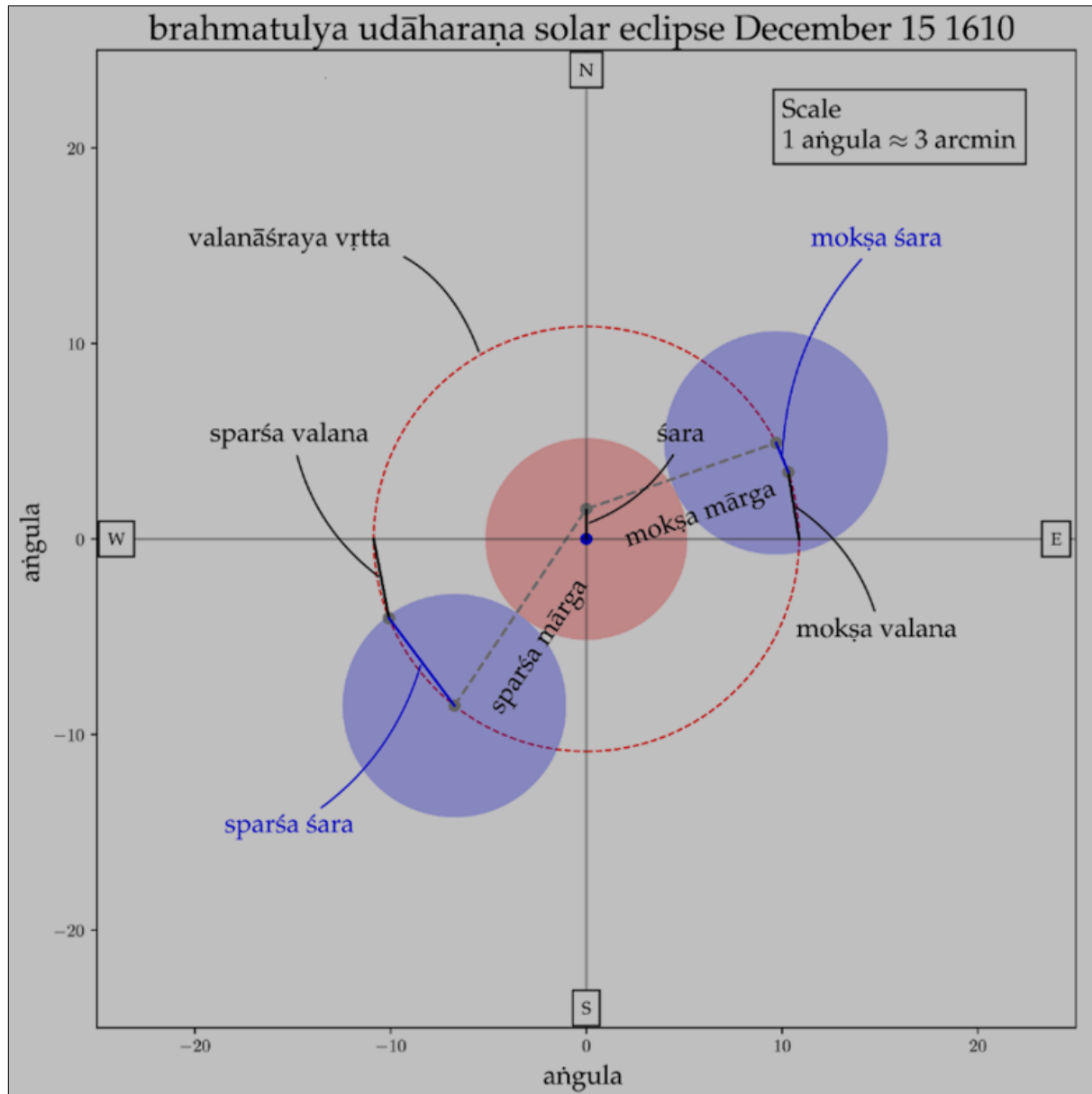


Figure 5: The drawing constructed for the solar eclipse of 15 December 1610 described in the *Brahmatulya Udāharaṇam*.

Figure 4c includes the words *Sparśa* in the North-east and *Mokṣa* in the West. The terms *Sammilana* (second contact, or the beginning of totality) and *Unmīlana* (third contact, or the end of totality) are also marked. These words correspond to two thick lines. The function of the spike-like radial lines, however, is not evident (unless these are merely an element of artistic licence).

3.1.2 Solar Eclipses

The *Brahmatulya Udāharaṇam* provides an example using the 15 December 1610 eclipse. Figure 5 shows the drawing based on the text's procedure, and can be verified from interactive tools such as Xavier Jubier. The two visuals demonstrate clear agreement, with a further

discussion of timing and obscuration provided separately (Shubha, 2020).

3.2 Illustration From the *Ekanātha Karaṇa*

Ekanatha, an astronomer from the fourteenth century, wrote the *Ekanātha Karaṇa*, a commentary on the *Karaṇakutūhala* of Bhāskarāchārya II. We studied the manuscript, which has examples of many celestial events solved in detail (Shylaja and Shubha, 2025). Here are the examples for which we prepared drawings.

3.2.1 Lunar Eclipses

The examples are for the lunar eclipse of *Śaka* 1288, *Magha Masa*, *Pūrṇimā* (16 January, 1367). After verification of the calculations for

