Indian Mathematics: Engaging with the World from Ancient to Modern Times. George Gheverghese Joseph. World Scientific Publishing Europe Ltd, 57 Shelton Street, Convent Garden, London WC2H 9HE. 2016. xi + 489 pages. Price: US$ 98.

The study of Indian science, and mathematics in particular, of ancient and premodern era, is facing multiple problems. On the one hand there is very little investment, both in terms of human and material resources, in developing the infrastructure for such a study. On the other hand whatever limited engagement there is with the topic, is to quite an extent afflicted by partisan political mindsets and jingoistic tendencies; I am not referring here only to the recent years – the neglect and the revivalist thrust have gone hand in hand for long, and have perhaps been feeding each other at some level.

Specifically, the output of literature in the subject at research and expository level has been dismal, especially when compared with other cultures. While there is a lot of writing churned out at 'popular' level with many unsubstantiated claims, spawning bellicose emotions, there is acute dearth of material giving a good insight into things as they were. As the author of the book under review notes (page 10) 'At present, a yawning gap is clearly discernible between the embarrassed silence and neglect of Indian mathematics on the part of Western and Indian scholars and the emerging triumphalism of certain Indians and their foreign camp-followers; ...'. He also writes 'In the case of Indian scholarship, there has been another problem. The historians of Indian mathematics working within India have generally tended to overlook the social and global context in which their subject arose. ...'. Evidently the author means to eschew such a shortcoming in presenting his version of the story. And though this reviewer is not convinced that he achieves the objective in adequate measure, the approach does bring a whiff of fresh air. The author endeavours to place the progress of mathematics in India in a global context, involving not just the Greeks and the western culture, but other cultures as well, going beyond the all too common 'we did it first (!)' syndrome.

The author has had two earlier books to his credit, apart from related research works, in the general area: *The Crest of the Peacock*[1], which was published in 1991 and ran into the third edition in 2011, and the more recent, *A Passage to Infinity*[2] published in 2009. The former was noted for its polemical approach, both from a supportive and contrarian perspective. While the author has retained what may be viewed as his motto, of the universality of mathematics, the present book would be found amiable by readers of varying dispositions. The author shows considerable open-mindedness on points where available evidence turns out to be inconclusive. Also, on the whole the author has a chatty, fluent style, contributing to readability of the book.

The book contains a good deal of information on various topics in ancient Indian mathematics, though it cannot serve as a comprehensive reference work. The period covered extends all the way from the Indus valley civilization until the period of the legendary genius Srinivasa Ramanujan; both these ends are often missed in the literature. Needless to say it includes along the way discussions on the sulvasutras, the Buddhist and Jaina contributions, the enigmatic Bakhshali manuscript, the Siddhanta tradition of mathematical astronomy featuring Aryabhata, Brahmagupta, Bhaskara, Narayana and others, works of Sridhara and Mahavira, and the advent of the Kerala School of Madhava. There is also a short chapter on mathematics outside the Sanskrit tradition, which includes brief notes on Thakkura Pheru and also Indian mathematics from Persian and Arabic sources.

Before going into the works the author undertakes a discussion, in chapter 1, of the ground level difficulties in the subject, which is very illuminating. There is also an overview in chapter 2 which would be helpful to the reader. The discussion of development of mathematics in the subsequent chapters proceeds more or less chronologically in terms of the main players, incorporating the related works of the later commentators along with it, except for a chapter on trigonometry and the one relating to mathematics outside the Sanskrit tradition mentioned above. A variety of details apart from the mathematics itself are included, putting the material in perspective. Each chapter has numerous 'endnotes' which are very informative. The chapter on the mathematical developments during the colonial era, discusses explorations by westerners into the Indian heritage, subsequent analyses and their eurocentric bias, the work of Yesudas Ramachandra, and a brief write-up on Ramanujan.

Notwithstanding the satisfaction with the overall approach and various features mentioned above, the reviewer is dismayed over some aspects of the contents. At a micro level one finds a lack of urge to grasp and convey the real mathematical significance of the developments, and a propensity to simply put together information; one senses a certain casualness in dealing with finer details. Also, historical aspects internal to the systems are not paid much attention to. These points come through in an acute fashion in the following examples. At the bottom of page 79 the author lists certain constructions stated to be from the Sulvasutras. The first one is to 'Divide a circle into any number of *equal* areas by constructing diameters'. (emphasis added). Now from the standpoint of basic geometry this is a nontrivial task and a reader would wonder how they would have done it. A perusal of the original sutras reveals however that there is no condition restricting the areas to be equal, nor is the construction specified to be by constructing diameters and there is no indication of such intent either; so there is no essential geometrical issue involved. The second construction is to 'Divide a triangle into a number of equal and similar areas'. Again, in the sutra concerned there is no stipulation of 'equal and similar areas', whatever it is supposed to mean! The next three constructions in the list are, (a) 'Draw a straight line at right angles to a given line', (b) 'Draw a straight line at right angles to a given line from a given point on it' and (c) 'Construct a square on a given side' (tagged here for convenient reference below). One wonders why the three appear individually in a list that is actually pronounced at the outset to be a selective one; clearly anyone who can deal with (b) can perform the other two tasks as well. Parenthetically we are informed that (a) and (b) are from the Katyayana sulvasutra and (c) is found in all the sulvasutras. An uninformed, but perceptive, reader may be tempted to conclude that to be the reason for mentioning (c) separately. However, that would be patently wrong. In fact it is a more worrisome point that (b) which was in fact bread and butter of the entire Sulvasutra corpus, all the way from the most ancient Baudhayana sulvasutra, is referred by the author only to the Katyayana sulvasutra, which is the last among the significant sulvasutras that have come down to us, and post-dates the oldest one by about half a millennium! I may also add here, without elaboration, that the references given for (a) and (b) are strictly speaking not correct.

