

## English Translation of Second part of *Siddhānta Śekhara* of Śripati\*

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*Siddhānta Śekhara* of Śripati is one of the greatest astronomical works of ancient India. This work has been published by University of Calcutta in the year 1932 in two volumes, edited by Mr. Bhavuji Mishra (Sri Krishna Mishra). The first part of this book consists of 12 chapters. English translation with explanatory notes of the first part was submitted to INSA in 2012. Second part of this work is completed which consists of eight chapters. Bhāskaracārya of 12<sup>th</sup> century freely borrowed from *Siddhānta Śekhara* to compose his masterpiece *Siddhānta Śiromaṇi*. Pandit Bapudeva Shastry who edited *Siddhānta Śiromaṇi* refers Śripati at several places with quoting the verses from *Siddhānta Śekhara*. Śripati composed this text with attractive style using different meters. An earnest effort has been made to translate the second part of *Siddhānta Śekhara* which consists of eight chapters. The objective of this English translation is to take this ancient wisdom to modern scholars who do not know Sanskrit.

The second part of *Siddhānta Śekhara* of Śripati consists of eight chapters. They are *Vyaktagaṇitādhyāya*, *Avyaktagaṇitādhyāya*, *Golavāsanādhyāya*, *Golavarṇanādhyāya*, *Rāhunirākaraṇādhyāya*, *Grahopapattivārṇanādhyāya*, *Yantrādhyāya* and *Praśnadhyāya*. Altogether there are 318 verses which are composed in different meters. After an in-depth study of the text it is realized that Śripati had profound knowledge of Sanskrit. He was well-versed in the other *sāstras* and their branches like

*vyākaraṇa*, *chandasa*, the *vedas*, *purāṇas*, apart from *jyotiṣa*. As it is already mentioned in the first part, Śripati closely follows Lalla and Brahmagupta to compose his text *Siddhānta Śekhara*.

The first chapter *Vyaktagaṇitādhyāya* consists of 55 verses. Śripati explains various arithmetical formulae in this chapter but does not give examples for them. Śripati begins the chapter with praising the mathematician who knows all types of arithmetical calculations. He explains the process of multiplication, division, square, square root, cube and cube root. Śripati also spells out the formulae for addition, subtraction, multiplication and division of the fractions. Further he explains the rule of three, the rule of five, the method to find simple interest, method to find share of profit, arithmetic progression and serial progressions. Next he describes the method to find area of quadrilateral and triangle, the method to find projections and perpendicular in the right angled triangle. He also gives the method to find the radius of circum-circle of triangle. Śripati further explains the method to find diagonals in the quadrilateral and the method to find circumference and area of a circle.

He expounds the method to find approximate square root of a number which is not a perfect square. In the verses 37 to 40, Śripati gives the formula to find chord and arrow in a circle and the method to find diameter when the

\* Accomplished under the sponsorship of Indian National Commission for History of Science between the period August 2012 and August 2015.

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arrow and the chord are given. Śripati also explains the method to construct quadrilateral with two right angled triangles. Śripati explicates the methods to find the accurate volume of a ditch, a globe of stone, heap of grain and to find the number of bricks in a heap. At the end of the chapter Śripati describes the formula to find shadow, the length of the lamp etc.

In the chapter named *Avyaktagnitādhyāya* Śripati, describes the formulae of Algebra in 37 verses. At some places there is no clarity in the subject as some text is missing in the verses. He begins the chapter with stressing the need of algebra. Śripati explains mathematical operations with positive and negatives quantities, process of subtraction, addition, multiplication and division of the unknown quantities. In the sixth verse he throws light on the operations with zero. In this context, he asserts that a number divided by zero is *Khahara* i.e. infinite. As in the case of arithmetic, Śripati never gives examples for the formulae he propounds in algebra. Further, he explains the operations with surds extensively in six verses. He describes the method of transition, the square transition, equation in one variables etc. In the next verses he gives the process of *Bhāvitam* and *Kuṭṭaka* process of calculations. Śripati throws light on the process of *Vargaṅprakṛiti* in 32<sup>nd</sup> and 33<sup>rd</sup> verses.

