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Prof. K. C. Acharya

that is laid by the schools of Indian Philosophy. Ghoshal Sastri observes,[55] "Almost all Philosophies discard the mundane life. Only the Philosophy of Aesthetics and Esoterics appreciate it. A physically fit, mentally balanced and ethically measured life may enjoy the real bliss of enjoyment and renunciation, that repeatedly vouchsafed the *Upaniṣad* and is the morale of Indian Socialism *'tena tyktena bhuñjithāḥ'*, i.e. have your own, by sharing it with others, who deserve; what converts sorrow into happiness, poison (of materialistic life) changes into nectar and makes the domestic life of hermitage; which assures us Peace, Bliss and Salvation for good and leads to Truth, Beauty and the Supreme Good."

> *duḥkhānyapi sukhāyante viṣam apy amṛtāyate*
> *mokṣāyate ca samsāra eṣa mārgo hi śānkaraḥ.*[56]

55. Ibid., p. 219.
56. *pāṭhabheda .....Yatra mārgaḥ sa śānkaraḥ. Stotrāvali;* cited in *Mahārthamañjarī-parimalaṭīkā* of Maheśvarānanda, (*ṭika* on verse 54 and 64) . Kashmiri Series of Texts and Studies, No. XI. The Research Department of J. & K. State, 1918, p. 118 and p. 141.

VEDIC MATHEMATICS vs. MATHEMATICS IN THE VEDA

Sreeramula Rajeswara Sarma

Science enjoys today an unprecedented prestige and its byproduct, sophisticated technology, governs the material life of our times. The encounter with these emanations of the Western material culture generates various kinds of responses in India One typical response is to greedily accept the fruites of this culture but at the same time deny and credit to the West either by declaring that all this had already been stated or anticipated long ago in India or by claiming that the Western inventions are indeed based on the study of Sanskrit texts. One might think that this reaction is limited to the circle of uninformed laymen but even the present occupant of the august position of the General President of the All-India Oriental Conference is not free from this malaise, when he states the following in his address to the conference in November 1990.

> It is just possible that many of the discoveries in the field of Science and Technology made by experts abroad have their crucial clues in some Sutras contained in Sanskrit literature.[1]

He goes on to say that foreigners are learning Sanskrit now and collecting original texts precisely with this purpose in mind.

An enlarged version of the paper read originally at the National Seminar on 'Spiritual Interpretation of the Veda', Department of Sanskrit, Aligarh Muslim University, Aligarh 1989.

1. *Address of the General President Ramaranjan Mukherji;* All-India Oriental Conference; Thirty-fifth Session, Gurukula Kangri Vishvavidyalaya, Hardwar, November 16-19, 1990, p.13.

The idea underlying this attitude is that Sanskrit literature, in particular the Veda, is supposed to contain all modern science and technology in a coded language. Western scholars have coined a name for this attitude-'inclusivism'. In recent decades, the urge to decode our ancient scriptures and to interpret them 'scientifically' has become so strong that history of science has become quite a popular pastime, Srotriyas vying with one another in unravalling the scientific secrets from the Veda. This raises a host of questions.

If the Veda is venerated merely because it is a book of science in a coded form - be at a stronomy, chemistry, cybernetics, or nuclear physics, should we not then venerate other books of science also- if not the NCERT text books, at least Bhaskara's Līlāvatī? Why is it that we rediscover in the Veda only those things that have already been discovered in the West, and not new things unknown to the West, for example, an efficient and cheap solar energy conductor or a good remedy for common cold ?

The next problem is somewhat more weighty. In science there is no final word. It is always possible that current notions may be refuted tomorrow, or at least modified or revised. Therefore, if a particular scientific idea is read into the Veda today and if this idea is refuted tomorrow, then the Veda also runs the risk of being refuted. To give an example, nuclear fission was supposed to be the greatest achievement of humankind until recently. As consequence, there have been many an effort to trace nuclear physics in the Veda. Since the disaster at Chernobyl in the USSR a few years ago, however, the West has started rethinking about the supposed benefits of nuclear energy. Time is not far off when nuclear energy will no more be regarded as a blessing. What then will be the position of the Veda if it is interpreted as textbook on nuclear physics in a religious disguise?

