Bhāskarācārya's Theories on the Construction of the Sine

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Abstract: Within the domain of Indian mathematical astronomy, Siddhānta Jyotisa serves as a foundational pillar, specifically for the construction of the pañcāṅga (almanac) and the determination of grahasphuta (true planetary longitudes). Central to these astronomical computations is the science of Jyotpatti the derivation and calculation of chord- based sine functions. This paper explores the theoretical framework of Jyotpatti as expounded by the pre- eminent mathematician Bhāskarācārya in his seminal work, Siddhāntasīromani [1]. The study focuses on the four fundamental sine quantities : bhujājyā (sine), kotijyā (cosine), utkramajyā (versed sine), and koṭyutkramajyā (versed cosine). By analyzing primary verses from the Golādhyāya and Gaṇitādhyāya, this research presents a detailed study of Bhāskarācārya's geometric and algebraic methods. Key derivations discussed include the sine of half- arcs, the theorem of addition and subtraction of sines, and the computation of sines for specific angles such as 30° and 45. This study highlights the historical significance and technical sophistication of Indian trigonometry prior to its modern developments.

Keywords : Jyā, Bhujajyā, Koṭijyā, Bhujotkramajyā, Koṭyutkramajyā

I Introduction

The term Jyotpatti is a saṣṭhī- tapturusa compound representing the "origin" or "production" of sines. In technical terms, it refers to the mathematical science of calculating and constructing sine tables. In traditional geometry, a straight line connecting two points on a circle's circumference is known as the pūrṇajya (full chord). However, in Indian astronomical computation (grahaganita), only the half- chord, or ardhajyā, is employed. This convention is foundational, as all planetary calculations rely on the half-chord rather than the full chord. As Bhāskarācārya explicitly states in the Siddhāntasīromani [1]:

अर्धज्याग्रे खेचरो मध्यसूत्रात् तिर्यक्संस्थो जायते येन तेन ।

अर्धज्याभिः कर्म सर्वं ग्रहाणामर्धज्यैव ज्याभिधानात्र वेद्या ॥[1]

This verse confirms that a planet's position is determined relative to the extremity of the half-chord from the madhyasūtra (mean line). Consequently, in the context of Siddhānta Jyotiṣa, the term jyā universally denotes the ardhajyā [2, 3, 4]. This ardhajyā is categorized into two primary forms : kramajyā (direct sine) and utkramajyā (versed sine). These are further subdivided into four functional types:

1. Bhujājyā : Sine
2. Koṭijyā : Cosine
3. Utkramajyā : Versed sine
4. Koṭyutkramajyā : Versed cosine

Bhāskarācārya occupies a pre-eminent position among the mathematicians who advanced the study of Jyotpatti. His work in the Siddhāntaśiromaṇi [1, 5, 6] provides the rigorous geometric and algebraic framework for these sine theories. This paper presents a detailed study of the principal doctrines propounded by him.

II Rule for the Computation of the Sine of Forty-Five Degrees

Bhāskarācārya propounds the rule for computing the sine of 45° in the Golādhyāya of the Siddhāntaśiromaṇi [1, 7, 8, 9]. This rule appears in both the Chedyakādhikāra and the Jyotpatti section :

.....................त्रिभमौर्विकायाः ।

वर्गार्धमूलं शरवेदभागजीवा ततः कोटिगुणोऽपि तावान् ॥[2]

त्रिज्यावर्गार्धपदं शरवेदांशज्यका भवति ॥[3]

propounded a special rule for the computation of the sine of forty-five degrees.

The rule states that the square root of half the square of the radius (R) is the bhujājya (sine) of 45°. At this specific angle, the kotijya (cosine) is equal to the bhujājya.

$$\sqrt{\frac{R^2}{2}} = R\sin 45^\circ R\sin 45^\circ = R\cos 45^\circ \tag{1}$$

In his Vāsanābhaśya [1, 10, 11], Bhāskarācārya provides a geometric derivation. He explains that if we consider a square inscribed within a circle, the radius serves as both the base and the altitude for the calculation of the chord.

The logic follows that the square root of the sum of the squares of the radius results in the side of an inscribed square, which corresponds to the chord of 90°. Since the jya is the half-chord (ardhajya), the formula simplifies to the square root of half the square of the radius.