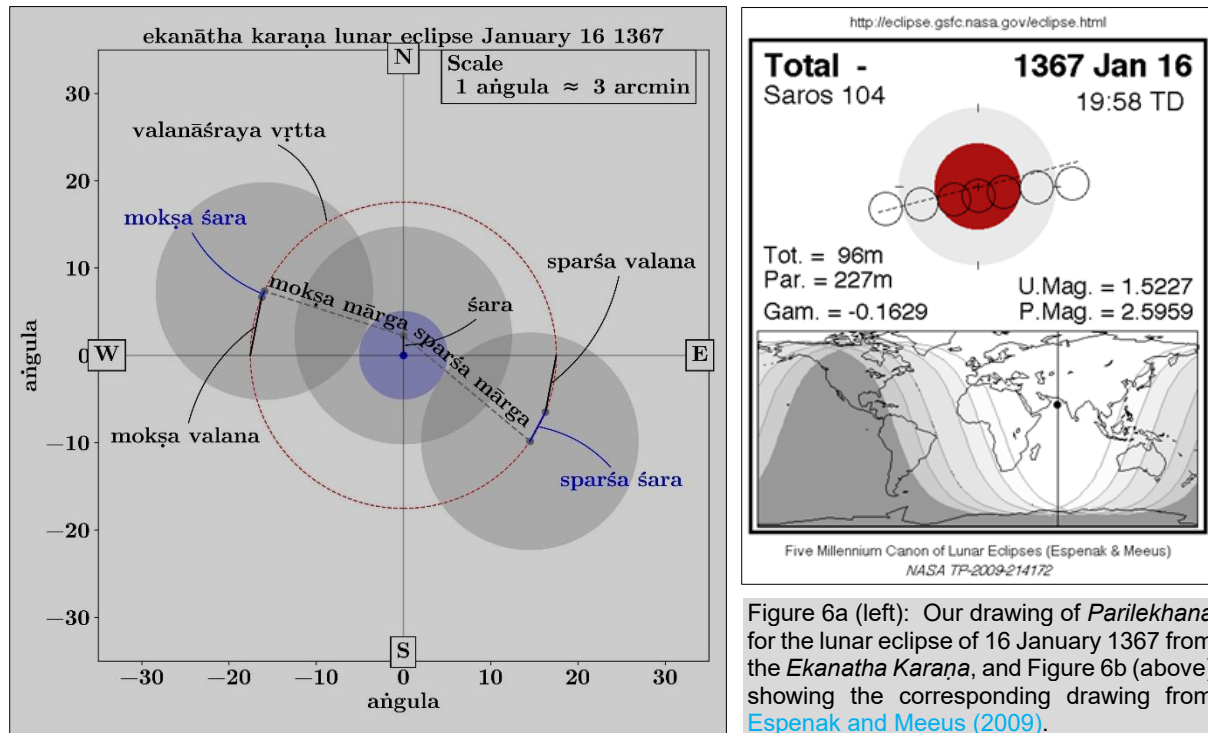


Figure 6a (left): Our drawing of *Parilekhana* for the lunar eclipse of 16 January 1367 from the *Ekanatha Karaṇa*, and Figure 6b (above) showing the corresponding drawing from [Espenak and Meeus \(2009\)](#).

the drawings, [Figure 6](#) was constructed based on those parameters. The drawing is not included in the original manuscript. Comparison with conventional diagrams as we render them today is equally important to establish the veracity of the procedure. We used the NASA compilation ([Espenak and Meeus, 2009](#)) for the lunar eclipses. [Figure 6a](#) shows the diagram constructed with the same parameters as for the eclipse of the second example above, as per the current convention. [Figure 6b](#) is the corresponding diagram enlarged to match the size. We need to compare only the umbral shadow. The two drawings are mirror images, with East and West reversed. In other words, the drawings present the view as if one were to see the eclipse with a mirror. This also justifies the titles of many eclipse-related texts.

The conventional drawing of the eclipse has the Moon moving through the shadow from West to East. This will be explained in detail in Section 5, below.

3.2.2 Solar Eclipses

The example from the *Ekanatha Karaṇa* is for the partial solar eclipse of *Śaka 1297 Soumya Jyeṣṭha māsa* (5 June, 1369). We have verified that the parameters, including the timings and relevant values, were correct, and we used them to construct [Figure 7](#).

3.3 Illustrations From the *Brahmatulya Tippanī*

The next set of examples are from the *Brahma-*

tulya Tippanī. As per the colophon, the text was written by Ratneshwara, from Simhapura.

3.3.1 Lunar Eclipses

The example presented is a partial eclipse that occurred on 26 September, 1624. The parameters for this event were verified, and the drawing shown in [Figure 8a](#) was constructed based on the verified values. [Figure 8b](#) displays the corresponding diagram from the NASA canon of eclipses.

3.3.2 Solar Eclipses

The *Brahmatulya Tippanī* refers to the solar eclipse of 1 September, 1644, as an example with a drawing. We have verified all the parameters required for creation of the *Parilekhana*. A drawing of the eclipse from the manuscript is shown in [Figure 9a](#). [Figure 9b](#) shows our drawing.

4 DISCUSSIONS ON ECLIPSE DRAWINGS

4.1 The Convention of the Moving Shadow Versus the Moving Moon

As established in the procedure, diagrams are rendered with the *Chādaka* (the obscurer) traversing the *Chādya* (eclipsed body). While this accurately depicts the mechanics of a solar eclipse, a conceptual compromise is required for lunar eclipses, where the obscurer is the Earth's shadow.

As depicted in [Figure 4](#) the *Sparśa* and *Mokṣa* (the First Contact and the Last Contact)

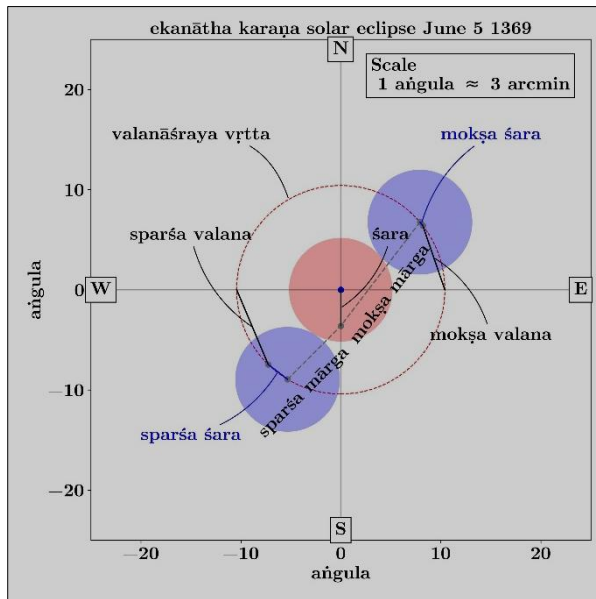


Figure 7a (left): The drawing for the partial solar eclipse of 5 June 1369, and Figure 7b (right) the corresponding visualization from the interactive tool of Xavier Jubier.

