

GEOMETRICAL AND ARTISTIC SYMMETRY IN THE ŪULBA SŪTRAS

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Publications: *Applied Geometry of the Sulba Sutras (in Geometry at Work, C.A. Gorini, Ed., MAA Notes, Washington, 2000, pp.46-55).

*Foreign Exchange Option Symmetry (with V.A. Kholodnyi) World Scientific, New Jersey, 1998

*Bandwidth versus time concentration: the Heisenberg-Pauli-Weyl inequality, (with M.G. Cowling) SIAM Journal of Mathematical Analysis 15 (1984), 151-16.

Abstract: The Ūulba SŪtras, part of the Vedic literature of India, describe many geometrical properties and constructions such as the classical “Pythagorean” relationship between the sides of a right-angle triangle and arithmetical formulas such as calculating the square root of two accurate to five decimal places. Beyond these constructions, there are deep and elegant symmetries such as a pair of formulas for converting a square to a circle and vice versa. Also there are beautiful blueprints for constructing citis or ceremonial platforms in images such as falcons, wheels and tortoises. At this level the Sutras seem to be a finely crafted manual for expert artisans. Certain key words, however, suggest that the applications go far beyond

1. ŪULBA SŪTRAS

The Ūulba SŪtras are part of the Vedic literature, an enormous body of work consisting of thousands of books covering hundreds of thousands of pages. Maharishi Mahesh Yogi explains that the Vedic literature is in forty parts consisting of the four Vedas plus six

sections of six parts each. These sections are the Vedas, the Vedāngas, the Upāngas, the Upa-Vedas, the Brāhmanas, and the Prātishākyas. Each of these parts has been described as by Maharishi as “expressing a specific quality of consciousness”. This means that often we have to look beyond the surface meanings of many of the texts to find their deeper significance.

The Āulba Sūtras form part of the Kalpa Sūtras which in turn are a part of the Vedāngas. There are four main Āulba Sūtras, the Baudhayāna, the Āpastamba, the Mānava, and the Kātyāyana, and a number of smaller ones. The general formats of the main Āulba Sūtras are the same; each starts with sections on geometrical and arithmetical constructions and ends with details of how to build citis which, for the moment, we interpret as ceremonial platforms or altars. One of the meanings of āulba is “string, cord or rope.” This could be a reference to the fact that measurements for the geometrical constructions are performed by drawing arcs with different radii and centres using a cord or sulba.

Three outstanding features are the wholeness and symmetry of their geometrical results and constructions, the elegance and beauty of the citis, and the indication that the Sūtras have a much deeper purpose.

1.1 Wholeness and Symmetry

When each of the main Āulba Sūtras is viewed as a whole, instead of a collection of parts, then a striking level of symmetry and efficiency becomes apparent. There are exactly the right geometrical constructions to the precise degree of accuracy necessary for the artisans to build the citis. Nothing is redundant. For example, the units of measurement used could supply accuracy for the diagonal of one of the main bricks of “roughly one-thousandth of the thickness of a sesame seed.”

There is also a remarkable degree of internal symmetry such as the way that the ‘square to circle,’ ‘circle to square’ and ‘square root of two’ constructions fit together with an accuracy of 0.0003%.

1.2 Beauty of the Citis

Each of the citis are low platforms consisting of layers of carefully shaped and arranged bricks. Some are quite simple shapes such as a square or a rhombus while others are much more involved such as a falcon in flight with curved wings, a chariot wheel complete with spokes, or a tortoise with extended head and legs. These latter designs are particularly beautiful and elegant depictions of powerful and archetypal symbols, the falcon as the great bird that can soar to heaven, the wheel as the ‘wheel of life,’ and the tortoise as the representative of stability and perseverance.

1.3 Deeper Significance

Sanskrit is a rich language full of subtle nuances. Words can have quite different meanings because of their context and, in any case, frequently there is no reasonable English equivalent. We shall examine examples such as *citi*, *vedi* and *purusa*.

When these and other examples are combined with the general direction of all the Vedic literature towards describing “qualities of consciousness,” we are led to the conclusion that the Āulba Sūtras are describing something far beyond procedures for building brick platforms, no matter how far-reaching their purpose.

2. Geometrical Symmetry

Most of the geometric procedures described in the Āulba Sūtras start with the laying out of a *prācī* which is a line in the east-west direction. This line is then incorporated into the final geometric objects or constructions, generally as a centre line or line of symmetry. Some of the constructions include methods for determining the length of the diagonal of a right-angled triangle (referred to in the west as Pythagoras’s theorem), constructing a square equal to the sum of two other squares and constructing a square equal to the difference of two squares. We outline the procedure in the Baudhāyana Śulba BSS for converting a square into a circle and a circle into a square.

2.1 Converting a square into a circle

Verse I, 58 of the BSS describes the procedure for constructing a circle with area approximately equal to that of a given square. A pictorial outline of the procedure is given in Figure 1. In modern mathematical terms, the sūtra asserts that the radius r of a circle with area equal to the area of a square with side b is

$$r = b \times (2 + \sqrt{2}) / 3.$$

2.2 Converting a circle into a square

Verse I, 59 of the BSS states:

If you wish to turn a circle into a square, divide the diameter into eight parts and one of these eight parts into twenty-nine parts; of these twenty-nine parts remove twenty-eight and moreover the sixth part (of the one part left) less the eighth part (of the sixth part).

In mathematical notation, starting with a circle of diameter d , the length of the side of the corresponding square is

$$d - d/8 + d / (8 \times 29) - d / (8 \times 29) ((1 / 6 - 1 / (6 \times 8))) = 9785 \times d / 11,136.$$

2.3 Symmetry of the square-circle constructions

Even though each of the previous constructions have a considerable degree of accuracy (around 1.7 %), certainly sufficient for a construction of bricks and mortar, it when the two constructions are combined that we see something quite remarkable.

Suppose we start with a square of side 2 and hence area 4. By using the above procedure we would convert this to a circle with area approximately equal to 4.069. Now converting this back to a square using the square-to-circle construction, we arrive at a square with side 2.00006, giving an accuracy of 0.0003%.

3. Applications to the construction of citis

In the second part I will describe the applications of the geometrical and arithmetical constructions of the Āulba Sūtras to the construction of citis. Each of the citis is constructed from five layers of bricks, the first, third and fifth layers being of the same design, as are the second and fourth.

A lengthy sequence of units is used; the two that are referred to the most are the angula and the purusa.. They are approximately 2 cm and 240 cm with 120 angulas equal to a purusa.

The heights of each layer are 6.4 angulas which is about 13 cm and the successive layers are built so that no joins lie along each other. This last requirement is sometimes difficult to achieve and adds to the aesthetics of the finished product as much as to its strength. Generally each layer has 200 bricks.

The following are displays of the ōyena or falcon citi and the rathacakra or wheel citi. I will explain in more detail the geometrical and construction features of these and other citis in my presentation.

4. Discussion

In a final discussion I shall argue that the Āulba Sūtras were written by people with a high level of mathematical knowledge and that they are part of a description, or perhaps a map, of the structure and qualities of the field of consciousness.

(Picture is available by request.)