As stated in the Vāsanābhaśya [1, 12] :

त्रिज्या भुजस्त्रिज्या च कोटिस्तद्वर्गयोगपदं वृत्तान्तःसमचतुरस्रस्य भुजः स्यात् । सैव नवतिभागानां ज्या । तदर्धं ग्राह्यम् । अतो वर्गयोगस्य चतुर्थांशः कृतः । तदेव त्रिज्यावर्गार्धमतस्तन्मूलं शरवेदभागज्येत्युपपन्नम् ॥[4]

In the provided figure, AOC is an isosceles right- angled triangle where:

$$\text{OC} = \text{base(bhujā)} \tag{2}$$

$$\text{AO} = \text{perpendicularoraltitude(koti))} \tag{3}$$

$$\text{AC} = \text{hypotenuse(karnā)} \tag{4}$$

Given that AO and OC are radii (R) of the same circle, we have

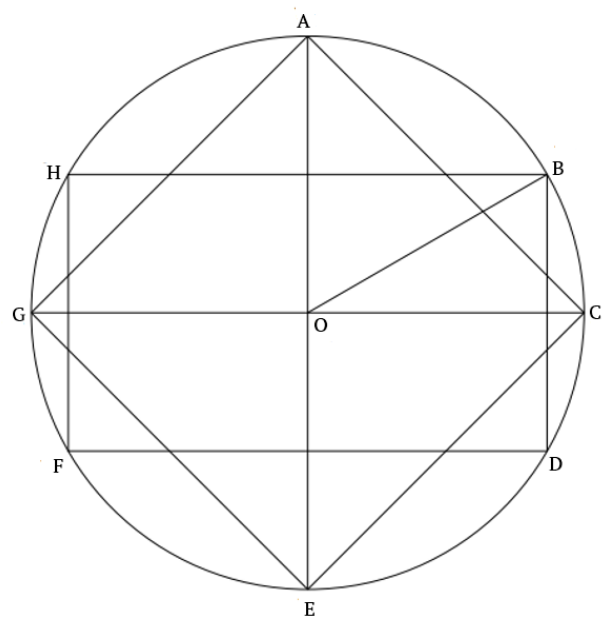

Figure 1: Proof for the Rule for Finding Rsin 45°

$$\mathrm{AO} = \mathrm{OC} = \mathrm{R} \tag{5}$$

According to the Pythagorean theorem (Baudhayana- Pythagoras principle):

$$(\mathrm{AO})^2 + (\mathrm{OC})^2 = (\mathrm{AC})^2 \tag{6}$$

$$\mathrm{R}^2 + \mathrm{R}^2 = (\mathrm{AC})^2 \tag{7}$$

$$2\mathrm{R}^2 = (\mathrm{AC})^2 \tag{8}$$

Here, AC represents the side of an inscribed square ACEH. In the same circle, another square BDFH is inscribed, whose side BH represents the full chord (pūrṇajyā) of 90° . Since all squares inscribed in the same circle are congruent, their sides are equal:

$$AC = BH = \sqrt{2R^2} \tag{9}$$

The jyā (sine) used in astronomical calculations is the half- chord (ardhajyā). The sine of 45° (R sin 45°) is derived by taking half of the chord of the double arc (90°) .

However, Bhāskarācārya's rule specifically simplifies this relationship. As shown in the Vāsanābhāṣya, [1], the derivation for the half- chord is as follows:

$$2 \cdot R\sin 45^\circ)^2 = 2R^2 \tag{10}$$

$$4 \cdot (R\sin 45^\circ)^2 = 2R^2 \tag{11}$$

$$(R\sin 45^\circ)^2 = \frac{2R^2}{4} = \frac{R^2}{2} \tag{12}$$

Taking the square root on both sides:

$$R \sin 45^\circ = \sqrt{\frac{R^2}{2}} \tag{13}$$

Thus, the formula propounded by Bhāskarācārya is mathematically established.

III Computation of the Sine of the Half of a Desired Arc

For the computation of the bhujajyā (sine) of half of a desired arc, the venerable Bhāskarācārya, in the Golādhyāya of the Siddhāntaśiromaṇi, both at the beginning of the Chedyakādhikāra and again at the end of the Golādhyāya in the section on Jyotpatti, propounded two rules. Of these, the first rule is based on the direct sine (kramajyā) and the versed sine (utkramajyā), while the second rule is based on the radius and the versed sine.