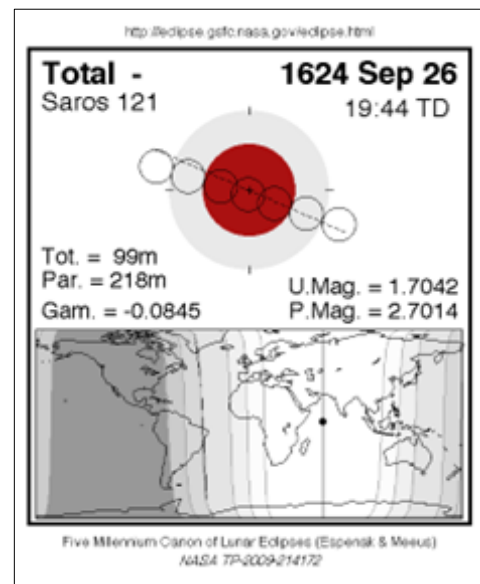
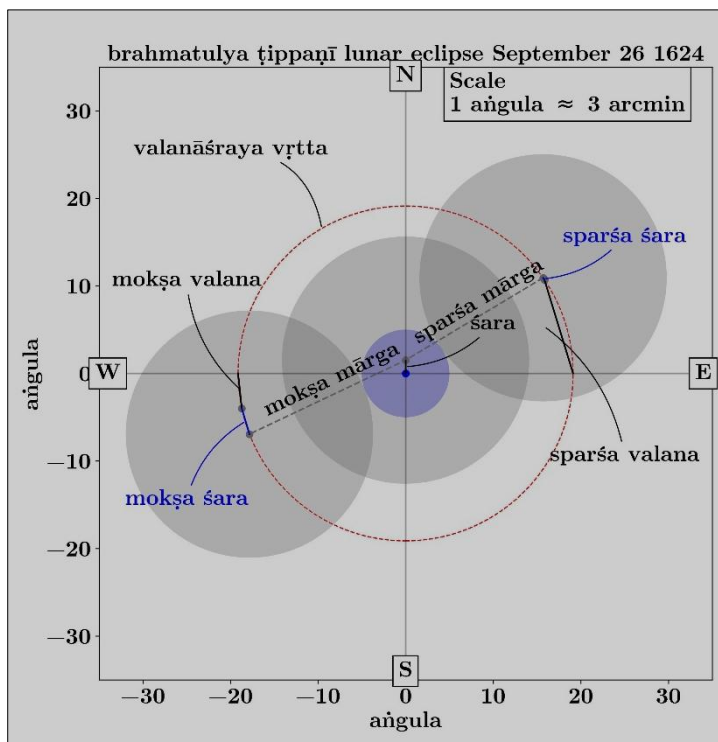


Figure 8a (left): Our drawing of *Parilekhana* for the lunar eclipse of 26 September 1624 from the *Brahmatulya Tippani* and Figure 8b (above), showing the corresponding drawing from [Espenak and Meeus \(2009\)](#).

can be understood by the projection of the diagram on to the sky. The extension to total eclipse requires a clarification on the conventions. We have shown below the sequence of the shadow moving across the disc of the Moon. [Figure 10a](#) depicts *Sparaśa* (First Contact) in the North-east direction; [Figure 10b](#) represents *Sammīlana* (Second Contact on the *Sparaśa Mārṅga*, marking the beginning of totality); [Figure 10c](#) illustrates *Unmīlana* (Third Contact, corresponding to the end of totality on the *Mokṣa Mārṅga*); and [Figure 10d](#) denotes Last

Contact, and the end of the eclipse (*Mokṣa*).

All these stages are consolidated into a single schematic representation in [Figure 11](#) and compared with the diagram in the manuscript, with suitable labels. The representation is evident in [Figure 11b](#) with terms *Sparaśa* (First Contact), *Sammīlana* (Second Contact), *Unmīlana* (Third Contact), and *Mokṣa* (Last Contact) all labelled within a single diagram in the manuscript. Also, see Appendix 10.3 for details of the calculations.

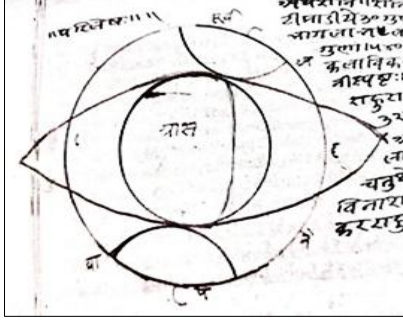
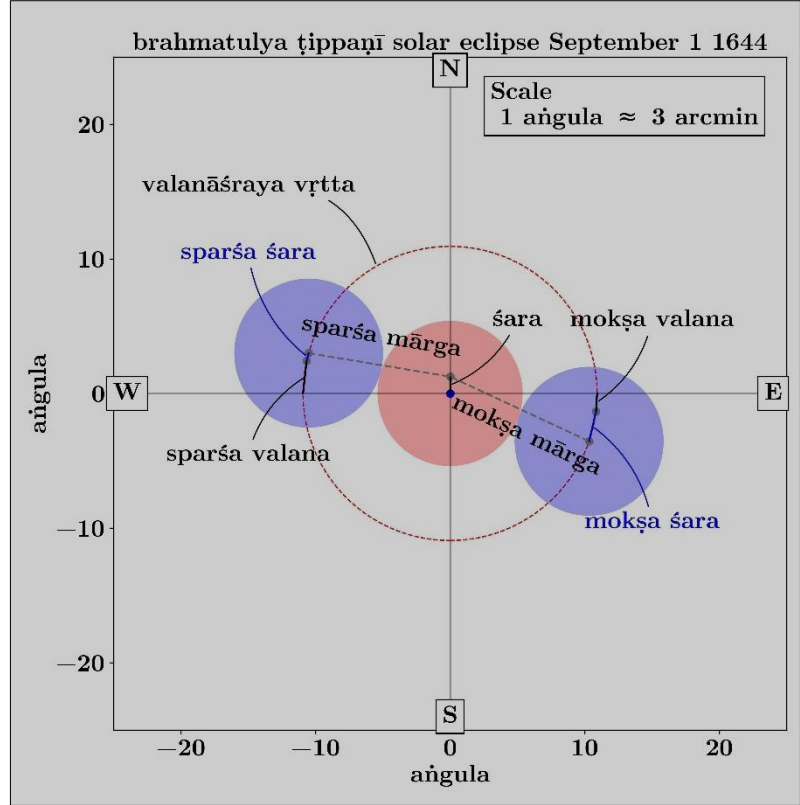


Figure 9a (above): The diagram of the solar eclipse as depicted in the *Brahmatulya Tippani*. It was a partial eclipse, and the word *Grāsa* refers to the fraction covered by the Moon. North is to the left and East to the top, as per the text. Figure 9b (right), shows our drawing constructed as per the text, and to the same scale.



The parameters may be transformed to represent the eclipse according to the contemporary convention, in which the Moon moves beneath the shadow. This representation appears more realistic, as the Moon moves faster. Figure 12b shows the sequence with the same parameters and East and West reversed for comparison with drawing Figure 12b from the canon of eclipses of NASA (n.d.).

While examining the diagrams preserved in only a handful of manuscripts, it is essential to bear in mind the convention of a stationary Moon. The relevant points are not always accompanied by explicit legends; instead, they are often indicated merely by markers. This interpretation is further verified by the two instances of Figure 9a and Figure 11a.