This sort of confusion between the nature of the science on the one hand and that of the scriptures on the other[2] is best exemplified by a book called *Vedic Mathematics* which attained enormous. popularity in the last decade. Since many misconceptions prevail about this book, I will briefly narrate how it came to be published, what it contains and how it became popular. The *Vedic Mathematics* was written by Bharati Krsna Tirtha who was the Sankaracarya of the Govardhana-pīṭha of Puri from 1925-1960. The book was published posthumously in 1965 by Banaras Hindu University through the efforts of Mrs Manjula Trivedi, a desciple of the *Śaṅkarācārya*.[3] This book teaches, in English, how to perform arithmetical operations like multiplication, division, factrisation, squaring, cubing, extracting square-roots, cube-roots, etc. of very large numbers. The basic rules are, however, given in 16 sūtras and 13 upasūtras which are composed in Sanskrit in sūtra style, e.g. 1. *ekādhikam pūrveṇa, i. ānupūrvyeṇa* 2. *nikhilaḥ navataś caramaṃ daśataḥ*, ii. *śiṣyate śeṣasaṃjñaḥ*.

What is the connection of these sūtras with the Veda / Do they occur in any Vedic text ? If they do, why did they escape the notice of commentators like Sāyaṇācārya or mathematicians like Āryabhaṭa or Bhāskara ? Bhāratī Kṛṣṇa Tīrtha answers some of these questions in the introduction to his book. It will be

2. On this see, Debiprasad Chattopadhyaya, "Scientific Thought in the Vedic Age," G. Ramakrishna (ed.), *Studies in Indian Culture : Sāhitya Śiromaṇi Professor S. Ramachandra Rao Felicitation Volume*, bangalore 1986, pp. 80-12.

3. Jagadguru Swāmī Śrī Bhāratī Kṛṣṇa Tīrthajī Mahārāja, *Vedic Mathematics or Sixteen Simple Mathematical Formulae from the Vedas (For one-line Answers to All Mathmatical Problems)*, Banaras Hindu University, Varanasi 1965 (Nepal Endowment Hindu Vishvavidyalaya Publications Series). Several reprints by Motilal Banarsidass, Delhi, from 1970 onwards.

necessary to quote him at some length as his statements also dwell on the nature of the Veda. He declares :

> The very word 'Veda' has this derivational meaning, i.e. the fountainhead and illimitable store-house of all knowledge. This derivation, in effect, means, connotes and implies that the Vedas should contain within themselves all the knowledge needed by mankind, relating not only to the so-called 'spiritual' (or otherwordly) matters but also to those usually described as purely 'secular', 'temporal', or 'worldly'...

> In other words, it connotes and implies that our ancient Indian Vedic lore *should* be all-round complete and perfect and able to throw the fullest necessary light on all matters...

> And the contemptuous or, at best patronizing attitude adopted by some so=called Orientalists... strengthened our resolute determination to unravel the too-long hidden mysteries of philosophy and science contained in ancient India's Vedic lore, with the consequence that, after years of concentrated contemplation in forest solitude, we were at long last able to recover the long lost keys (i.e. *sūtras*) which alone could unlock the portals thereof.[4]

He goes on to say that these 'ultra easy Vedic *sūtras* (are) contained in the Pariśiṣṭa of the *Atharvaveda*.'[5] Do they really occur in any known Pariśiṣṭa ? His pupil, Manjula Trivedi, says :

> Revered Guruji used to say that he had reconstructed the sixteen mathematical formulae (given in the text) from the Atharvaveda after assiduous research and 'Tapas' for about eight years in the forest

4. Ibid, Author's Preface, pp. xiii-xv.
5. Ibid, p. xv.

> surrounding Sringeri. Obviously these formulas are not to be found in the present recensions of the Atharvaveda; they were actually reconstructed, on the basis of intuitive revelation, from materials scattered here and there in the Atharvaveda.[6]

In other words, the sutras were invented and composed by Bharati Krsna Tirtha himself and cannot be located in any Vedic text. V.S. Agrawala, who published the book on behalf of the Banaras Hindu University, attempts to reconcile this in the following manner :

> this work of Śrī Śaṅkarācāryajī deserves to be regarded as a new Pariśiṣṭa by itself and it is not surprising that the Sutras mentioned herein do not appear in the hitherto known Pariśiṣṭas.[7]

Thus these sūtras are 'Vedic' only by courtesy. At the most, one can argue, after Suśruta, in the following manner :

> *ṛṣivacanaṃ vedaḥ/śaṅkarācāryaḥ ṛṣiḥ/śaṅkarācāryavacanaṃ vedaḥ/ śaṅkarācāryaproktaṃ gaṇitaṃ vaidika-gaṇitam/QED*