III.a First Rule - Method for Computing the Sine of the Half of a Desired Arc from the Direct and Versed Sines

Bhāskarācārya, in the Golādhyāya of the Siddhāntaśiromaṇi, at the beginning of the Chedyakādhikāraḥ and again in the Jyotpatti section at the end of the Golādhyāya, stated the first rule for computing the sine of half of a desired arc in the following half-verse:

क्रमोत्क्रमज्याकृतियोगमूलाद्दलं तदर्धांशकशिञ्जिनी स्यात् ।[5]

The half of the square root of the sum of the squares of the direct sine (bhujajyā) and the versed sine (bhujotkramajyā) gives the sine corresponding to half of the desired arc.

Symbolically:

$$\frac{\sqrt{(bhujajy)^2 + (bhujotkramajy)^2}}{2} = \text{sine of half the desired arc} \tag{14}$$

The justification of this rule is explained by the illustrious Bhaskaracarya in the Vasanabhaya [1] under the Chedyaka-adhikāra in the Golādhyāya, in the following passage:

अतः प्राग्वदुत्क्रमज्या । षष्टिभागज्ययोना त्रिज्या राशेरुत्क्रमज्या । सा कोटिरूपिणी । क्रमज्या भुजरूपिणी । तदग्रयोर्निबद्धसूत्रं तत् कर्णः । तत् त्रिंशद्भागानां ज्यारूपम् । अतस्तदर्धं पञ्चदशभागानां ज्यार्धमित्युपपन्नम् । एवं सर्वत्र तदर्धांशकशिञ्जिनीनामुपपत्तिर्ज्ञेया ।[6]

In this explanation, the versed sine is considered in the same manner as before. The versed sine is obtained by subtracting the sine of sixty degrees from the radius. It assumes the form of the perpendicular *(koṭi)*, while the direct sine represents the base *(bhujā)*. The line joining their extremities becomes the hypotenuse *(karṇa)*. This corresponds to the sine of thirty degrees; therefore, half of it corresponds to the sine of fifteen degrees. In this manner, the derivation of the sine of half of any arc should be understood. The geometrical demonstration of this rule is explained by me below by means of a diagrammatic construction2.

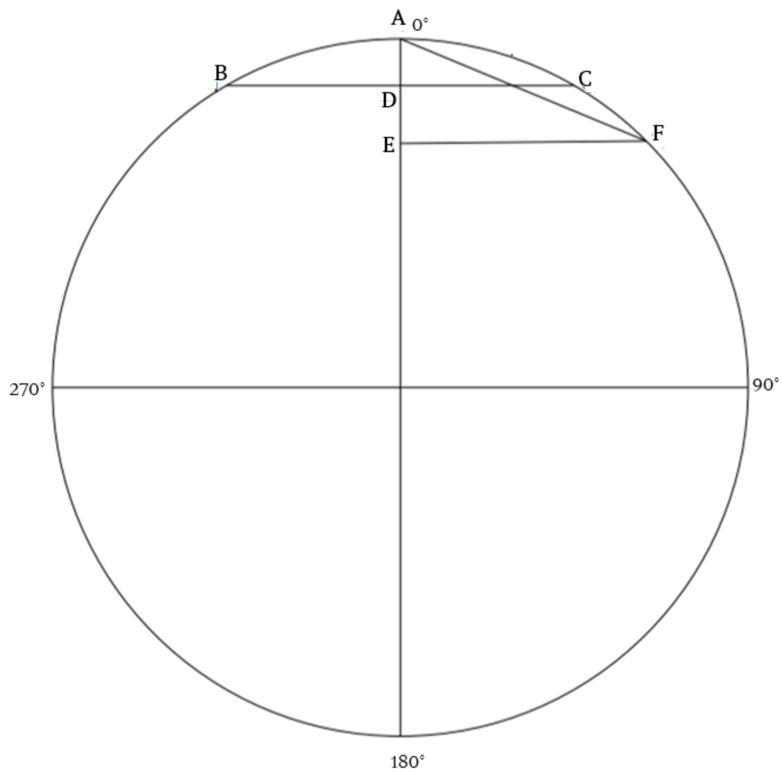

Figure 2: Proof for the Rule for the Computation of the Sine of Half of a Desired Arc from the Direct and Versed Sines

The point on the circumference of the circle which we designate as 0° is conceived as the middle point of the circle. Thus, in the present diagram, point **A** is taken as the middle point of the circle shown. From this middle point, the desired arc is measured along the circumference of the circle. In this circle, let arc **ACF** be considered the desired arc. The line **FE** is the sine *(bhujajyā)* of this arc. The arc **AC** is half of the arc **ACF**. The line **CD** is the sine of this arc. That is to say, here **CD** represents the sine of half of the desired arc. Similarly, **CB** represents the full chord corresponding to twice the half of the desired arc (that is, equal to the full chord of the desired arc).