The details presented here emphasize the importance of diagrams as a pedagogical tool among ancient Indian astronomers. This is further evidenced by texts such as the *Brahmatulya Udāharanam*, which explicitly states that these visuals were essential for teaching.

4.2 The Mirrored Drawings

As we noticed, there is an East–West reversal in the procedure. The introductory passage in *the Grahaṇamukura* (mirror for eclipses) justifies its title by stating that the purpose of the book is to render a drawing of the eclipse as though you see it in a mirror (Shylaja et al., 2024):

ಈ ಕರಣದಲ್ಲಿ ಗ್ರಹಣವ ಗುಣಿಸಿ ಪರಿಲೇಖನವ ಬರದು ನೋಡಲಾಗಿ ಕಂನುಡಿಯೊಳಗೆ ತೋರಿದ ಹಾಗೆ ವ್ಯಕ್ತವಾಗಿ ಕಾಣ ಬಂಧಿತಾಗಿ ಗ್ರಹಣ ಮುಕುರ ವೆಂಬ ಹೆಸರು ||

ī karaṇadalli grahaṇava guṇisi parilekhanava baradu noḍalāgi kamnūḍiyōḷagē

torida hāgē vyaktavāgi kāṇa baṁdhītāgi grahaṇa mukura vēṁba hēsaru ||

This *Karaṇa* text will provide you calculations with which you can draw the diagram of the eclipse, which appears as though you are seeing it in a mirror.

In another text, the *Gaṇitagannaḍi* (Shylaja and Javagal, 2021b), it is stated:

ग्राह्यस्य वृत्तो परितेन यावत्क्रान्तं ततोऽधस्तमसं तथा स्यात् ।

कुर्वन्विलेख्यं फलके पटे वा कुर्याद्दिशां व्यत्ययतां तु धीमान् || ८ ||

grāhyasya vṛtto paritena yāvatkrāntaṁ tatosdastamasam tathā syāt |

kurvanvilekhyam phalake paṭe vā kuryāddiśāṁ vyatyayatāṁ tu dhīmān || 8 ||

By this method, the circle drawn with the radius of the eclipsing body expresses what fraction of the eclipsing body is covered and also the maximum coverage (*Grāsa*). When this

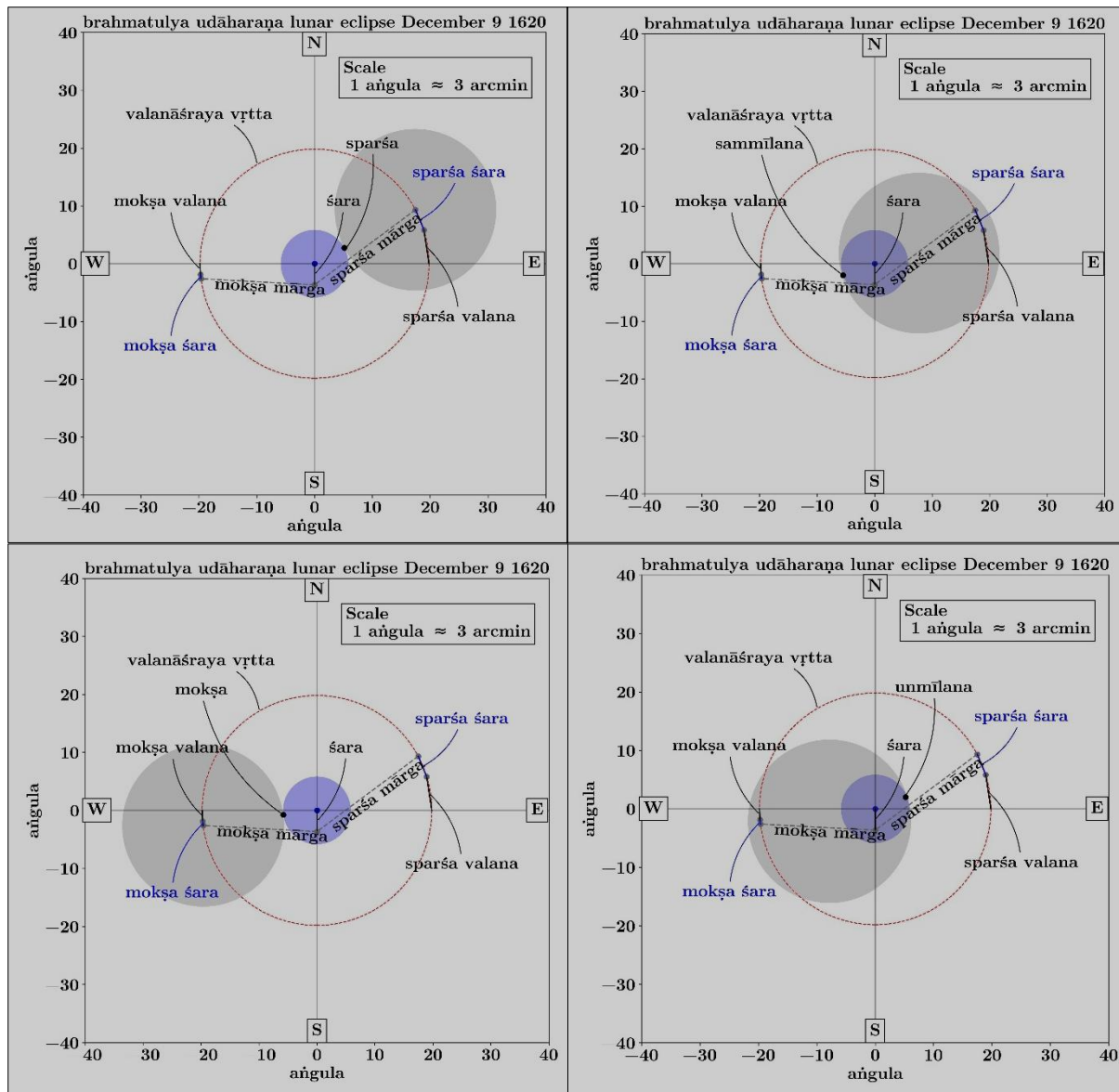


Figure 10: The various stages of an eclipse with the convention of the shadow moving across the Moon, clockwise from top left.

drawing is prepared on a board or a canvas the directions should be reversed—which implies that if *Valana* and *Vikṣepa* are indicated as South, they should be marked as North. The reason for this is the following: the drawing made in this reversed orientation should be viewed from beneath holding it above so that East on the drawing matches the East direction. Then the *Valana*, *Vikṣepa* and *Grāsa* will all appear as they are in the sky.

