Samanta Chandra Sekhar: Life and work

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Mahamahopadhyaya Sri Chandra Sekhar Simha Hari Chandan Mahapatra Samanta (1835–1904), generally known as Samanta Chandra Sekhar and more popularly as Pathani Samanta in Orissa, worked in astronomy following the traditional methods and composed a treatise entitled 'Siddhanta Darpana' in Sanskrit verse. It is a valuable work that records innumerable improvements over the ancient classics, namely, 'Surya Siddhanta' and 'Siddhanta Siromani', by incorporating original observations, calculations, instrumentation and theories. The aim of this paper is to outline and bring to the notice of a wider audience the genius of Chandra Sekhar and his contribution to astronomy. In addition, we also present a brief life-sketch of the astronomer.

India has a rich heritage of astronomy having produced great astronomers like Aryabhata, Varahamihira, Brahmagupta and Bhaskara. The genius of these luminaries bloomed at various places spread all over the country, scaling a time span of nearly 1500 years beginning with 5th century AD. Mahamahopadhyaya Chandra Sekhar Simha Harichandan Mahapatra Samanta, referred to hereafter as Samanta Chandra Sekhar, seems to be the last link of this long order of great Hindu astronomers. *Surya Siddhanta*, *Aryabhatiya*, *Panca Siddhantika*, *Brahmasphuta Siddhanta* and *Siddhanta Siromani* are prominent among the numerous astronomical works of our illustrious ancestors. *Siddhanta Darpana*[1], composed by Samanta Chandra Sekhar, looks to be the latest valuable classic of high order. It is a systematic record of Samanta's lifelong research in astronomy with substantial original contribution to the field. The treatise, written in beautiful Sanskrit verse after the time-honoured Hindu tradition, has great scientific value and is also a fine piece of literary work.

Chandra Sekhar was born in the royal family of one of the princely states of Orissa, at Khandapara in 1835. He is also fondly called Pathani Samanta in the state. Chandra Sekhar, when a child, was initiated to identify stars by his father. He received primary education from a Brahmin teacher. Thereafter, he started teaching himself *Lilavati*, *Bijaganita*, *Jyotisha*, *Siddhanta*, *Vyakaran* and *Kavya* using his family library. He was more attracted by mathematics and astronomy.

At the age of fifteen, he began to check the predictions of the *Siddhantas* with his observations. Ancient Indian works do not give details of instruments or methods of measurement explicitly, excepting hints here and there. So young Chandra Sekhar devised his own instruments. He noticed that, even classics like *Siddhanta Siromani* of Bhaskara and *Surya Siddhanta* did not agree with his observations, for the stars and planets did not appear in the sky as per their predictions.

Hence, young Chandra Sekhar assigned the job to himself and set out for observations night and day, checking every figure occurring in the earlier works.

He began recording his observations and formulations at the age of 23, and in the form of treatise, two years later. The manuscript of *Siddhanta Darpana* was ready in 1869 when he was 34. But it took another 30 years for the work, originally written on palm leaves in Oriya characters, to appear in Devanagari script printed on paper in 1899. Chandra Sekhar had *Surya Siddhanta* for his prime reference and *Siddhanta Siromani* as his guide.

This remarkable scholar and scientist, being confined to a small hilly state in a remote corner of Orissa, far away from the sphere of English education, was virtually doomed to obscurity but for his chance acquaintance with Mahesh Chandra Nyayaratna, Principal of Sanskrit College, Calcutta, who probably later on introduced him to Jogesh Chandra Ray of Cuttack College (today's Ravenshaw College). Nyayaratna's efforts[2] brought him the title of Mahamahopadhyaya, conferred by the British Government in 1893.

Ray was the key person under whose supervision and involvement *Siddhanta Darpana* was published in 1899 from Calcutta with the financial support of the kings of Athmallik and Mayurbhanj. It must be noted that the scholarly introduction of 56 pages in English therein by Ray[3] formed the window through which the outside world could get a glimpse of the valuable treasures contained in this monumental work couched in hardly accessible Sanskrit verse. The international journals *Nature*[4] and *Knowledge*[5] acknowledged the greatness of this contribution to astronomy by Chandra Sekhar and eulogized him in glowing terms. This Sanskrit classic underwent two Oriya translations[6,7] in 1975 and 1976. We present in the following a brief discussion of this work citing only a few important original contributions of its author.

