M. Rangacharya and His Century Old Translation of the *Gaṇita-sāra-saṅgraha*

Lots of Achievements in ancient Indian Mathematics as reflected in the works of Āryabhaṭa I (born 476 AD), Brahmagupta (seventh century AD) and Bhāskara II (twelfth century) were freshly made known in modern form to the Western world during the nineteenth century. Leading role in this regard was displayed by Western scholars such as R. Barrow, H. T. Colebrooke, S. Davies, C. Hutton, H. Kern, L. Rodet, E. Strachey and John Taylor.

Often some Indian scholars (e.g. Bapudeva Sastri and Sudhakara Dvivedi) were also involved and associated in this academic and educational propagation. However, according to the then well-known historian of mathematics, D. E. Smith, "native scholars under the English supremacy have done so little to bring to light ancient mathematical material known to exist and to make it known to the Western world". Nevertheless, he had soon found a sort of exception in Prof. M. Rangacharya whom he met in Madras (about 1905). He came to know about latter's edition and translation of the *Gaṇita-sāra-saṅgraha (=GSS)* then contemplated to be published for the first time. With Smith's introduction, the fruitful work appeared a century back (Madras 1912).

Prof. M Rangacharya (1861–1916)

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Rangacharya was born in 1861 in Melkote[†] (of the then Mysore State) where he also received his early education. In 1881, he passed the B.A. and worked in Madras Christian College. Soon, the Government College, Kumbakonam offered him a lecturership in science. On completing M.A. in Physical Sciences, he served the Govt. College, Rajahmundry, the Presidency College, Madras (1890), and the Maharaja College, Trivandrum after which he returned to the Presidency College. Here, he became professor of Sanskrit and Comparative Philosophy in 1901. It was the result of the great impression, influence and impact which he had already made by his scholarly lectures and publications. He also became Curator of the Govt. Oriental Manuscripts Library which was a literary 'Laboratory' for him. In 1903, the title "Rao Bahadur" was awarded to him. He died in 1916 and thus a brilliant career ended.

It is interesting to note that Rangacharya's interest in *GSS* was initiated by the then Director of Public Instruction, G. H. Stuart who had asked him to find out if the G. O. M. Library has "any work of value capable of throwing new light on the history of Hindu mathematics, and publish it, if found with English translation etc." A search yielded three incomplete manuscripts of *GSS* in the Library. On the advise of Stuart, some other *mss* (luckily found to be complete) were procured. The tough job of editing and translating could be taken to final stage due to Rangacharya's labour of love. Unfortunately, Stuart did not live long enough to enjoy the delight of seeing the final form.

Rangacharya was a remarkable scholar, scientist and educator. He enriched his formal routine knowledge further by self study of various branches of learning. As a result, he could successfully teach a variety of subjects such as biology, chemistry, physics, mathematics, history, philosophy, Sanskrit and Indology. The variety and depth of his scholarship is well reflected in his studies, researches and publications which cover scientific as well as humanity topics. We take an example.

The cyclic division of time is peculiar feature of ancient Indian Chronology. But the four *yugas* (called *kṛta, tretā, dvāpara and kali*) have also been given a variety of interpretation in Indology. For instance, the *Aitareya Brāhmaṇa* is said to have stated that "one who sleeps is *kali*, one who gets up is *dvāpara*, one who stands up is *tretā* and one who moves is *kṛta*" (Rajneesh, p. 18). Rangacharya interpreted the four *yugas* in terms of historical periods. According to him, the *kṛta* ("deed") *yuga* refers to the period when the Āryans performed heroic deeds in conquering lands and establishing their supremacy in the Indian subcontinent, the *tretā* i.e. the ("three" i.e. the three *nitya-agnis* dealt so frequently in *Śulba-sūtras*), *yuga* refers to the period when the Aryans were concentrating on the vedic sacrifices and priesthood, etc. (1909). He mentioned the Sanskrit *Sūrya-siddhānta* for giving the life of Brahmā as 31104×10^{10} solar years which are taken to form the life of universe according to Hindu theory of cycles of creation and *pralaya* (destruction). But some *Purāṇas* consider even Brahmā's whole life just as twinkling of the eye of Lord Kṛṣṇa or Śiva (Gangooly, p. 12)!

[†]For obvious reasons, the reading: 'Malkota' in the published article has been changed as above.

The *GSS* is a very significant work not only of the Jaina School but of ancient Indian Mathematics in general. However, due to religious bias, it did not find the mention it deserved in the works of Hindu mathematical writers belonging to ancient and medieval periods. Although entitled *saṅgraha* ("collection") it contains many original contributions of the author Mahāvīra who was a Digambara Jaina belonging to the ninth century.

