Hindu Mathematics – How Original Was It?

["Mathematics In India" by Kim Plofker, Princeton University Press, Jan 2009, 394pp, £28.95, Reviewed for Nature by Pervez Hoodbhoy, Department of Physics, Quaid-e-Azam University, Islamabad, Pakistan.]

In a world finely divided on issues of culture, politics, religion, and race, it is a relief to know one thing that stands above them – mathematics. The diversity among today's mathematicians shows that it scarcely matters who invents new concepts or proves new theorems; cold logic is immune to the prejudices of arbitrary whim and historical accident. And yet, over the ages, many were the ways by which different families of the homosapien species distilled the essence of the cosmos to capture the magic of numbers.

"*Mathematics in India*" by Kim Plofker, a German professor specializing in the history of mathematics, shows just how different one of these ways was and how culture and mathematical development can be intimately connected. This carefully researched chronicle of the principal contributions made by a great human civilization covers the earliest days of Indian history through the beginning of the modern period. Somewhat regrettably, it stops short of the period of the legendary mathematician, Ramanujan (b. 1897) whose name still appears in published papers.

Plofker's book fulfils an important need in a world where mathematical historiography has been largely shaped by the dominance of the Greco-Christian world view and the Enlightenment period. Too little has been written on the mathematical contributions of other cultures. One reason for neglecting Indian mathematics was Eurocentrism – British colonial historians in India generally paid little attention and assumed that the natives had been too preoccupied with spiritual matters to make significant contributions in the exact sciences. Another reason is that many ancient Indian mathematical texts have long been extinct. Often the only indication that they once existed comes from scholars referring to the work of predecessors from an earlier age. As Plofker wryly notes, two historians of Indian mathematics recently published articles in the same edited volume wherein the estimates of their subject's origins differed by about two thousand years.

Nevertheless, Sanskrit texts that survived the ravages of time reveal a rich tradition of Indian mathematical discoveries for well over 2500 years. In the Early Vedic period (600-1200 BC), a decimal system of numbers had already been established in India together with rules for arithmetic operations, (*ganita*) and geometry (*rekha-ganita*). These rules were encoded into a complex system of chants, prayers, hymns, curses, charms, and other religious rituals. For example, acclamations of praise to the air, sky, times of day or heavenly bodies were expressed in powers of ten that went to a trillion and more. Cryptic phrases called *sutras* contained arithmetic rules for activities such as laying out a temple building or for arranging a sequence of sacrificial fires.

As in other agricultural civilizations, Indian mathematics probably emerged in response to real needs such as measuring land areas and keeping track of financial transactions, incomes and taxation. A rigid caste and class hierarchy reserved the mystery of numbers for elite Brahmins. High status was accorded to the custodians of jealously guarded secrets. There was immense fascination with large numbers. Thus it is said that the young prince Buddha successfully competed for the hand of beautiful princess Gopa – he could recite a number table that included names for the powers of ten going up beyond the 20th decimal place, in addition to outshining his virile and handsome rivals in the martial arts.

The desire to preserve power also meant that the mathematically knowledgeable did not strive to make its communication easier. Modern mathematicians, used to simple tabular expressions, will find quite perplexing the rhythmic chant of the famous Aryabhata (5th century AD): *makhi-bhakhi-phakhi-dhaki-nakhi-nakhi-nakhi-hasjha-skaki-kisga-sghaki-kighva-ghaki…*(225-224-222-219-215-210-205-199-191,…). This chant, containing values of sine differences (in arc minutes), would be memorized by aspiring mathematicians in much the same way as verses of the *Gita*.

The book details the impressive achievements of Indian mathematicians: Aryabhatta, Brahmagupta, Mahavira, Bhaskara, Madhava…until the Sanskrit tradition finally became irrelevant with invasion of modern mathematics from Europe in the 19th century. Among prominent Indian achievements is discovery of the solution to indeterminate equations and the development of infinite series for trigonometric quantities. Discovered by the Kerala school (14th century) of Madhava, these series build upon the work of Bhaskara-II. By an ingenious computation of a circle's circumference by polygonization, Madhava was able to arrive at a numerical value of pi correct to the 11th decimal place. Indeed, a few significant developments preceded those in Europe. Intrigued by rules he discovered in an unnamed Sanskrit text, Reuben Burrow, a British mathematician posted in Bengal as an instructor in the engineers corps, wrote a paper in 1790 entitled: "A Proof that the Hindoos had the Binomial Theorem".

But how Indian was early Indian mathematics? Did it evolve in parallel or did it absorb ideas and knowledge from elsewhere? Cultural pride creates its own versions of truth. In a recently re-invigorated India, many wish to believe that that all worthwhile mathematics originated in ancient India. But this book may not please them. Plofker is not ready to certify that the concept of zero was an Indian invention; it could well have been conveyed by Chinese Buddhist pilgrims. Nor is she willing to believe that differential and integral calculus was anticipated in India ahead of Leibnitz and Newton.

The chapter "Exchanges with the Islamic World" is of particular significance. The Muslim conquest of India brought with it the Islamic mathematical tradition. Built upon the foundation of Greek mathematics, Muslims had made important advances between the 9th and 13th centuries. Greco-Islamic and Indian mathematics were structured quite differently with the former emphasizing proof and the latter result. Probably because of Islamic influence, Indian ideas of the nature of mathematical proof moved in the direction of greater rigour.

The book carefully separates fact from hyperbole, copiously quoting formulae. This makes it heavy reading in many places, and one wishes that it had been interspersed with vignettes and light anecdotes. It is more of a research monograph than a popular book. But that is the price that scholarship often exacts.

From this book one understands in fine detail how the early development of Indian mathematics was influenced by the need to build temples of specific proportions, astrological imperatives, etc. It could be argued that Islamic mathematics also had a religious motivation: the need to know precise times for the 5-times daily prayers, the direction of the *Qibla*, etc.

But, all said and done, mathematics is mathematics. The bottom line is that a quadratic equation solved by whoever and by whatever means has to give exactly the same solutions.

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