Therefore, the East–West reversal is a crucial feature in astronomical diagrams, not an error. It gives the fundamental difference between our perspective of the celestial sphere and a conventional map.

The tradition of creating astronomical drawings persisted, as evidenced by several examples. One such example is a drawing of an

eclipse from a nineteenth century manuscript from the Saraswathi Mahal Library in Thanjavur, South India. One of the authors (Shylaja) has reproduced this drawing as a freehand sketch (Figure 13a). The manuscript is dated Śaka 1787, corresponding to the partial lunar eclipse of 4 October 1865, which was visible just before dawn.

In this drawing, the points of *Sparśa* (First Contact) and *Mokṣa* (Last Contact) are marked by dots near the *Isānya* (North-east) and *Vāyavya* (North-west) directions, respectively. This configuration, as outlined in the texts, completes the drawing. A serpent is also depicted, representing the story that attributes the lunar nodes to *Rāhu* (the serpent’s head) and *Ketu* (the tail). Figure 13c provides our interpretation of the dots as the points of contact. The orien-

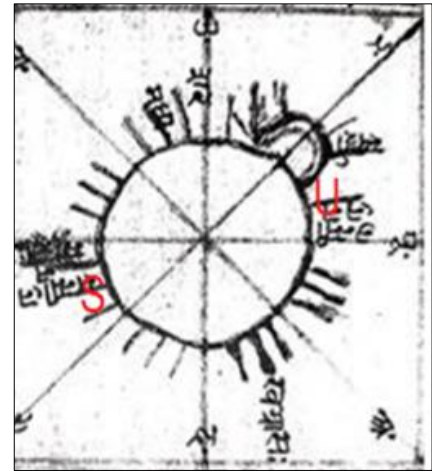
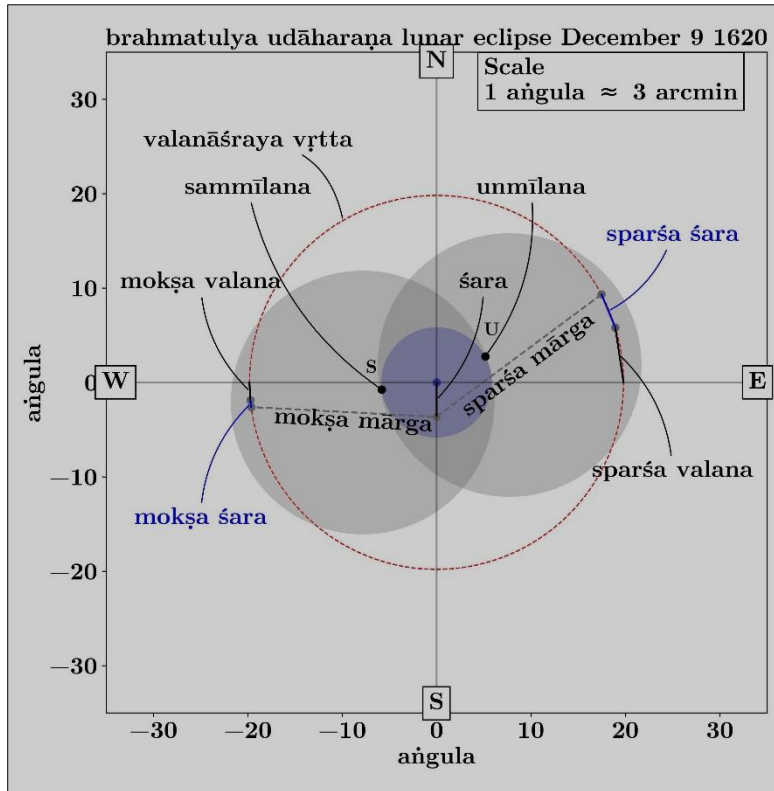


Figure 11a (left): The diagram combining the sequence from Figure 10 to show the onset and the end of totality. Figure 11b (above) is the same diagram from the manuscript shown in Figure 4c, but rotated by 90° for ease of comparison. The points marked 'S' and 'U' correspond to the *Sammīlana* and *Unmīlana*.

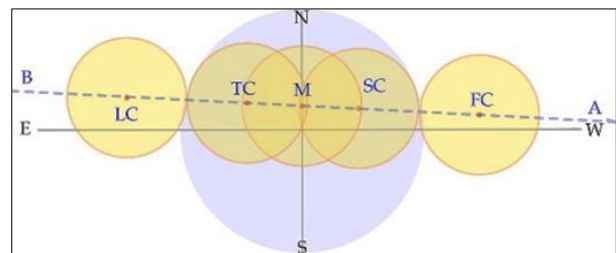
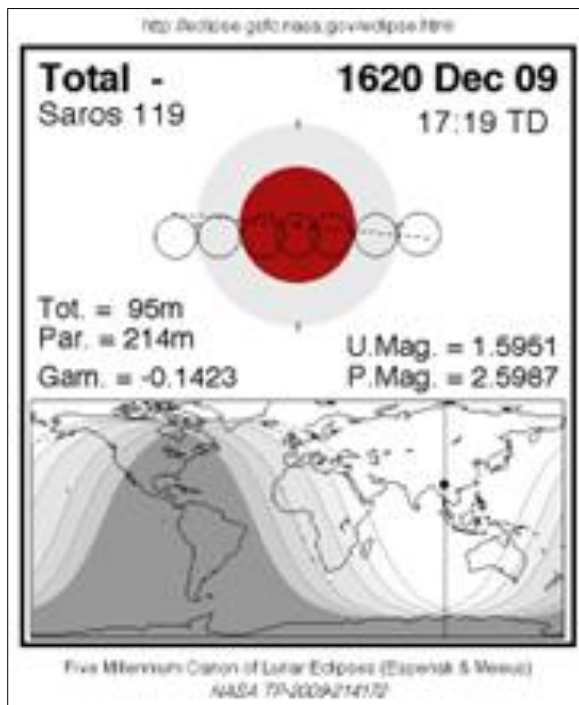
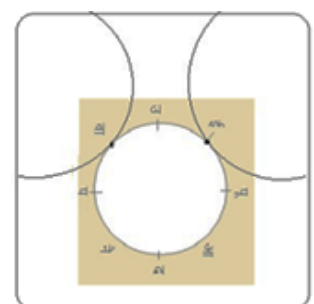
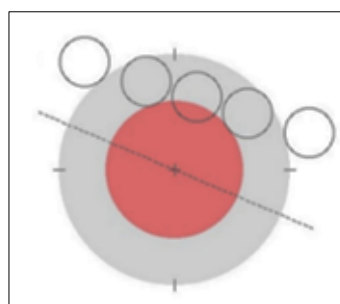
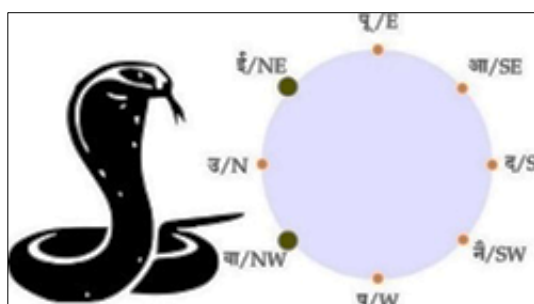


Figure 12a (left): The diagram from the NASA (n.d.) canon of solar eclipses compared (in Figure 12b, above) with the eclipse sequence redrawn using the parameters of a stationary shadow.