The translation of *GSS* into English is Rangacharya's greatest contribution to history of mathematics and by doing so he has made, in the words of Smith, "the mathematical world his perpetual debtor". The interest shown by Smith in *GSS* also helped in its quick worldwide publicity. Rangacharya's work has useful appendices. During the last 100 years, scholars in the field have been benefited by his clear edition of the Sanskrit text, faithful translation and accompanying notes. Scores of research papers, essays and popular articles on *GSS* as well as on its author have been published (see a brief bibliography at the end). There is a need to make a fresh and deep critical study of the *GSS*. It will not be out of place to mention a few things.

The *GSS* 1.49 gives the wrong rule $\frac{N}{0} = N$

possibly because division by zero was looked upon as of no effect (cf. distribution of N things among zero persons). Mahīdhara's commentary (1587) on *Līlāvatī* contains the above rule numerically with $N = 9$ (Ganitanand, p. 139). A simple and practical algorithm to express a given fraction $\frac{p}{q}$ into unit fractions is the Mahavira–Fibonacci method (Gupta 2010, pp. 87–88). A typically Jaina formula for finding the arcual length s of a circular segment of chord c and height h is their very ancient empirical rule (*Ibid*., pp. 66–68)

$$s = \sqrt{c^2 + 6h^2}.$$

Its history, rationale and related forms are interesting. GSS (VII. 63) appears to have used it for accurate rectification of the 'elongated circle' or ellipse (Gupta 1974).

Takao Hayashi has discussed several mathematical formulas and aspects of *GSS*. He [1987] gives a new interpretation of the Quiver Problem and [1992] deals with the Conch-like plane figure. Links between Mahāvīra and the non-Jaina Nārāyaṇa Paṇḍita (1356) are clearly reflected in many ways. For finding the area of the curved surface of spherical segment, *GSS* (VII. 25) prescribes.

$$A = \frac{p \cdot w}{4}$$

where p is the perimeter of the base circle and w is the curvilinear width of the bulged surface (Gupta 1989). This empirical rule easily leads to the expressions

$$S = \frac{C^2}{4} = \left(\frac{C}{2}\right)^2$$

for the full surface S of a sphere where C is the circumference of any great circle. Interestingly such a rule for finding S (in form of above expressions) was known to

Ṭhakkura Pherū (c. 1300) in India and to the seventeenth-century Japanese mathematicians as old method (Gupta 2011). Surprisingly, $S = (\frac{c}{2})^2$ also appears in some Italian manuscripts of the fourteenth and fifteenth centuries (Simi and Rigatelli., p. 469). *GSS* rules for volume of a sphere and frustum like solids have been given a new look (Gupta 1986 and 2011).

Rangacharya's endeavour could procure only a few manuscripts of *GSS* for consultation. Now D. Pingree's *Census*, Vol. 4 (1981), pp. 388–389, lists about 50 manuscripts. Daivajña Vallabha's *Kanarese* commentary on GSS is known and he is also claimed to be the author of a Telugu commentary on the same work. Other Commentators of *GSS* include Varadarāja and Sumatikīrti who belong to the sixteenth century (?). In the eleventh century, *GSS* was translated into Telugu by Pāvuḷūri Mallana, son of Sivanna. But he also made some changes and additions and the whole work is popularly called Pāvuḷūri Gaṇitamu. His grandfather was also named Mallana whom some scholars regard the real author of the Telugu work (Arunachalam p. 149).

It so happened that, about two centuries, a keen scholar-officer named Benjamin Heyne studied the Pāvuḷurī Gaṇitamu and translated its *kṣetragaṇita* chapter into English. This was published as "A free translation of the Chetri Ganitam or Field Measuring of the Hindoos" in *Tracts of India* (London 1814) [Gupta 2002].

According to Pingree (p. 388), *GSS* was translated into Rajasthani by Amīcandra in 1842. L. C. Jain's edition with Hindi translation (Sholapur, 1963) is based on Rangacharya's version. B. B. Bagi's Introduction says that "a new edition with English translation by an experienced mathematician who knows Sanskrit well is an urgent need". In 2000, Sri Hombuja Jain Math published the *GSS* with Rangacharya's translation along with a Kannada.

The relation and relative chronology of Mahāvīra (c. 850) and Śrīdhara (eighth century) has been often discussed by scholars. Although K. S. Shukla's introduction to Śrīdhara's *Pāṭīgaṇita* (Lucknow, 1959) placed Śrīdhara after Mahāvīra, later on he accepted the usual dates (see *Gaṇita Bhāratī*, Vol. 9, 1987, pp. 54–56, and Vol. 25, 2003, 146–149).

A critical edition of *GSS* based on more mss along with some ancient commentary will be a tribute to Rangacharya on the occasion of his coming death centenary.

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