On page 78, the author states, 'Different versions of the Pythagorean result are found in the Sulbasutras' and proceeds to state the result for the diagonal of a square and the general one for the diagonal of a *rectangle*, attributing the former to 'Baudhayana and others', and the latter (only) to Apastamba, clearly conveying the impression that the general statement is not found in the other sulvasutras. Here again, actually the general assertion is contained in all the four major sulvasutras.

The above examples also indicate that the author has not always accessed the original sources he is referring to, or even standard redactions available (e.g. (ref. 3) in this case), and rather relied on dubious secondary or tertiary sources for information.

The editing also leaves much to be desired. For example, the diagram at the bottom of page 84 which is supposed to be 'self-explanatory', hardly conveys anything, certainly not the formula the author adduces to it; it also does not conform to the original description in the sulvasutras. There are also many errors of typographical nature, or with similar import, to reckon with. Here are a few that seem worth noting. On page 175 the number of sides of the regular polygon that Aryabhata is supposed to have used in the computation of π should be 384 ($= 6 \times 2^6$) and not 348 as stated; incidentally the statement that the number could be inferred from verse 10 is not justifiable. On page 430 the pseudonym of the group of scholars, Sarma, Kusuba, Hayashi and Yano, who translated and edited *Ganitasarakaumudi* of Thakkura Pheru, is given as SANKHYA, whereas it is actually SAKHYA, composed from some initial letters from each of the names, with the word signifying friendship! And here is an amusing one: on page 95 for the diagonal, parenthetically, in place of *karna* we face *karma*!

Notwithstanding these criticisms the book is a welcome addition to the literature in the area, on account of the insights that it brings in, a dispassionate attitude, cross-references to a variety of related material, and also the overall context of paucity of material, noted earlier.

1. Joseph, G. G., *The Crest of the Peacock. Non-European Roots of Mathematics*, Third edition. Princeton University Press, Princeton, NJ, 2011, pp. xxx + 561.
2. Joseph, G. G., *A Passage to Infinity, Medieval Indian Mathematics from Kerala and its impact*, Sage Publications, Los Angeles, CA, USA, 2009.
3. Sen, S. N. and Bag, A. K., *The Śulvasūtras of Baudhāyana, Āpastamba, Kātyāyana, and Mānava*, Indian National Science Academy, 1983.

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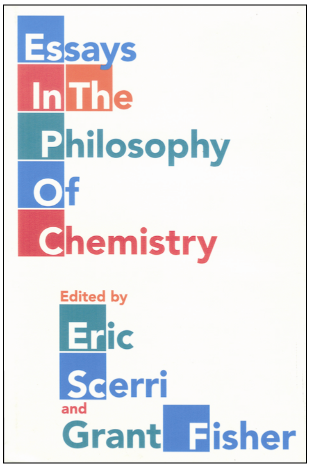

Essays in the Philosophy of Chemistry. Eric Scerri and Grant Fisher (eds). Oxford University Press, 198 Madison Avenue, New York, NY 10016, USA. 2016. ix + 410 pages. Price: £ 38.99.

The riddle that this collection of essays poses to the chemist, and to the interested general reader, is that while chemists seem to be inherently aware of the philosophical streams of thought that run through their subject, and while they are obviously the most adept at conducting their science and do not need advice from philosophers on how to do it, they are not particularly good at taking a step back from their work and describing and characterizing the nature of their work. The geniuses on the subject were different – they were fully aware of what they were doing in a broader philosophical context – but even here, there were differences in outlook. Lavoisier knew that he was starting a revolution in chemistry, perhaps the only revolution that the subject has ever seen, when he redefined chemistry as an oxygen-based subject. Mendeleev too knew what he was doing, when he stated probably the only law in chemistry, namely the periodic law of the elements, and I do believe he was sure that with his law, he was changing the subject forever. Pauling on the other hand was not willing to break ranks with traditional chemical orthodoxy when he postulated bond orbitals, resonance and electronegativity. He merely said in the 1930s that structural theory as it had developed from 1850 to 1915 still retained its validity but had become sharpened, and rendered more powerful by an understanding of the electronic structure of atoms, molecules and crystals.

This book is difficult reading. It is hard for the novice unless one has a philosophical bent of mind. I had to go through it several times, and analyse the nuances of argument among various authors. However, and as someone who has commented on similar matters in his own writings, I found it to be a worthwhile exercise. For a multi-author volume, it is surprisingly homogeneous, even when the points of view of several authors are in contradiction. The editors have done a good job and one of them, Eric Scerri is a well known proponent of the idea of the non-reducibility of chemistry into physics. Therefore, I was somewhat intrigued to read his essay on the 'changing views of a philosopher of chemistry'. While he concedes that not everything in chemistry is derived from quantum mechanics, he now says that the case for anti-reductionism is no longer so clear cut. He uses, what he calls the greatest triumph of reductionism in chemistry, Mendeleev's periodic table, to justify his changing stance!

A recurring theme in the chapters is the relationship of chemistry to physics. Is physics the standard science with which all other sciences should be related? While physics might have a special relationship with mathematics, does this