Figure 13a (below, left): Depiction of the 4 October 1865 lunar eclipse in a manuscript on display at the Saraswati Mahal Library in Thanjavur, India. Figure 13b (below, centre): The corresponding diagram from the canon of lunar eclipses (Espenak and Meeus, 2009) and Figure 13c (below, right), our interpretation of the two dots as Contact points.



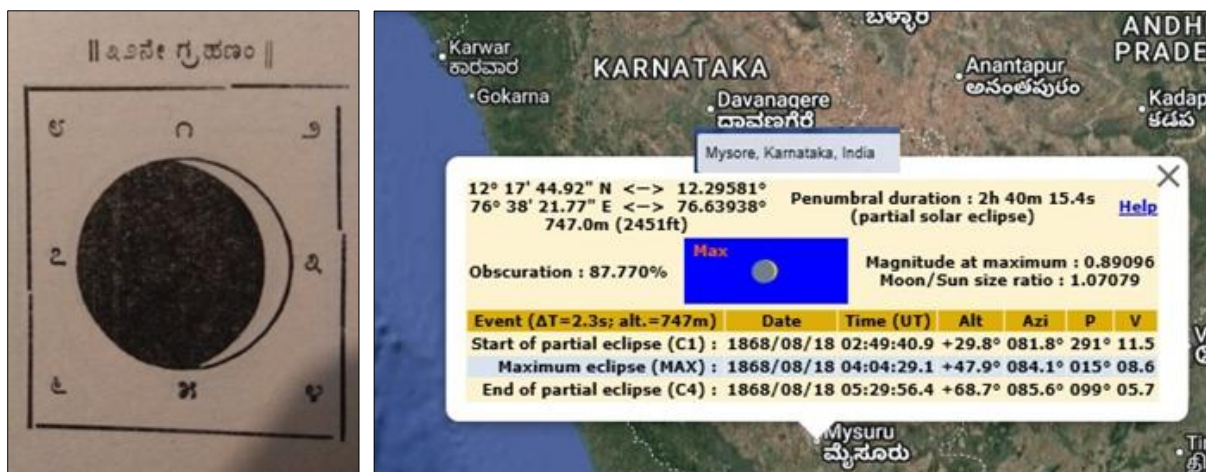


Figure 14a (left): The drawing of the solar eclipse of 1868 in the *Grahana Darpana*, and Figure 14b (right) the corresponding view as per the interactive tool of Xavier Jubier.

tation of this drawing has been adjusted to match the current convention shown in Figure 13b.

The *Grahanaṃālā*, a monograph prepared by Hemāṅgada Thakura (Thakkur, 1985), is a canon of eclipses from 1601 CE to 2160 CE. It has verses with details necessary to prepare the drawings, but does not have the drawings themselves.

The *Grahana Darpana* (Arasu, 1972) compiles the details of all eclipses from 1867 CE to 1900 CE visible from Mysuru in South India. Every eclipse entry includes a drawing that depicts the event at its midpoint. The timings and other details are conveyed in Sanskrit verses using the numerical Bhūtasāṅkhyā System, while the entire text is transcribed in the Kannada script.

In Figure 14 is an extract of a page for the 11 August 1868 total solar eclipse. The path of totality passed across South India and attracted astronomers from England France and Germany and from within India itself (for a summary see Kochhar and Orchiston (2017: 737–740). This eclipse was of international importance because of the discovery of helium and the green coronium line (Nath and Orchiston, 2021). Mysuru was slightly to the South of the totality path, and the magnitude of the eclipse there was 0.9. It was described as “... kiñcat nyūnam pūrṇagrāsta ...”, which means “... slightly short of complete obscuration ...”

5 PARILEKHANA FOR ŚRĠGONNATI

A unique feature of Indian astronomy texts is the chapter dedicated to the orientation of the Moon’s cusps, entitled *Śrīgonnati*. This section provides a method for the pictorial representation of the crescent Moon, where its specific orientation is determined by the observer’s

latitude and the Moon’s declination. A detailed discussion, with examples, is presented by Shubha et al. (2020).

6 CONCLUDING REMARKS

The accurate visual representation of celestial events was a fundamental aspect of astronomical practice in Classical Indian astronomy. Astronomers demonstrated their computational expertise to rulers and the public by drawing eclipse diagrams on walls, allowing for the direct and immediate verification of their calculations against actual observations. While these diagrams were rarely transcribed onto palm-leaf manuscripts, the primary challenge lay not only in the precision of the calculations but also in the consistency of the final depiction, which served as crucial evidence of an astronomer’s proficiency.

7 NOTES

1. For a listing of specialised Sanskrit astronomical terms used in this paper see the Glossary in Appendix 10.2.

8 ACKNOWLEDGEMENTS

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Ekanātha Kkaraṇa, Bhandarkar Oriental Research Institute (BORI) in Pune, India, MS 298/1882-83.

Brahmatulya Uudāharaṇam, Bhandarkar Oriental Research Institute (BORI) in Pune, India, MS 883 of 1891-95

Brahmatulya Uudāharaṇam, Bhandarkar Oriental Research Institute (BORI) in Pune, India, MS 954/1886-92

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10 APPENDICES

10.1 The Stone Inscription at Kalludi

The afore-mentioned stone inscription is shown in [Figure 15](#).

It is from the village of Kalludi near Bengaluru, and is dated 24 September 1388 CE.

It mentions the naming of a canal constructed by a *jalasutra* (engineer for canals and water works) named Singaya Bhatta for his expertise in water instruments, alchemy and the science of sounds. The water level instruments were known to these engineers ([V.S.S. Sastry, pers. comm, April, 2024](#)).

