Lilavati and Vedic Mathematics

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ABSTRACT

Lilavati and Vedic Mathematics are two treatises on mathematics written in different time periods. They seem to be independent and have different interpretations of mathematical rules. But both of them are written from the same foundation of the Vedic tradition. So, in reality they have many similarities. For an instance, the squaring rules of any number given by them are very similar. Although the forms of formulae seem to be different they follow the same philosophy of mathematics.

Key words: *Lilavati, Ista, Vedic Mathematics.*

1. INTRODUCTION

Bhaskara and his works represent a significant contribution to mathematical and astronomical knowledge in the 12th century. His main work, *Siddhānta Shiromani,* is divided into four parts called *Lilāvatī*, *Bījagaṇita*, *Grahagaṇita* and *Golādhyāya*. These four sections deal with arithmetic, algebra, mathematics of the planets, and spheres, respectively.

Bhaskara was born in 1036 Saka era which is 1114 AD. He writes his date of birth and his age of 36 when he wrote his main work in a beautiful verse in Sanskrit as,

रसगुणपूर्णमहीसमशकनृपसमये भवत् ममोत्पत्ति

रसगुणबर्षेण मया सिद्धान्तशिरोमणी रचितः ॥

rasa-guṇa-pūrṇa-mahīsama śhaka-nṛpa samaye 'bhavat mamotpattiḥ /
rasa-guṇa-varṣeṇa mayā siddhānta-śiromaṇī racitaḥ //

Lilavati includes a number of methods of computing numbers such as multiplications, squares, and progressions, with examples using kings and elephants, objects by which a common man could understand and enjoy mathematics.

The book contains thirteen chapters, mainly definitions, arithmetical terms, interest computation, arithmetical and geometrical progressions, plane geometry, solid geometry, the shadow of the gnomon, the Kuṭṭaka - a method to solve indeterminate equations, and combinations.

In Arithmetical calculations, Bhaskara gives a rule to find the square of any number. In this rule, to find the square of a number, say x, any other number is taken and added and subtracted to that x so that the resulting numbers will be easy to multiply. The product of the resulting numbers is the square of x. This method is discussed vividly in the upcoming paragraphs comparing to the similar method given by Bharati Krishna Tirtha in his book *Vedic Mathematics*.

Bharati Krishna Tirtha was the Sankaracharya of the Govardhan Math, Puri, from 1925 to 1960 AD. He is most noted for, first, as being the inventor of and author of Vedic Mathematics. Swami

Bharati Krishna Tirthaji was born in March 1884. He was awarded the title Saraswathi. It was during his deep meditation retreats between the years 1911 and 1919 in the Shringeri forests that he became aware of the sutras he later associated with Vedic Mathematics. Apparently, over that eight-year period he worked on the sutras, writing all sixteen volumes by hand into school notebooks, treating each together as one independent volume.

Bharati Krisna Tirtha attained Mahasamadhi February 2, 1960. His book was published posthumously in 1965. In this book we can see a rule to find the square of a given number. In this rule 10 or 50 or 100 is taken as base numbers and by the Yavadunam or Yavadadhikam rule the square of the required number is calculated easily. This is discussed in the following paragraphs comparing it to the rule of Bhaskara.

2. SQUARING METHOD IN LILAVATI

Method of squaring the numbers in Lilavati is इष्टो न युग् राशिवधः कृति स्यात् इष्टस्य वर्गेण समन्विता वा, meaning: Suppose an *Ista* (a number which make you easy to use) is added and subtracted to the given number, multiply them and add the square of the *Ista*.

If a is the number to be squared then an *Ista* number, b, is chosen in such a way that $(a+b)$ and $(a-b)$ can be easily multiplied. The square of b is then added since, $a^2 = (a+b)(a-b) + b^2$.

The method is explained through the following examples:

Example: 13^2

If we want to find the square of 13 then we can suppose an *Ista* as 3 then the method will be like this: subtract and add the *Ista* with the number, multiply them and then add the square of *Ista*.

$$(13-3)(13+3) + 3^2 = 10 \times 16 + 9 = 160 + 9 = 169$$

If the *Ista* is 2 then,

$$(13-2)(13+2) + 2^2 = 11 \times 15 + 4 = 165 + 4 = 169$$

Example: 46^2

For 46^2 and with an *Ista* of 4,

$$46^2 = (46-4)(46+4) + 4^2 = 42 \times 50 + 16 = 2100 + 16 = 2116$$

Alternatively, with an *Ista* of 6,

$$46^2 = (46-6)(46+6) + 4^2 = 40 \times 52 + 36 = 2080 + 36 = 2116$$

The *Ista* can be chosen to make the resulting multiplication easy.

Example: 98^2

With 98, an obvious *Ista* is 2.

$98^2 = (98-2)(98+2) + 2^2 = 96 \times 100 + 4 = 9600 + 4 = 9604$.

Example: 153^2

Now consider squaring a three-digit number by the same method, say 153^2 .

One way is to choose an *Ista* of 3,

$153^2 = 150 \times 156 + 9 = 3 \times 50 \times 156 + 9 = 3 \times 7800 + 9 = 23409$.

Another way is to choose an *Ista* of 53 and then repeating the method for finding the square of 53,

$153^2 = 100 \times 206 + 53^2 = 20600 + 50 \times 56 + 9 = 20600 + 2800 + 9 = 23409$.

In terms of the sutras of Vedic mathematics the Lilavati method comes under *By addition and subtraction*.

3. SQUARING METHODS IN VEDIC MATHEMATICS

In Vedic Mathematics, there are two types of techniques: special case techniques and general techniques. The special case techniques are those which are fast and effective but can only be applied to a particular combinations of numbers. Here we look at one special case technique.

As a sub-sutra of the Nikhilam rule Tirthaji gives, *Whatever the extent of its deficiency, lessen it to the same extent and also set up the square of the deficiency*. The Sanskrit for this is यावदूनम् तावदूनीकृत्य वर्गं च योजयेत्.

Example: 96^2

In this case, take the nearest power of ten is 100. The difference of 100 and 96 is 4 (the deficiency) and so we further subtract 4 from 96 and make 92 for the LHS. 4^2 is 16 and this forms the RHS. The complete answer is 9216.

Example: 13^2

10 is the closest base and, in this case 13, has a surplus of 3. The surplus is added to give 16 for the LHS. The square of the surplus is 9 for the RHS and so the answer is 169.

Example: 108^2

$108 + 8 = 116$ for the LHS and $8^2 = 64$ for the RHS. The answer is 11664.

4. COMPARISON OF RULES GIVEN BY BHASKARA AND BHARATI KRISHNA

In Lilavati we are free to take any *Ista* but in Vedic mathematics we are not free to take a number. If we are squaring 13, we must take 3 as *Ista* in Vedic mathematics but in Lilavati we can take any *Ista* like 2, 3, 5 or any other number, but it is easier to take *Ista* as three. Only the rule to take *Ista* is different but the mathematics behind the rule is the same.

The method of Lilavati and the method of Vedic Mathematics are more or less similar. So we can say that the methods from Lilavati seem to have been modified by Tirthaji. I think Vedic

mathematics and Lilavati both go together and if we do research in one then we should also do research the other.

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