Thus, arc **AC** is half of arc **ACF**, and it is also half of arc **BAC**

Therefore:

$$AC = CF \tag{15}$$

$$AC = AB \tag{16}$$

Hence:

$$\overline{AC} = \overline{CF} = \overline{AB} \tag{17}$$

$$\overline{AC} + \overline{CF} = \overline{AC} + \overline{AB} \tag{18}$$

$$\overline{AC} + \overline{CF} = \overline{AC}F \tag{19}$$

$$\overline{AC} + \overline{AB} = \overline{CA}B \tag{20}$$

Therefore:

$$\overline{AF} = \overline{CB} \tag{21}$$

Because equals added to equals are equal. In the same circle, equal arcs have equal chords. In this diagram, arc **ACF** is equal to arc **CAB**. The line **AF** is the full chord of arc **ACF**, and **CB** is the full chord of arc **CAB**. Therefore, the full chord **AF** is equal to the full chord **CB**.

Since angle AEF is a right angle, $\triangle AEF$ is a right-angled triangle. In this triangle:

- **FE** is the base,
- **AE** is the perpendicular,
- **AF** is the hypotenuse.

In a right-angled triangle, the square root of the sum of the squares of the base and perpendicular equals the hypotenuse. Therefore: $\mathbf{(FE)^2 + (AE)^2 = (AF)^2}$

But, **AF = CB**. Hence : $\mathbf{(FE)^2 + (AE)^2 = (CB)^2}$ Here : **FE** is the sine *(bhujajyā)* of the desired arc, AE is the versed sine *(bhujotkramajyā)* of the desired arc, **CB** is the full chord corresponding to twice the half of the desired arc, which is equal to the full chord of the desired arc. Thus, it is established that the square root of the sum of the squares of the sine and the versed sine equals the full chord corresponding to half of the desired arc taken twice.

Symbolically:

$$\sqrt{(bhujajy\bar{a})^2 + (bhujotkramajy\bar{a})^2} = \text{full chord of twice the half of the desired arc} \tag{22}$$

Taking half of this gives the half-chord (sine) of half of the desired arc.

Therefore:

$$\frac{\sqrt{(bhujajy\bar{a})^2 + (bhujotkramajy\bar{a})^2}}{2} = \text{sine of half the desired arc} \tag{23}$$

Thus, the formula is established.

III.b Second Rule – Method for Computing the Sine of Half of a Desired Arc from the Radius and the Versed Sine

Just as we are able to compute the sine of half of a desired arc by means of the direct sine (bhujajyā) and the versed sine (bhujotkramajyā), in the same manner it can also be computed by means of the radius and the versed sine. That method was propounded by Bhāskarācārya in the Golādhyāya of the Siddhāntaśiromaṇi [1], both at the beginning of the Chedyakādhikāra and at the end of the Golādhyāya in the section on Jyotpatti, in the following half-verse :

त्रिज्योत्क्रमज्यानिहतेर्दलस्य मूलं तदर्धांशकशिञ्जिनी वा ।[7]

The square root of half the product of the radius and the versed sine gives the sine of half of the desired arc.

$$\sqrt{\frac{R \times (R\text{versine})}{2}} = \text{sine of half of the desired arc} \tag{24}$$

In the Vāsanābhāṣya [1, 13] under the Chedyakādhikāraḥ in the Golādhyāya of the Siddhāntaśiromaṇi, Bhāskarācārya establishes the proof of this formula by algebraic reasoning, beginning with symbolic notation. He explains that when the versed sine is subtracted from the radius, the result is the cosine (koṭijyā). By squaring and manipulating the expressions, the required relation is derived. The passage concludes:

तत्राद्याक्षरचिह्नैर्बीजप्रकारेण कथ्यते । तत्रोत्क्रमज्योना त्रिज्या किल कोटिज्या । तस्या वर्गोऽयम् । उव १ उत्रिभा २ त्रिव १ अनेनोना त्रिज्याकृतिर्दोर्ज्याकृतिः स्यात् । उव १ उत्रिभा २ । अयं क्रमज्यावर्ग उत्क्रमज्यावर्गयुतो जातः । उत्रिभा २ । अस्य चतुर्थभागः । उत्रिभा $\frac{१}{२}$ । अस्य मूलं ग्राह्यम् । अत उक्तं त्रिज्योत्क्रमज्यानिहतेरित्यादि । एवं तस्या अप्यन्या तदर्धांशकशिञ्जिनीति ।[8]

Thus the rule is established.

Detailed Algebraic Demonstration as follows :

Radius − versed sine = cosine

We assume Radius = R, Versed sine = V

Squaring both sides :

$$R^2 - 2RV + V^2 = (\cos ine)^2 \tag{25}$$

But,

$$R^2 - (\cos ine)^2 = (\text{sine})^2 \tag{26}$$

Substituting and simplifying according to the rule ”a quantity subtracted from itself becomes zero”, we obtain:

$$2RV = (\text{full chord of twice the half desired arc})^2 \tag{27}$$

$$\therefore \frac{2RV}{4} = (\text{sine of half of the desired arc})^2 \tag{28}$$

Therefore:

$$\frac{R \times V}{2} = (\text{sine of half of the desired arc})^2 \tag{29}$$

Taking the square root:

$$\sqrt{\frac{R \times V}{2}} = \text{sine of half of the desired arc} \tag{30}$$

Thus, by this algebraic demonstration, it is established that The square root of half the product of the radius and the versed sine yields the sine of half of the desired arc.

IV The Theorem of Addition and Subtraction of Sines

If the sines of two different arcs are known, then for the purpose of determining the sine corresponding to the sum of those arcs as well as the sine corresponding to their difference, Bhāskarācārya propounded a rule. This rule is known as the Theorem of the Addition and Subtraction of Sines. It is stated as follows:

चापयोरिष्टयोर्दोर्ज्ये मिथः कोटिज्यकाहते ।

त्रिज्याभक्ते तयोरैक्यं स्याच्चापैक्यस्य दोर्ज्यका ॥

चापान्तरस्य जीवा स्यात् तयोरन्तरसम्मिता ।[9]

If we suppose that α and β are two arcs of a circle whose radius is R, then the rule stated in the above verse may be expressed as:

$$\sin(\alpha \pm \beta) = [\{\frac{\sin\alpha.\cos\beta}{R}\} \pm \{\frac{\cos\alpha.\sin\beta}{R}\}] \quad (31)$$

The addition of sines is called samasbhavana (concept of combination). The subtraction of sines is called antarabhavana (concept of difference).