Siddhanta Darpana

Chandra Sekhar in the 17th *Sloka* of the first chapter of the treatise enumerates the requisite characteristics of a *Siddhanta*. The work that deals with the theoretical division of time from the smallest unit of *Truti* (0.274348×10^{-6} s)

Table 1. Summary of the contents of *Siddhanta Darpana*

Name of section	Chapter number	Chapter content	Number of *Slokas* in the chapter
Madhymadhikara	1	Description of time	55
	2	Description of *Bhagan*, etc.	25
	3	Mean planet positions	77
	4	Various corrections	57
Sphutadhikara	5	True planet positions	221
	6	Finer corrections	161
Triprasnadhikara	7	Gnomons, etc.	94
	8	Lunar eclipse	87
	9	Solar eclipse	78
	10	Parilekha description	37
	11	Transit, etc., of planets	111
	12	Alignments of planets	93
	13	Risings and setting of planet	84
	14	Phases of the moon	67
	15	Description of Mahapata	70
Goladhikara	16	A set of questions	79
	17	Description of the Earth	159
	18	Description of the Earth (contd.)	175
	19	The celestial sphere	123
	20	Description of instruments	111
	21	Some deeper questions	249
Kaladhikara	22	Description of years, etc.	76
	23	Prayer to Purusottama	55
	24	Conclusion	156
Total			**2500**

to *Pralaya* (10^{13} solar years), along with the motion of the celestial objects, their rotations, orbits, alignments, occultation and eclipses, etc., with the relevant mathematics like algebra, arithmetic, geometry and trigonometry and also concerns with the question of the origin of the universe is called a *Siddhanta*. One will notice that *Siddhanta Darpana* with 24 chapters and 2500 *Slokas*, out of which 2284 are Samanta's own composition and 216 are citations from the ealier authors, falls short of none of these qualifications. Chandra Sekhar has made original contributions to most of the aforesaid topics dealt with in his astronomical treatise.

It will not be out of place here to give a brief contentwise description of *Siddhanta Darpana*. It is broadly divided into two parts, viz. *Purvardha* (first half) and *Uttarardha* (latter half). The first half contains 15 chapters and the latter half 9. The chapters are further grouped under five sections, namely, *Madhyadhikara*, *Sphutadhikara*, *Triprasnadhikara*, *Goladhikara* and *Kaladhikara*. The first two sections deal with the mean motion and the true positions of the planets, respectively. The third section deals with motion described in terms of space, time and direction. The fourth section gives an account of the relevant mathematics like spherical trigonometry and geometry, etc. The fifth section describes different ways of reckoning time. The distribution of chapters and *Slokas* along with the title of the topic dealt with in each chapter, is given in Table 1.

The contents of *Siddhanta Darpana* look amazing as the achievement of a single mind. Chandra Sekhar has observed, verified and corrected wherever necessary all that was known to the Hindu astronomers for thousands of years. Very often he has gone beyond them to discover new phenomena and to give new formulations and comes out with predictions supposed to remain valid for at least 10,000 years to come. We give below an outline of his contributions to the four important aspects of astronomy, namely (i) observation, (ii) calculation, (iii) method of measurement and instrumentation and (iv) theory and model.

Observation

As indicated in the introduction, the discrepancy between predictions of the ancient *Siddhantas* and his own observations prompted Chandra Sekhar to embark upon serious investigation. He has made it clear that, apart from purely theoretical questions, nothing has been recorded in the *Darpana* without verification through observations.

In the third chapter of the treatise, Samanta enters into discussion on the planets. Let us look at the sidereal periods (time taken for a complete revolution with respect to 'a fixed' star) of the planets as ascertained by him. For comparison, the periods given in *Surya Siddhanta* and *Siddhanta Siromani*, the

Table 2. Sidereal periods of the planets in mean solar days. The data in the last column are taken from ref. 19 and the remaining ones from refs 3 and 20

Planet	*Surya Siddhanta*	*Siddhanta Siromani*	*Siddhanta Darpana*	European values as in 1899	Modern values
Sun	365.25875	365.25843	365.25875	365.25637	365 25636
Moon	27.32167	27.32114	27.32167	27.32166	27.3216615
Mars	686.9975	686.9979	686.9857	686.9794	686.97982
Mercury	87.9585	87.9699	87.9701	87.9692	87.969256
Jupiter	4332.3206	4332.2408	4332.6278	4332.5848	4332.589
Venus	224 6985	224.9679	224.7023	224.7007	224.70080
Saturn	10765.7730	10765.8152	10759.7605	10759.2197	10759 23