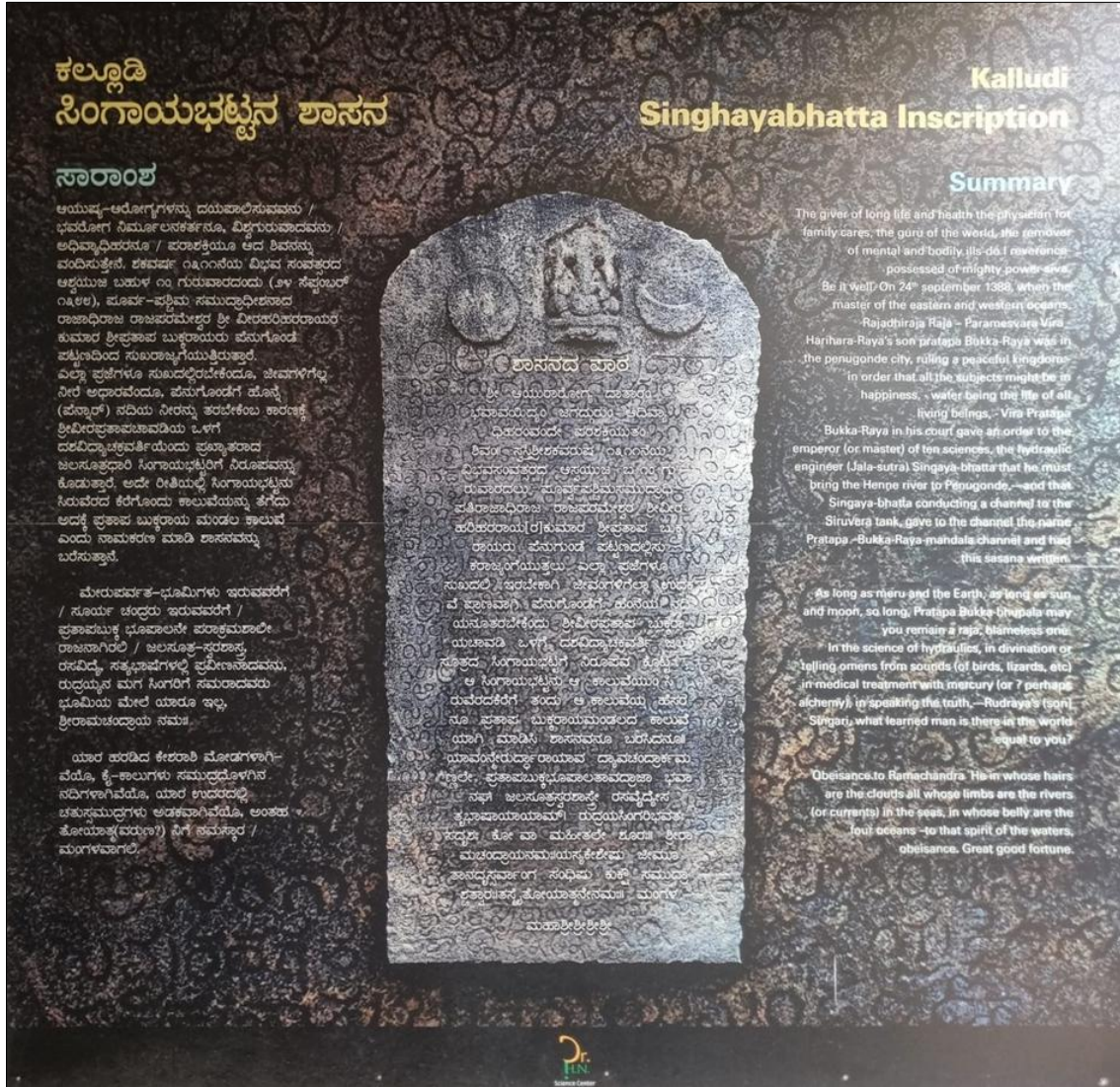


Figure 15: The elaborate stone inscription found near Kalludi (photograph courtesy: V.S S.Sastry).

10.2 Glossary

Table 1: Sanskrit astronomical terms mentioned in this paper.

Sanskrit Word	Meaning	Sanskrit word	Meaning
<i>Āṅgula</i>	Unit of measurement taken to be approximately one inch	<i>Akṣa</i>	Terrestrial latitude
<i>Akṣavalana</i>	Deflection due to the latitude of the observer	<i>Ayanavalana</i>	Deflection due to the declination
<i>Bimba</i>	Disc or diameter of Moon, Sun or Earth's shadow cone in an eclipse	<i>Chādyā</i>	Eclipsed body
<i>Chāyā/ Bhūbhā</i>	Shadow	<i>Ghaṭikā</i>	Unit of time (1 day = 60 ghaṭikās)
<i>Grāsa</i>	Fraction of the eclipsed body which is obscured	<i>Kalā</i>	Minute of an arc (angular measure)
<i>Mokṣa Kāla</i>	Instant of last contact	<i>Natāmśa</i>	Hour angle in degrees
<i>Matsya-utapādyā</i>	Bisection of a line	<i>Rātryardha</i>	Half duration of night
<i>Praci Sadhana</i>	Procedure for finding the cardinal directions	<i>Parvānta</i>	The instant of conjunction
<i>Nimīlana Kāla</i>	Commencement of total eclipse	<i>Sphuṭa Gati</i>	Instantaneous speed
<i>Sparśa Kāla</i>	Instant of first contact	<i>Sthiti</i>	Half duration of a partial eclipse
<i>Śṛṅgonnati</i>	Elevation of the lunar horns (cusps)	<i>Valanāśraya Vṛtta / Mānaikyārdha Vṛtta</i>	The circle with the radius equal to the sum of <i>chādyā</i> and <i>chadaka</i> .
<i>Unmīlana Kāla</i>	End of total eclipse	<i>Vikṣepa</i>	Celestial latitude

10.3 Solar and Lunar Eclipse Values

Table 2: Values for solar and lunar eclipses listed in the three manuscripts discussed in this paper.