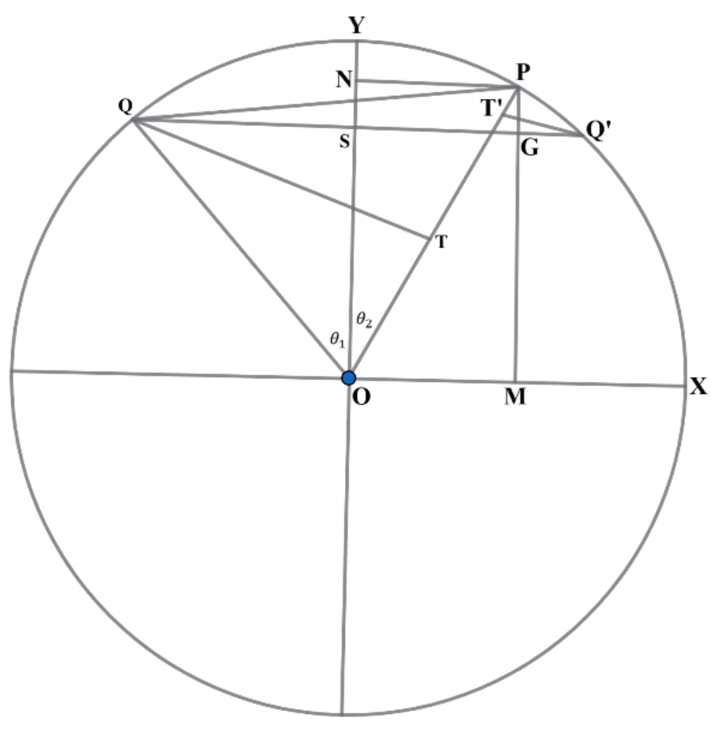

Figure 3: Proof for the Theorem of Addition and Subtraction of Sines

In this figure,

$$\text{R} = \text{Radius} \tag{32}$$

$$\widehat{YQ} = \alpha \tag{33}$$

Let it subtend an angle θ_1 at the center.

$$\widehat{YP} = \beta \tag{34}$$

Let it subtend an angle θ_2 at the center.

$$\alpha > \beta \tag{35}$$

Joint OP and OQ lines.

From point P, draw a perpendicular PM onto OX and a perpendicular PN onto OY. Similarly, from point Q, draw a perpendicular QS onto OY. When it is extended in the same direction, let it intersect the circumference of the base circle at point Q. Let QT and Q'T' be perpendicular to OP.

$$PN = R\sin\beta = R\sin\theta_2 \tag{36}$$

$$ON = R\cos\beta = R\cos\theta_2 \tag{37}$$

$$QS = R\sin\alpha = R\sin\theta_1 \tag{38}$$

$$OS = R\cos\alpha = R\cos\theta_1 \tag{39}$$

$$NS = PG = R\cos\beta - R\cos\alpha \tag{40}$$

$$= R\cos\theta_2 - R\cos\theta_1 \tag{41}$$

$$QG = R\sin\alpha + R\sin\beta \tag{42}$$

$$= R\sin\theta_1 + R\sin\theta_2 \tag{43}$$

$$QT = R\sin(\alpha+\beta) = R\sin(\theta_1+\theta_2) \tag{44}$$

$$PT = R - R\cos(\alpha+\beta) \tag{45}$$

$$PG^2 + QG^2 = QP^2 = QT^2 + PT^2 \tag{46}$$

Now, substituting the values of PG, QG, QT and PT in (1).

$$(R\cos\beta - R\cos\alpha)^2 + (R\sin\alpha + R\sin\beta)^2 = \{R\sin(\alpha+\beta)\}^2 + \{R - R\cos(\alpha+\beta)\}^2 \tag{47}$$

Simplifying this,

$$R\cos(\alpha+\beta) = \left(\frac{1}{R}\right)\{(R\cos\alpha.R\cos\beta) - (R\sin\alpha\cdot R\sin\beta)\} \ldots (2) \tag{48}$$

$$R\cos(\theta_1+\theta_2) = \left(\frac{1}{R}\right)\{(R\cos\theta_1.R\cos\theta_2) - (R\sin\theta_1.R\sin\theta_2)\} \quad (3) \tag{49}$$

$$cos(\theta_1 + \theta_2) = (cos\theta_1.cos\theta_2) - (sin\theta_1.sin\theta_2) \tag{50}$$

$$QT^2 = QQ^2 - OT^2 \tag{51}$$

$$\begin{gathered}\{R\sin(\alpha+\beta)\}^2 = R^2 - \{R\cos(\alpha+\beta)\}^2 \\ = \left(\tfrac{1}{R^2}\right)\{R^4 - \{(R\cos\alpha.R\cos\beta) - (R\sin\alpha \cdot R\sin\beta)\}^2 \\ = \tfrac{1}{R^2}[\{(R\sin\alpha)^2 + (R\cos\alpha)^2\}\{(R\sin\beta)^2 + (R\cos\beta)^2\} - \{(R\cos\alpha.R\cos\beta) \\ -(R\sin\alpha.R\sin\beta)\}^2]\end{gathered} \quad (4) \tag{52}$$