As we said, the book was published in 1965. It was reviewed in the *Vishveshvarandanda Indological Journal* in 1966, and the reviewer remarked : "His (the author's) effort to glorify the Vedas and Hindu Culture by these false claims will only create revulsion of feeling when the truth is known. The pity is that what the author gives is not even Hindu classical mathematics.[8]

6. Ibid, pp. ix-x
7. Ibid, General Editor's Foreword, pp. 6-7
8. T. S. Kuppanna Sastry in *Vishveshvarananda Indological Journal* 9 (1966), pp. 108-109, see also A. K. Bag, *Indian Journal of History Science* 13 (1968), pp. 59-60; R. C. Gupta, Ibid, p. 223.

Then for the next fifteen years or so, not much scholarly notice was taken of this book, until A.P. Nicholas, then Senior Lecturer, Department of Accounting and Administration, Polytechnic of North London, became interested in the early eighties. He travelled to India in search of Bhāratī Kṛṣṇa Tirtha's other works, lecture records and other information, lectured at various universities and conducted courses at Nagpur on 'Vedic Mathematics".

It is sad to think that but for the exertions of this Englishman, India would not have paid much attention to this book, which contains brilliant computational methods- only these are Bhāratī Kṛṣṇa Tīrtha's own methods and not from the Veda. But now there are many exponents with a missionary fervour. There are correspondence courses on 'Vedic Mathematics', a journal styled *Vaidik Gaṇit* and TV programmes. With the typical zeal of a new religious cult, the literature speaks of a Rourkee professor giving hundreds of hours of lectures in scores of universities all over the globe. Newspapers, generally illiterate in matters cultural, write about 'the great Vedic mathematician Varāhamihira' and similar absurdities. Worse still is the academic research. I have had occasion once to look at a Ph.D thesis on 'Vedic Mathematics'. Each one of its 800 pages is filled with discourses such as the following, which is being reproduced exactly as it occurs :

> Vedic mathematics with lorescence systems of sunlight works out the universal set of Human Beings as a set of individualistic displays within Human frame which is flourishable as a noble set of processes into which the Human frame is flourishable consists of a processing-process, a flourishment process, a channelizing process, and a fountaining process. This is Purusha Vidya, the Mathematics of Eternal Paths within human frame. Vedic Mathematics works its out within a six dimensional domain.

Surely this has nothing to do with mathematics, or with the Veda, or with history of science. That it has very little relation to the English language needs no emphasis.

Let me reiterate that Bhāratī Kṛṣṇa Tīrtha's work contains exceptionally creative mathematics and that the teachers of mathematics who are conducting courses and exposing young pupils to these techniques are doing laudable work.[9]

But the fiction of this system of mathematics being 'Vedic' is not just causing terminological confusion in the historiography of mathematics but the glamour this system came to acquire is making us lose sight of the solid, if not so spectacular, achievements India made in the realm of mathematics in the Vedic period.

Fortunately, much valuable work has already been done and the credit for unravelling the mathematical content in Vedic literature goes to another Svāmījī, viz. Svāmī Vidyāranya, who was well known in his Pūrvāśrama as Vibhutibhusan Datta. The chapter on Vedic Mathematics, which he contributed to the first edition of the Cultural Heritage of India, The Science of the Śulba, and the History of Hindu Mathematics, though published more than half a century ago, are still regarded as authoritative.[10]

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9. On these computational techniques, several books have appeared now, such as, Narinder Puri, *Muskurātā Gaṇit* (Prācīn Vaidik Gaṇit, Pushp 1), Roorkee 1988; *A Magic Till Understood* (Ancient Vedic Mathematics, Pushp 2), Roorkee 1988; *Mathematics with a Smile* (Ancient Vedic Mathematics, Pushp 3), Roorkee 1989; James Clover; *Vedic Mathematics for Schools;* Book I, London 1990.