The chapter named *Golādhyāya* consists of 74 verses. Śripati emphasizes the need of spherical knowledge for an astronomer in the first five verses. He says that an astronomer must process stuff in mathematics and doctrine of sphere. Later he presents the theories of Purāṇas, Jains and the Baudhas with regard to the shape and the state of the earth. Śripati refutes all these theories and presents his own. Śripati argues that the earth is globular in shape and the man situated at the surface of the earth, thinks that he stands upright and the earth is under his feet. He claims that the globe of the earth stands unsupported at centre of the universe by its inherent power. In

support of his claim he gives convincing examples beautifully. As heat is inherent property of the Sun and fire, cold of Moon, hardness of stones, volatility of air, fluidity of water so is the unsupported existence of the earth in the space is natural without any reason. Hereafter Śripati gives geographical description of the earth that is propounded in the Purāṇas. He describes the places of the Gods and the demons. Śripati states that the four famous towns, namely Lanka, Yamakoti, Siddhapura and Romaka are situated from its adjoining one at the distance of one fourth part of the earth's circumference. So that, when it is sunrise at Lanka, it is Sunset at Siddhapura; if it is midday at Yamakoti and it is midnight at Romaka. Śripati further explains that the Jambudveepa is spread into the northern hemisphere of the earth lying north of salt sea. All the other seas and the islands are lying in the southern hemisphere beginning from salt sea. Śripati describes famous mountains in the northern hemisphere and the countries exist between them. Śripati further gives the descriptions of famous gardens of the Gods and the famous towns of Brahma, Viṣṇu and Śiva. Śripati says that there are seven winds around the earth and the Bhuvayu spreads to the extent of 12 *yojanas* from the earth. The next is the *pravāha* wind which moves the stars and the planets. Śripati also explains that the stellar circle along with the planets moves westward by the force of the wind *pravapāha* but the planets always move with slow eastward motion just as insects move reversely on a whirling potter's wheel. Śripati then elucidates the day and the night of the Gods and the demons, who reside at North Pole and at South Pole respectively and also that of the Brahma and the manes. Śripati gives astronomical definitions of civil days of the planets, of the Lunar month, the *Adhimāsa*, *Tithikhyāya* etc. Further he explains the need of *Deśāntara* Correction to the planets, and explains the reason for unequal angular velocity of the planets. Śripati concludes the chapter with descriptions of *Spuṭaparidhi* (rectified

circumference of the earth.) The chapter named *Bhuvanakośādhya* of *Siddhānta Śīromaṇi* of Bhāskara closely resembles with the chapter of *Golavasānādhya* of Śrīpati.

The chapter named *Golavasānādhya* consists of 64 verses. At the beginning of the chapter Śrīpati explains the theories of *manda* and *śighra* correction with *miśra bhangī*. If the diagrams of the eccentric and epicycle are drawn united, such diagram is called *miśra bhangī*. Śrīpati further elucidates the point where the mean motion of the planet coincides with its true motion. Later Bhāskaracārya in his *Siddhāntaśīromaṇi* refutes the theory of Śrīpati and presents correct one. Next Śrīpati spells out the method to construct the half chords in a circle and explains the method to obtain 3<sup>rd</sup>, 6<sup>th</sup>, 8<sup>th</sup> and 12<sup>th</sup> R sines. Śrīpati states the method to obtain *sputa koṭi* and tells the places of *kaṛṇa*, *bhujajya* and *kotijya*. He gives the reasons for the correction called *bhujāntara* and also gives the reasons for the decrease and the increase in the length of day and night. In the next verse he logically explicates why the length of day and night are always equal at the equator. He also spells out the *caradala* correction. Śrīpati explains the method to prepare *gola*, the armillary sphere and to fix the different circles like celestial equator, ecliptic, the meridian, diurnal circle etc. in the verses 29 to 38. He also describes different *śankus* like *sama śanku*, *koṇa śanku* and *madhya śanku* etc. In the verses from 43 to 46 he gives the definitions of *dr̥g̥jya*, *akṣamsa*, *lambamsa*, *udaya lagna*, *asta lagna* and *dr̥nmandala*. Then he gives some latitudinal triangles and their elements. In the verses 50 to 55 Śrīpati elaborates on why the signs of ecliptic do not take equal time to rise and in the verses 56 and 57 he explains the visibility and the invisibility of the signs according to the latitudes of the places. Here Śrīpati follows the theory of Lallacārya which was bluntly refuted by Bhāskara in his *Siddhāntaśīromaṇi*. Further in the chapter Śrīpati deals with some subjects which are important astronomically. The *Chedyak-*

*adhikāra* and the *Golavandhādhikāra* of *Siddhānta Śīromaṇi* of Bhāskara are similar to the *Golavarṇaṇādhya* of Śrīpati.