SOLAR ECLIPSES			
Text	<i>Ekanatha Karaṇa</i>	<i>Brahmatulya Udāharaṇam</i>	<i>Brahmatulya Tippanī</i>
Epoch	Saka 1291, Jyeṣṭha Masa	Saka 1551, Jyeṣṭha Masa	Saka 1566, Aśwayuja Masa
Date	5 June 1369	21 June 1629	1 September 1644
<i>Aharaṇa</i> (civil days elapsed)	68038	163009	168560
True longitudes (degrees)	Ravi: 2 8 8 36	2 11 43 46	4 20 35 6
	Candra: 2 8 8 36	2 11 43 46	4 20 35 5
<i>Lambana</i> (parallax longitude, elongation) (<i>Aṅgula</i>)	I iteration: 3 7	I iteration: 3 30	I iteration: 2 53
	II iteration: 3 37	II iteration: 3 34	II iteration: 4 21
	III iteration: 3 40	III iteration: 3 43	III iteration: 4 14
	IV iteration: 3 40	IV iteration: 3 43	IV iteration: 4 15
<i>Ravi Bimba</i> (<i>Aṅgula</i>)	10 21	10 19	10 47
<i>Candra Bimba</i> (<i>Aṅgula</i>)	10 37	11 25	10 1
<i>Manikya Khanda</i> (<i>Aṅgula</i>)	10 29	10 52	10 17
<i>Sparśa Kala</i> (<i>Ghati/Vighati</i>)	12 0	2 27	5 12
<i>Mokṣa Kala</i> (<i>Ghati/Vighati</i>)	21 44	4 4	10 34
<i>Sparśa Valana</i> (<i>Aṅgula</i>)	6 29 S	4 3 S	2 24 N
<i>Mokṣa Valana</i> (<i>Aṅgula</i>)	6 40 N	3 25 N	1 21 S
<i>Sara</i>	2 25 S	5 24 S	1 15N
Name of the place	Mahad (Maharashtra)	Varanasi	Ujjain
Longitude (current convention)	73. 41°E	82. 97° E	75. 78°E
Latitude (current convention)	18. 09°N	25. 31°N	23. 17° N
LUNAR ECLIPSES			
Text	<i>Ekanatha Karaṇa</i>	<i>Brahmatulya Udāharaṇam</i>	<i>Brahmatulya Tippanī</i>
Epoch	Śaka 1288, Magha Masa	Śaka 1542 <i>Mārgaśira Masa</i>	Śaka 1546 <i>Aśwayuja Masa</i>
Date	16 January 1367	9 December 1620	26 September 1624
<i>Aharaṇa</i> (civil days elapsed)	67167	159893	161280
<i>Spasta</i> value (True longitudes)	Sun: 281.53° Moon: 101.51°	Sun: 239° Moon: 345.178°	Sun: 165.83° Moon: 345.17°
	<i>Sara</i> (<i>Aṅgula</i>)	2 16 N	3 39 N
<i>Ravi Bimba</i> (<i>Aṅgula</i>)	11 5	11 09	10 47
<i>Candra Bimba</i> (<i>Aṅgula</i>)	10 9	11 41	11 4
<i>Bhūbhā</i> (shadow diameter; <i>Aṅgula</i>)	24 56	27 56	28 14
<i>Grāsamāna</i> (obscuration; <i>Aṅgula</i>)	15 16	15 51	15 32
<i>Sparśa Sthiti</i> (<i>Aṅgula</i>)	4 25	4 36	4 36
<i>Mokṣa Sthiti</i> (<i>Aṅgula</i>)	4 29	4 28	4 40
<i>Sparśa Marda</i> (<i>Aṅgula</i>)	1 49	1 52	2 0
<i>Mokṣa Marda</i> (<i>Aṅgula</i>)	1 53	1 44	1 57
<i>Sparśa Kala</i> (<i>Ghati/Vighati</i>)	12 14	7 14	11 3
<i>Sammilana Kala</i> (<i>Ghati/Vighati</i>)	16 29	9 58	13 42
<i>Madhya Kala</i> (<i>Ghati/Vighati</i>)	18 22	11 50	15 43
<i>Unmilana Kala</i> (<i>Ghati/Vighati</i>)	21 44	13 34	17 40
<i>Mokṣa Kala</i> (<i>Ghati/Vighati</i>)	22 18	16 18	20 19
<i>Sparśa Valana</i> (<i>Aṅgula</i>)	6 29 S	5 13 N	10 42 N
<i>Mokṣa Valana</i> (<i>Aṅgula</i>)	6 40 N	4 23	4 40 S
<i>Manikya Khanda</i> (<i>Aṅgula</i>)	24 56	19 30	19 38
<i>Sparśa Sara</i>	3 47 N	1 59 N	0 16 S
<i>Madhya Sara</i>	2 16 N	3 36 N	1 31 N
<i>Mokṣa Sara</i>	3 47 N	5 8 S	3 3 N

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She initially completed a graduate degree in fluid dynamics through the Mathematics Department at Bangalore University. She then taught undergraduate mathematics at MES College of Arts, Commerce & Science in Bengaluru, before getting an MPhil from Samskrit University (Bengaluru), studying the tables from the sixteenth-century manuscript the *Mahādevi Sārīṇi*. She then followed this with a doctorate from the same University with detailed critical studies of the *Brahmatulya Udāharaṇam*, *Brahmatulya Tippanī* and *Ekanātha Karana*.

She has published papers in various academic journals and has been actively involved in several research projects, with a particular focus on Medieval astronomical manuscripts preserved at the Oriental Research Institute, Mysore, India.

Dr. B.S. Shylaja hails from Bengaluru. After completing an MSc in Physics at Bangalore University, she had a brief tenure at the National Aerospace Laboratories and the Central Power Research Institute before joining the Indian Institute of Astrophysics. There she studied binary stars with Wolf-Rayet companions for her PhD thesis (1987) under the guidance of the late Professor M.K.V. Bappu.

Shylaja also studied comets (including 1P/Halley), metallic line stars and cataclysmic variables (CVs). The rapid oscillations of the CVs were recorded with a fast photometer that was designed to record lunar occultations. She also studied the signatures of winds of the massive stars in the infra-red while at the Physical Research Laboratory in Ahmedabad.

After joining the Jawaharlal Nehru Planetarium in Bengaluru in 1994 she began studying historical aspects of Indian astronomy. She translated into English the monograph about the 1874 transit of Venus written by Chintamani Ragoonatha Charry in Kannada, a language of South India; this throws light on the techniques used by the Indian astronomers of that era. She has also written many books in Kannada and in English. These include books on the transit of Venus and a book on understanding the Jantar Mantar, with pop up pages. She also has studied the temples of India for their astronomical significance.



Shylaja has found a new source of astronomical records—stone inscriptions—all over India and South Asia. Her book *History of the Sky – On Stones* (2016, co-authored by Gettha Ganeshha) is a compilation of the eclipse and planetary conjunctions cited in these inscriptions. They have been found very useful in that they extend back more than 1500 years. She has also published a translation, with commentary, of the seventeenth century manuscript *Gaṇitagannaḍi: Mirror of Mathematics* (2020, co-authored by Seetharama Javagal).

As a former observational astrophysicist Shylaja also has studied the records of observations of stars from various texts and from the traditions of the navigators, with the aim of deducing the earlier observational techniques that were prevalent in India.