10. Bibhutibhusan Datta, "Vedic Mathematics," *The Cultural Heritage of India;* Calcutta 1937, vol. 3, pp. 378-401; *The Science of the Sulba,* Calcutta 1932 ; jointly with Avadhesh Narayan Singh, *History of Hindu Mathematics; A Source Book,* Lahore 1935, 1938; Reprint : Bombay 1962; "Hindu Geometry", rev. by Kripashankar Shukla, *Indian Journal of History of Science* 15 (1980), pp. 121-188 "Hindu Trigonometry", rev. Kripa Shankar Shukla, ibid, 18 (1983), pp. 39-108; "Use of Calculus in Hindu Mathematics", rev. Kripa Shankar Shukla, ibid, 19 (1984), pp. 95-104. See also Sukomal Dutt, "Bibhuti Bhusan Datta (1888-1958) or Swami Vidyaranya, " *Gaṇita-Bhāratī* 10 (1988), pp. 3-15.

What then is the mathematical knowledge contained in Vedic literature and the real contribution of the Vedic Age to world of mathematics ? It is threefold: (i) the number system with decimal place value and the concept of zero (ii) combinatorics, and (iii) geometry of the Śulbasūtras. It is not my intention to discuss here these three areas in detail. I only wish to make a few comments concerning research in these areas since Bibhutibhusan Datta, or the lack of it.

It is well known that the numerical system universally in practice today, consisting of the digits from 1 to 9 and zero, with decimal place value, owes its origin to India. Datta has shown 'that from the earliest known times, ten has formed the basis of numeration in India, [11] and that from the *Vājasaneyi-saṃhitā* onwards there are passages containing numeral denominations, such as the following :

imā ca agna iṣṭakā dhenavaḥ santu / ekā ca daśa ca, daśa ca śatañ ca, śatañ ca sahasrañ ca, sahasrañ cāyutañ, cāyutañ ca niyutañ ca, niyutañ ca prayutañ cārbudañ ca nyarbudañ ca samudraś ca madhyañ cāntaś caparārdhaś caitā me agna iṣṭakā dhenavaḥ santv amutramusmil loke [12]

This passage mentions the following thirteen denominations, each succeding term being ten times the previous one.

11. *History of Hindu Mathematics*, part I, p. 9 ff.
12. *Vajasaneyi-saṃhitā* XVII. 2. For other passages of the same nature, see Datta, *loc. cit;* B. V. Subbarayappa and K. V. Sarma, *Indian Astronomy : A Source-Book*, Bombay 1985, pp. 46-47.

eka	1	=	10^0
daśa	10	=	10^1
śata	100	=	10^2
sahasra	1000	=	10^3
ayuta	10000	=	10^4
niyuta	100000	=	10^5
prayuta	1000000	=	10^6
arbuda	10000000	=	10^7
nyarbuda	100000000	=	10^8
samudra	1000000000	=	10^9
madhya	10000000000	=	10^{10}
anta	100000000000	=	10^{11}
parārdha	1000000000000	=	10^{12}

This passage, of course, does not exhibit the entire numerical system but only the beginnings of the terminology of decimal denominations.

Again, Datta has shown that the indubitable instance for the concept and symbol of zero occurs in the following passage [13].

rūpe śūnyam / dviḥ śūnye / tāvad ardhe yad guṇitam /
(Pingala's *Chandaḥsūtra* 8.29-30)

"When unity (is substracted then write) a zero. (Multiply by) two when zero. Square when halved."

These three sūtras teach how to calculate the number of variations in a metre with a given number of syllables. Their meaning will be clear from the following

13. *History of Hindu Mathematics*; part I, pp. 75-77.

calculation for the Gāyatrī metre, which has 6 syllables in each pāda. Required are the number of variations when each one of the six syllables is either a long one (guru) or a short (laghu) one. We proceed as follows:

	A		B
Write the number of syllables	6		
halve it; the result	3	Write separately	2
3 cannot be halved; therefore subtract 1, the result	2	,,	0
halve it; the result	1	,,	2
1 cannot be halved; therefore subtract 1; the result	0	,,	0
The process comes to an end			

Thus in column A, the number of the syllables is successively halved, and whenver there is an odd number, it is reduced by 1. In column B, on the other hand, we write only two kinds of markers : We write '2' when halving is possible and '0' when it is not. Now the calculation commences from the last marker in column B. Taking unity, double it whenever there is '0' and square it whenever there is '2'. We write below column B in the first line, doubling or squaring in the next line.

B		0	2	0	2	
	1	2	2^2	$2^2.2$	$(2^2.2)^2$ =	2^6

The answer to the above problem is 2^n, when n is the number of syllables in the metre. The process laid down by Pingala reduces the number of operations. In the case of Gāyatrī, if we try to compute 2^6 directly, we have to multiply 2 by 2 five times. i.e. it involves five operations. Pingala's method involves only three operations : (i) square 2; result $2^2 = 4$; (ii) multiply by 2; result 2^3 or 8; (iii) square again; result 2^6 or 64.