Simplifying this,

$$R\sin(\alpha+\beta) = \left(\frac{1}{R}\right)\{[R\sin\alpha.R\cos\beta + Kojyaa \cdot jya\beta]\} \quad (5) \tag{53}$$

$$R\sin(\theta_1+\theta_2) = \left(\frac{1}{R}\right)\{[R\sin\theta_1.R\cos\theta_2) + (R\cos\theta_1.R\sin\theta_2)] \quad (6) \tag{54}$$

$$sin(\theta_1 + \theta_2) = \{[sin\theta_1.cos\theta_2) + (cos\theta_1.sin\theta_2)] \quad (7) \tag{55}$$

$$(PG)^2 + (Q'G)^2 = (Q'P)^2 = (Q'T')^2 + (PT')^2 \quad (8) \tag{56}$$

$$(R\cos\beta - R\cos\alpha)^2 + (R\sin\alpha - R\sin\beta)^2 \quad (8) \tag{57}$$

$$= \{[R\sin(\alpha-\beta)\}^2 + \{R - R\cos(\alpha-\beta)\}^2] \tag{58}$$

Just as formulas (2), (3), and (4) were derived from (1), by simplifying the identity obtained from (8), the following formulas are obtained:

$$cos(\alpha-\beta) = \left(\frac{1}{R}\right)\{(cos\alpha.cos\beta) + (sin\alpha.sin\beta) \quad (9) \tag{59}$$

$$Or \tag{60}$$

$$R\cos(\theta_1-\theta_2) = \left(\frac{1}{R}\right)\{(R\cos\theta_1.R\cos\theta_2) + R\sin\theta_1.R\sin\theta_2\} \quad (10) \tag{61}$$

$$Or \tag{62}$$

$$cos(\theta_1 - \theta_2) = \{(cos\theta_1.cos\theta_2) + sin\theta_1.sin\theta_2\} \quad (11) \tag{63}$$

Just as formulas (5), (6), and (7) were obtained from (4) above,

$$\begin{gathered}(Q'T')^2 = \{(OQ')^2 - (OT')^2\} \\ \{sin(\alpha-\beta)\}^2 = R^2 - \{cos(\alpha-\beta)\}^2\end{gathered} \quad (12) \tag{64}$$

From this identity,

$$\{sin(\alpha-\beta)\} = \left(\frac{1}{R}\right) - \{sin\alpha.cos\beta\} - (cos\alpha.sin\beta) \quad (13) \tag{65}$$

$$R\backslash sin(\theta_1-\theta_2) = \left(\frac{1}{R}\right)\{(Rsin\theta_1.Rcos\theta_2) - Rcos\theta_1.Rsin\theta_2) \quad (14) \tag{66}$$

$$sin(\theta_1-\theta_2) = \{(sin\theta_1.cos\theta_2) - cos\theta_1.sin\theta_2) \quad (15) \tag{67}$$

are obtained.

V Conclusion

Among astronomers and mathematicians, Bhāskarācārya occupies the highest position. Likewise, among the works of Siddhānta Jyotiṣa, the Siddhāntaśiromaṇi composed by Bhāskarācārya shines in a pre-eminent place. Among the major doctrines of Siddhānta Jyotiṣa, the theories of Jyotpatti hold a distinguished status, and Bhāskarācārya's contribution to these theories is of great importance. In the Siddhāntaśiromaṇi, he expounded numerous doctrines concerning Jyotpatti [1, 14, 15]. The Jyotpatti theories stated by Bhāskarācārya [16] are significant even from the standpoint of modern trigonometry. Due to limitations of space, only some of these doctrines have been presented here. It is hoped that by reading this research paper, students and seekers of knowledge will gain familiarity with the principal doctrines concerning Jyotpatti as propounded by Bhāskarācārya. With this expectation, the present paper is hereby concluded.

Verse References

1. *Siddhāntaśiromaṇiḥ* – Grahagaṇitādhyāyaḥ – Spaṣṭādhikāraḥ – Verse 2 [1]
2. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verse 3 [1]
3. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Jyotpattiḥ – Verse 6 [1]
4. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verses 2–6 (Vāsanābhāṣyam) [1]
5. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verse 4;
   Siddhāntaśiromaṇiḥ – Golādhyāyaḥ – Jyotpattiḥ – Verse 10 [1]
6. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verses 2–6 (Vāsanābhāṣyam) [1]
7. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verse 5;
   Siddhāntaśiromaṇiḥ – Golādhyāyaḥ – Jyotpattiḥ – Verse 10 [1]
8. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Chedyakādhikāraḥ – Verses 2–6 (Vāsanābhāṣyam) [1]
9. *Siddhāntaśiromaṇiḥ* – Golādhyāyaḥ – Jyotpattiḥ – Verses 21, 22 [1]
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