Table 3. Inclination of the orbits of planets to the ecliptic. The data in the last column are taken from ref. 19 and the remaining ones from refs 3 and 20.The quantities are in degree, minute and second

Planet	*Surya Siddhanta*	*Siddhanta Siromani*	*Siddhanta Darpana*	European values as in 1899	Modern values
Moon	4 30 0	4 30 0	5 09 0	5 08 48	5 08 33
Mars	1 30 0	1 50 0	1 51 0	1 51 2	1 50 59
Mercury	5 55 0	6 55 0	7 2 0	7 00 08	7 00 18
Jupiter	1 0 0	1 16 0	1 18 0	1 18 41	1 18 18
Venus	2 46 0	3 6 0	3 23 0	3 53 35	3 23 41
Saturn	2 0 0	2 40 0	2 29 0	2 29 40	2 29 10

Table 4. Greatest equations of sun and moon (see text). The data are taken from ref. 3. The quantities are in degree, minute and second

Celestial body	*Surya Siddhanta*	*Siddhanta Darpana*	Western astronomy as in 1899
Sun	2 10 30	1 55 33	1 55 19
Moon	5 2 46	5 1 10	6 3 41

European values as known in 1899, and the modern ones are presented side by side in Table 2. It may be noted that Chandra Sekhar has arrived at the same values for the periods of the sun and the moon as in *Surya Siddhanta*, which agree with the modern values up to second and third decimal places, respectively. But in the case of the slow-moving planets like Jupiter and Saturn, his results are surprisingly in closer agreement with the modern values than those of the other two *Siddhantas*. Table 3 gives a comparison of the mean inclination of the orbits of the planets to the ecliptic. It can be seen that, of the three classical works quoted here the values of *Siddhanta Darpana* are the closest to those of modern astronomy.

The angular position of a planet in its orbit, with respect to the force centre, is called the 'true anomaly'. The eccentric angle of the planet on the auxiliary circle is the 'eccentric anomaly'. Their difference is the equation of anomaly, the greatest value of which is a measure of eccentricity. The greatest equations given by Samanta in the case of the sun and the moon agree within seconds with the Western astronomy (Table 4). The intersection positions of the moon's orbit with the ecliptic are called *Rahu* and *Ketu* in the traditional Indian astronomy. In the Western astronomy they are called the nodes of moon. The minimum distance position of the moon from the earth is called the *perigee*. Table 5 shows a comparison of the sidereal periods of these nodes and the perigee.

Further, Chandra Sekhar gives a correction to be applied to *Mandocca* (the farthest position on the orbit from the force centre) of Mercury, Mars and Saturn and calls it '*Parocca correction*'. The maximum values of these corrections are 12°20′, 7°30′ and 5° for the above three planets, respectively.

In observation of the moon, Samanta Chandra Sekhar noticed three important irregularities. They are *Tungantara* (evection), *Pakshika* (variation) and *Digamsa* (annual equation). In terms of modern understanding[8,9], recognition of these three irregularities is as follows:

(i) *Tungantara* (evection) is the largest of the irregularities. It depends on the changing position of the apse line (the line joining the maximum and the minimum distance positions from the force centre, i.e. the earth) in successive lunar months. It further has the following two effects:

(a) The apse line advances as a whole while undergoing oscillatory motion. However, it retrogrades when the perigee (maximum distance from the earth) occurs at the first and third quarters of a lunar month.

(b) The eccentricity also oscillates, attaining a maximum of 0.066, when perigee occurs at new or full moon, and a minimum of 0.044, when it occurs at first or third quarter. This perturbation effectively puts the moon forward or backward from the expected position by about a degree. The maximum of this irregularity according to modern astronomy is 1°17′, whereas Samanta Chandra Sekhar observed it to be at most 2°40′.

(ii) *Pakshika* (variation): From new moon to full moon, i.e. during the bright fortnight of the lunar month, the attractive force of the sun on the moon retards it. And during the dark fortnight, the effect is opposite and the moon is accelerated. This causes a maximum shift in the position of the moon by 39′31″ according to modern astronomy. Samanta's value of 38′12″ for maximum of this effect is surprisingly close to the modern value.