The '2' and '0' written in column B have no numerical significance. They are just markers to indicate the performance or otherwise of certain operations. In their stead, any two arbitrary symbols could have been used. But Pingala's insistence of using zero shows that by his time, i.e. circa 200 B.C., the symbol for zero had become widely known.

Next comes the question of the antiquity of place value in India.[14] Place value means that a digit acquires value according to its notational place. This phenomenon has been used in a fine simile in the Vyāsabhāṣya (650-850 B.C.) on the Yogasūtra III.13 :

yathikā rekhā śatasthāne śatam daśathāne daśaikā caikasthāne tathā caikatve 'pi strī mātā cocyate duhitā ca svasā ceti'

"Just as a stroke denotes 100 in hundreds place, 10 in tens place and 1 in units place, even so one and the same woman is called mother, daughter and sister (by different persons).

Of course, place value is implied in the Āryabhaṭīya (449 A.D.) of Aryabhata and still earlier works, but the known written records using the numeral symbols in decimal place value system are not so old, the earliest being an inscription from the year 595 A.D.

Of course, since Datta wrote, a large number of inscriptions have been unearthed but these have yet to be studied from the viewpoint of the numerical system present in them.

14. Ibid, pp. 38-51

The origin of the second area; i.e combinatorics, is traced to the chapter on Pratyayas in Pingala's *Chandaḥsūtra*, from which an example has been cited just above. In recent years, the Pratyaya sections of several other works on prosody have been studied. But a large number of works exclusively on Pratyayas are still in manuscript form and deserve to be studied; likewise the combinatorics occurring in manuals on music, architecture etc. Ludwig Alsdorf has made a comprehensive study of the development of combinatorics and their rationale in his long article entitled 'Die Pratyayas: ein Beitrag zur indischen Mathematik" (1933). This article is now available in my English translation. [15]

Finally, on the geometry of the Śulbasūtras, creditable work has been done by S.N. Sen, A.K. Bag, R.P. Kulkarni and others, but a significant contribution by Axel Michaels appeared in German from Wiesbaden in 1978 and is inaccessible to Indian historians of science. Its major concern can be understood from the title *Beweisverfahren in der vedischen Sakralgeometrie : ein Beitrag zur Entstehungsgeschichte von Wissenschaft* (Method of Proof in Vedic Ritual Geometry : A contribution to the History of Origin of Science).[16] In 1983, Michaels also brought out *A Comprehensive Śulvasūtra Word Index*, whose unility needs no emphasis.

But there is a larger question that remains untouched. The chief sources for all the branches of mathematics enumerated above are late Vedic texts : Sulbasūtras for ritual geometry including the twofold enunciation of the Pythogoras Theorem; Pingala's *Chandaḥsūtra* for mathematics of combination and permutation, including the binomial notation, Pascal's triangle etc., the same section of the *Chandaḥsūtra* provides also the proof for the existence of a specific symbol for zero at that time. In these sources, we find already quite a developed form of the three branches of mathematics. Can we go further backwards in time and locate

15. " The Pratyayas : Indian Contribution to Combinatorics" by Ludwig Alsdorf, tr. from the German by Sreeramula Rajeswara Sarma, *Indian Journal of History of Science* 26.1 (January 1991), pp. 17-61.

their early stage of development, or their origins, in the early Vedic literature like the Saṃhitās, Brāhmaṇas and Āraṇyakas ? This would involve patient gleaning of scattered references to numbers and geometrical figures in the Saṃhitās and Brāhmaṇas, particularly in the *Taittirīyasaṃhitā* and the *Śatapatha-brāhmaṇa*, and then interpreting the data without any pre-conceived notions.

Such an exploration will indeed constitute research in the real Vedic mathematics. But again this exploration should strictly follow the accepted norms of research methodology. Only then will it be possible to fulfil what Joseph Needham, the author of the monumental *Science and Civilisation in China,* had hoped; namely that future research in the history of science and technology in Asia will, in fact, reveal that the achievements of these peoples contributed far more, in all pre-renaissance periods, to the development of science than has yet been realised.[17]

16. See my review in *Orientalistische Literaturzeitung* 79.1 (1984) pp. 76-79.
17. "History of Science and Technology in India and South-East Asia," *Nature* 168 (July 1951) p. 65.