The chapter named *Rāhunirākaraṇādhya* consists of 15 verses. The subject discussed in the chapter is not much of a relevance to astronomy. Śrīpati describes how Rāhu, the demon became a planet. Śrīpati tells that because of the boon conferred on Rāhu by Brāhmaṇ he became a planet. The whole chapter is a part of *Rāhunirākaraṇādhya* of *Bṛhatsaṃhitā* of Varāhamihira. All the verses mentioned in this chapter closely follow the first 14 verses of *Rāhunirākaraṇādhya* content-wise and order-wise. It is very clear that Varāhamihira composed these verses in accordance with the texts of earlier sages and basing on the Purāṇas. Śrīpati presents different opinion regarding the shape of Rāhu and he refutes them all. He also gives the references from *dharmaśāstra* and the Vedas in connection with the eclipses of the Sun and Moon. Śrīpati explains why the lunar eclipse begins at the eastern limb and the solar at the western limb and spells out the difference between them. At the end of the chapter he gives the causes of the Lunar and Solar eclipses.

The chapter named *Gṛahopapattivarṇaṇādhya*, consists of 18 verses. Śrīpati in the first six verses elaborates the cause of parallax in latitude and parallax in longitude, during the course of solar eclipse. He further shows where the parallax in longitude is zero and where it is maximum and also explains why there is no parallax in longitude and parallax in latitude during the course of lunar eclipse. He propounds why the solar eclipse is seen differently from place to place. Later he explains why the Sun appears subtle in the zenith and big at the horizon. Here he tells that when the Sun is positioned in the zenith, his disc is submerged by his own rays, so he looks subtle and when he positioned in the horizon he is far away from the earth and his brightness will be obstructed by the globe of the

earth, so the Sun looks big, and easily visible. Further Śripati propounds that because of the proximity to the Sun, there is no darkness in the discs of Mercury and Venus as these are in the lower orbits and smaller in shape. At the end of the chapter Śripati narrates the reason for giving *Drkkarma* correction to the planets at the rising and the settings.

The chapter named *Yantrādhyāya* consists of 27 verses. The astronomers in ancient times have devised some astronomical instruments to examine and determine certain facts of Astronomy. The descriptions of such *yantras* are given in this chapter. In the early verses Śripati throws light on the purpose and the importance of the *yantras*. Śripati describes the *Golayantra* in the verses 3 to 6. He explains the method to fix several circles such as ecliptic, celestial equator and tells how to determine the elapsed time of the day from the Sunrise with this *Yantra*. Further, Śripati describes the instruments like *Ciriyāntra*, *Kartariyantra*, *Kapālayantra*, *Pithayantra*, *Ghaṭīyantra*, *Śaṅkuyantra*, *Yaṣṭīyantra* etc. At some places the descriptions of the *yantras* are not clear.

The chapter named *Praśnadhyāya* consists of 28 verses. It was a common practice of ancient astronomers to raise some intelligent questions to test the skill of the readers in their works. Some of the problems Śripati raises in this chapter are already solved by him in the first part of the text. For example, the problem he raises in the verses, like finding of R sine's without using the tabled sine's, is one among them. Here in this chapter Śripati also shows his poetic skill and extensively uses similes while raising the problems.

### CONCLUSION

Śripati had strong scientific temper which clearly reflects in his text. While explaining the shape and the state of the earth he refutes the theories of Purāṇas, Baudhas and Jains and presents his own. He propounds that the earth is

globular in shape and stands supportless in the sky. He explains that as an iron ball stands on magnetite likewise the globe of the earth, the supporter of all, stands in the sky supportless. Śripati adds one chapter named *Rāhunirākaraṇādhyāya* where he strongly negates the role of the demon Rāhu in the eclipses of the Moon and the Sun. He scientifically explains the causes of eclipses of the Sun and the Moon. But Śripati tries to reconcile between the theories of astronomy and the statements of sacred scriptures. He tactically explains that the Rāhu due to the influence of the boon conferred on him by Brahma enters the shadow of the earth obscures the Moon on full Moon day and enters the disc of the Moon and obscures the Sun during the eclipses.

As found in the first part of *Siddhānta Śekhara*, it is realized in the second part also that Śripati composed his text taking clues from the earlier texts like *Brāhmasphuṭa Siddhānta* of Barhmagupta and *Siśyadhivṛdhida* of Lalla. His presentation is similar to that of Lalla who uses poetic style. As it is already been mentioned in the first part of the work of Śripati, Bhāskaracārya closely followed Śripati to compose his master piece *Siddhānta Śiromaṇi*. A good number of verses of second part of *Siddhānta Śekhara* also found place in *Siddhānta Śiromaṇi*.

An earnest effort has been made to give correct translation of the text. While translating the text explanations are given wherever it is felt necessary.

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