(iii) *Digamsa* (annual equation): This is another irregularity in the position of the moon, which arises due to variation in sun–moon distance as the earth orbits round the sun. Obviously, its period is one year. The maximum value of this correction is 11′9″ as per modern astronomy, and Samanta's value of 12′ is fairly close to it.

Chandra Sekhar has clearly mentioned in *Siddhanta Darpana* that *Tungantara* was known to his predecessors. However, J. C. Ray in his introduction to *Siddhanta Darpana* says: 'In computing the moon's place, Chandra Sekhar has discovered some original corrections – original in the sense of their having been unknown to the ancient astronomers of our country'[3]. Even Burgess[10] in his English translation of *Surya Siddhanta* says that the Hindus did not take any notice of evection. However, the latest view on this issue is that of P. C. Sengupta[11], who concludes that evection and variation were introduced by Munjala and Bhaskara. Nevertheless, it is definite that Samanta Chandra Sekhar was the only Indian astronomer of traditional school to have discovered *Digamsa* and took into account all the three irregularities and measured them with utmost accuracy. In passing, it will not be out of place to mention that Tycho Brahe was the first

Table 5. Sidereal periods of the nodes (*Rahu* and *Ketu*) and the perigee in mean solar days (see text). The data in the last column are taken from ref. 19 and the remaining ones from refs 3 and 20

Entity	*Surya Siddhanta*	*Siddhanta Siromani*	*Siddhanta Darpana*	European values as in 1899	Modern values
Moon's nodes	6794 3948	6793 2535	6792 644	6789 270	6793 470
Moon's perigee	3232 094	3232 734	3232 657	3232 575	3232 600

Table 6. Rates of mean motion of the planets per day. The quantities in the upper line in each row in the third and fourth column are in sexagesimal system and the ones in the corresponding lower lines are in decimal system. The data under modern value are taken from ref. 19 and those due to other *Siddhantas* from ref. 20. The quantities are in degree, minute and second

Planet	Modern value (Lahiri)	Brahmagupta Sripati Bhaskar	Samanta Chandra Sekhar
Sun	0 59 08.2	0 59/8/10/21	59/8/10/24/12/30/4/0/4
		0 59 8.1725	0 59 8.1733912182
Moon	13 10 35.0	13/10/34/53/0	13/10/34/52/03/49/08/02/16/10/11
		13 10 34.8833	13 10 34 8677275173
Mars	0.31 26.5	0/31/26/28/7	0.31 26.5018877228
		0 31 26.4686	
Mercury	4 05 32.4	4/05/32/18/28	
		4 5 32.3077	
Jupiter	0 04 59.1	0/04/59/9/9	0/04/59/05/37/0/36/41/17/01/51
		0 04 59.1525	0 04 59.0936139473
Venus	1.36 07.7	1/36/7/44/35	
		1 36 7.74305	
Saturn	0 02 01.9	0/20/0/22/51	
		0 2 0.380833	0/02/0/26/55/02/53/21/02/04/54
Moon's nodes	–0 03 10.6	0/03/10/48/20	0 2 0.448624511
		0 30 10.8055	0 03 10.7946631769

Western astronomer to have detected and measured all these three irregularities.

Another improvement made by Chandra Sekhar was in the case of parallaxes of sun and moon. Parallax is defined as the angle subtended by the radius of the earth at a heavenly body. The earlier *Siddhantas* took it to be 3′56″at sun and 52′42″at moon. But since these are the quantities that enter into calculation of eclipses, Chandra Sekhar changed them to make the predictions agree with the observations. The ancient Indian astronomers place the sun at a distance not more than 14 times that of the moon from the earth. Chandra Sekhar hiked this ratio by more than ten times, to 154, which is much closer to the modern value of 390.

Calculation

Astronomy is a science in which observation goes hand in hand with calculation. Besides a thorough knowledge of the motion of the celestial objects, it requires sufficient computational skill to tackle the vast multitude of big numbers We will see in this section that Chandra Sekhar was extraordinary in this respect. Very often he has gone beyond his predecessors in precision of computation and in giving new methods of calculation.

To get positions of planets one has to do extremely careful calculations. In the traditional method one first calculates a mean position and then applies corrections to arrive at the true position. The calculation of mean position requires a mean rate of motion. Works in traditional astronomy clearly give these rates as accurately as possible. The earlier works are found to give these rates (mean angular displacements per day) at best to five places in the sexagesimal system. But Chandra Sekhar gives these rates to ten places in the same system. For comparison, we have presented in Table 6 the modern values of these rates in the decimal system and also given the traditional data converted into decimal system.

