Indian Mathematics and Astronomy – Some Landmarks

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This is an excellent introduction to Indian mathematics and astronomy right from the Vedic times. I have learnt quite a few things from it. This corrected and enlarged third edition was necessitated by the strong positive response the earlier ones received from the academic community. The author specifically highlights discoveries in mathematics and astronomy made in India several years before they were rediscovered in the west. Although the author gets a bit passionate at times, on the whole, he has managed to keep the discussion reasonably free of prejudice and many results quoted are juxtaposed with the corresponding text from the original references. The book can be read and enjoyed by any person acquainted with high school mathematics.

Many readers would be astonished to discover that a number of results popularly credited to modern-day mathema-ticians and astronomers were already anticipated by the ancient Indian greats. Typically, theorems in mathematics were discovered and used without actually writing down proofs. One very well-known example is the Pythagoras theorem, whose statement and manifold applications appear in the Sulvasutras. One must keep in mind that there were other cultures which too 'knew' the Pythagoras theorem – see Rahul Roy's article [1] in *Resonance* on the Babylonians' contributions. Yet another (now well-documented) example is that of the so-called Pell's equations (named after a 17th century mathematician) to which Brahmagupta (born in the 6th century) and later Bhaskara II (born in early 12th century) made outstanding contributions – they not only solved the equations completely; they even gave powerful algorithms to solve them. This last aspect has been elaborated upon by Amartya Dutta [2] in *Resonance*.

The author aptly devotes the three biggest chapters – 30 pages each – to Aryabhata (born 5th century), Brahmagupta (born 6th century) and the astronomers from Kerala (from the 12th century through to the 17th century); each of these deserves the maximum attention. We mention three noteworthy results from the chapter on Aryabhata. In the 10th stanza of the 2nd part of the Aryabhatiyam, the value of π is given accurately to 4 decimal places; it is remarkable that Aryabhata mentions the word 'Aasanna' meaning 'approximate'. In the 6th stanza of the same part, he gives the formula for the area of a general triangle in terms of a base and the altitude to it. In the 4th part of Aryabhatiyam, Aryabhata writes that the Earth is spherical ('Bhoogolaha sarvato vrttaha') [3].

In this 3rd edition, apart from certain minor corrections, the major change from the 2nd edition is the addition of a chapter on Samanta Chandrashekhara Simha (1835-1904). He was an astronomer from Orissa who, unaware of the work of the Western astronomers, had devised instruments and used them to make his own astronomical observations. All chapters are written in a lively style. We mention a few snippets which are rather surprising in as much as quite a few of them are thought to be discoveries made only much later.

The composition of quadratic forms was essentially the 'Bhavana' method of Brahmagupta. The familiar formula

$$\binom{n}{r} = \frac{n(n-1) \quad (n-r+1)}{r!}$$

for the binomial coefficient already appears in the 9th century mathematician Mahavira's work 'Ganita sarasangraha' (shloka 218). Bhaskara II solves the equation $61x^2 + 1 = y^2$ in integers already in the 12th century in his Bijaganitam as an application of the already well-developed Chakravala method. It is amusing to note that Fermat (1602-1665) posed this very same problem and it was only 'solved finally' by the great Euler in the 18th century! Bhaskara II also mentions two facts *Bimbaardhasya kotijyaagunastrijyaharaha phalam dorjyayorantaram* and *Yatra grahasya paramamphalam tatraivagatiphalaabhavena bhavitavyam*). These can be interpreted, respectively, as saying that

$$\sin y' - \sin y = (y' - y) \cos y$$

(for small $y' - y$) and that 'where motion is maximum, there the fruit ('= derivative') is absent.'

Finally, I mention something that I noticed accidentally much to my surprise. In the book *Amusements in Mathematics* by the famous puzzlist Henry Dudeney (1847-1930), I found the following problem (problem number 186). A clothesline is tied from the top of each of two poles to the base of the other. Given the heights of the two poles, the problem is to find the height from the ground where the two cords cross one another. Looking at the interesting sample of problems that the present author reproduces in chapter 8 from Bhaskara II's *Lilavati*, I discovered that this very same problem occurs as problem number 162 in *Lilavati*. Remarkable indeed!

In conclusion, this book would surely be a welcome addition to any library.

[1] *Resonance*, Vol.8, No.1, pp.30-40, 2003.
[2] *Resonance*, Vol.7, Nos.4 and 10, 2002; Vol.8, No.11, 2003.
[3] A 3-part article by Amartya Dutta on Aryabhata's work is expected to appear in *Resonance* soon.

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