Chandra Sekhar recognized that, in addition to the usual correction to the mean position, further finer corrections are needed from time to time to make accurate predictions. For each planet, he has provided such a correction to be applied for hundred million (one *Arbuda*) years. There are as many as 55 tables, each on an average having 50 numbers, sometimes given up to five places in sexagesimal system. These tables appear to be a challenge for one's unaided computational skill.

Regarding the measurement of longitudes of the celestial bodies, there is a fundamental difference between the Western system and that of the Hindus. In the former system, it is measured with respect to the vernal equinox, i.e. one of the point of intersection of the celestial equator with the ecliptic. The Hindu system measures it with respect to a fixed point (a particular star) on the ecliptic. It is the starting point of zodiac and its longitude is the *Ayanamsa*. But it may be pointed out that the axis of the earth undergoes a precessional motion with a period of about 25,800 years. This causes a shift in the position of the equinox and also in that of the reference star, which according to the traditional Indian astronomy is called *Ayanacalana*. So, this effect must be taken into account in fixing the *Ayanamsa* of the reference point. A correct determination of the *Ayanamsa* involves a number of factors like the rate of precession, the exact length of a year, the year of the zero *Ayanamsa* and the star of reference. A critical discussion of the matter is found in the introduction to *Siddhanta Darpana*[3]. *Surya Siddhanta*, *Soma Siddhanta*, *Sakalya Siddhanta*, and *Laghu Vasistha*, etc., have given the rate of precession as lying in the range 54″ to 46″.25 per year. However, *Bhasvati* and *Graha Laghava* have found the value to be nearly 60″. But Chandra Sekhar's value is 57.615″ per year.

The modern value of the precessional rate is, however, 50.3″ per year. Thus, it appears that the Indian rates quoted above are in disagreement with the modern value. Therefore, it is desirable to understand how such varying rates of precision which sensitively affect the fixation of *Ayanamsa* could give meaningful prediction in the ancient Indian astronomy. Ray gives a solution to this puzzle. He points out that the Indian astronomers take the sidereal year for calculation of the rate of precession, in contrast to the tropical year, taken in the West. Since the sidereal year is longer by a few minutes, the sun advances by an amount of 8.4″ during this interval of time difference. This has an effect on the calculation of precession of equinox and the amount has to be deducted from the rates given by various authors. When this correction is taken into account, Samanta's value turn out to be 49″.179 per year, which is much closer to the modern value.

Chandra Sekhar has devised a diagramatic or graphical method (*Parilekha*) for calculations of eclipses and many other phenomena. In this method, when the nature and periodicity of the motion of the heavenly bodies are known, one can simulate the phenomena by constructing geometrical diagrams on the plain surface and use them for computation of dynamical quantities. This method might be akin to the numerical evaluation of integrals. Especially, he tackles the calculations of the three well-known irregularities of the moon with simple geometrical arguments. It is needless to say that his calculations of eclipses are accurate and agree with observations. It may be noted here that this has been the guide in the preparation of the almanac used in Orissa since about 1870.

Before concluding this section, we would like to point out at least two facts of mathematical interest from *Siddhanta Darpana*. Samanta does not accept the value of π as 22/7; instead, he takes it to be 3927/1250 and also 600/191. He seems to have provided a new method for computing the cube root of numbers which is different from that of Bhaskara.

Measurement and instrumentation

Chandra Sekhar was unaware of the scientific and technological developments that had already taken place in the West. He had not seen or even heard of a telescope until his very old age. So he employed the traditional methods for astronomical measurements. He had devised some new instruments for the purpose. It is a remarkable point that Jai Singh in the 18th century built a number of observatories in the northern part of the country. His instruments for measurements in these observatories are rather gigantic. In sharp contrast, Chandra Sekhar, who worked about 150 years later, fabricated quite simple and small devices and made accurate observations.

Before attempting to give an account of his astronomical *Yantras*, we would like to mention an interesting fact about Chandra Sekhar's ability for measurements. The children at primary schools in Orissa today read it as a myth that Samanta measured the heights of distant mountains with a pair of tiny sticks. The simplest of his stick instruments is the *Sanku* (pole). Of course, it was used also by the Greeks under the name '*gnomon*'. It is not difficult to find out the latitude of a place by observing the shadow of the *Sanku*, cast by the sun. But more interesting is, Chandra Sekhar's calculation of local time from the shadow.

Chandra Sekhar's most talked of instrument is the *Mana Yantra*. Details of construction of this instrument have been described in *Siddhanta Darpana*. Chandra Sekhar used this *Yantra* as a multipurpose device. A simpler version of this *Yantra* is a two-stick arrangement in the form of 'T', which he could fabricate quickly, and measure the height and distance of mountains, etc., whenever occasion demanded.

Samanta has described in detail the construction techniques for varieties of *Gola-yantra* that he used to measure the positions of planets. There is a mention of as many as ten different devices for measurement of time in *Siddhanta Darpana*. Models of some of these, including a *Gola-yantra* have recently been exhibited at the Regional Science Centre, Bhubaneswar. Samanta Chandra Sekhar has devoted a full chapter of *Siddhanta Darpana* to describing the construction and use of instruments. Such instruments, by today's standard, are crude, but using them he could arrive at results in close agreement with modern values, primarily due to his skill, attained through long years of dedication and practice.

Theory and model

The most prominent of Chandra Sekhar's theoretical contributions is his model of the planetary system, which is different from those of his predecessors in India. Samanta supported a stationary-earth hypothesis, with sun, moon and stars revolving around the earth. But it has the novel feature that planets like Mercury, Venus, Mars, Jupiter and Saturn go around the sun, and the sun moves around the earth together with these companions. This is evident from the following *Slokas* of *Siddhanta Darpana*:

तत्रमध्यम–मार्त्तण्डः परितोमण्डलंभुवः
भ्रमन् ताराखेचराणां कक्षामध्यस्थ उच्यते।
तं भ्रमन्तो महीजाद्यास्तत्सङ्गेन भुवं पुनः
परिक्रामन्ति यत्तस्मात् स प्रोक्तः सर्वकर्षकः।

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Thus, he assigned heliocentric motion to the planets. Incidentally, a similar model was proposed by Tycho Brahe in the West in the late sixteenth century. A recent work by Ramsubramanian *et al.*[12] brings to light that a similar model of the planetary system was given by Nilakantha Somasutvan of the Kerala school by 1500 AD.

Conclusion

We have attempted to give a brief sketch of the extraordinary life and work of Samanta Chandra Sekhar here. Unfortunately, due to various historical and geographical reasons, his true position in ancient Indian astronomy has not been ascertained so far. Ray has drawn a nice parallelism between the life and works of Samanta Chandra Sekhar and of Tycho Brahe. The journal *Nature* comments[4] Prof. Ray compares the author very properly to Tycho. But we should imagine him to be greater.' The importance of Samanta's work and the quality of his observations with naked eye have got true recognition through the comments made in the journal *Knowledge*[5]: 'Of all the numerous works on astronomy that have been published within the last few years, this is by far the most extraordinary and in some respects the most instructive. ....It is a complete system of astronomy founded upon naked-eye observations only. ....The work is of importance and interest to us Westerners also. It demonstrates the degree of accuracy which was possible in astronomical observation before the invention of telescope.' Here it will be probably fair to state that Samanta Chandra Sekhar belongs to the same class of Indian astronomers as Aryabhata, Varahamihira, Brahmagupta and Bhaskara.

It is unfortunate that Chandra Sekhar is almost unknown outside Orissa. This has so happened probably because he lived and worked during a period which was about 300 years after Orissa lost its pristine glory and preeminent position in the Indian subcontinent[13-16]. Although Orissa came under British rule in 1803, it continued to remain in virtual darkness during the lifetime of Samanta, being deprived of the advantage of modern education.

Almost a century has passed since the publication of *Siddhanta Darpana*. Its author passed away in 1904 living in the midst of poverty and struggle. The only recognition for the scientist during his lifetime was the acceptance of his astronomical prescriptions for regulation of the rituals at the Jagannath temple and the award of the title of Harichandan Mahapatra by Gajpati king of Puri in 1870. Of course, the title of Mahamahopadhyaya was conferred upon him by the British Government in 1893.

It is a matter of some relief that Kochhar and Narlikar[17] and SriRam[18] have recently referred to the work of Samanta Chandra Sekhar. Nevertheless, *Siddhanta Darpana* continues to serve the people of Orissa by providing the basis for the preparation of its almanac.

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