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Influence of Brahmagupta on Bhaskara II

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Brahmagupta is regarded as one of the greats of the Ancient Indian Mathematicians. His voluminous work Brahmasphuta Siddhanta reflects his scholarship and mastery over mathematics. He was also known as Bhillamalakacharya (भिल्लमालकाचार्या). This name has been found in the commentary of Khandakhadya (खण्डखाद्य) written by Shri Varuna. Both Brahmagupta's works Brahmasphuta Siddhanta and Khandakhadya were translated into Arabic language as सिन्धिद and अल अरकण्ड respectively. This shows the popularity of Brahmagupta in ancient times. The Ancient Indian Astronomers of later period Sripati and BhaskaraII have freely borrowed from Brahmagupta.

The tradition of maintaining accuracy in astronomy was of paramount importance in ancient times. When the planets computed by the siddhanta system were found away from their observed positions the astronomers of ancient times used to make required corrections to the planets computed by the siddhantic system so that they accord with the observed ones. Brahmagupta was a keen observer of the sky. It was only after regular observations that he determined the number of the revolutions of the planets in a Kalpa and the length of a solar year. That is why his numbers were different from the Surya Siddhanta and Aryabhateeya. He gave most importance to the development of observational astronomy. In Yantradhyaya of Brahmasphuta Siddhanta he added some more Yantras (astronomical instruments) to the list.

ब्रह्मोक्तं ग्रहगणितं महता कालेन यद्खलीभूतम्।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन॥[1]
संसाध्य स्पष्टतरं बीजं नलिकादियन्त्रेभ्यः।
तत्संस्कृतग्रहेभ्यः कर्तव्यौ निर्णयादेशौ॥
ज्ञातं कृत्वा मध्यं भूयोऽन्यदिने तदन्तरम्।
त्रैराशिकेन भुक्त्या कल्पग्रहमण्डलानयनम्॥[2]
तन्त्रभ्रंशे प्रतिदिनमेवं विज्ञाय धीमता यत्नः।
कार्यस्तस्मिन् यस्मिन् दृग्गणितैक्यं सदा भवति॥[3]

These verses from Brahmasphuta Siddhanta clearly show his commitment towards maintaining accuracy in the computation of astronomical events. Brahmagupta's mathematical excellence can be known by some of his explanations. In Ancient Indian Astronomy Kalpa is the biggest unit of time which consists of 432,00,00,000 solar years. People may raise their eyebrows to know why such a big unit of time was taken into consideration. Brahmagupta in his Brahmasphuta Siddhanta gives appropriate answers with astronomical evidence.

कालर्क्षदेशयोगाद् भूयो ग्रहमन्दशीघ्रपातानाम्।

कल्पेन यतो योगस्ततः ग्रहयुगं कल्पः॥[4]

At the beginning of creation, it is presumed that the planets, also their apogees and their orbital nodes were in conjunction at the first point of zodiac named Ashwini. By the knowledge of the sidereal periods of these planets etc, and the interval time during all these an integral number of revolutions is calculated. This period is Kalpa. This idea has been found only in Brahmasphuta Siddhanta of Brahmagupta.

The method of computing the H sine of an angle and finding of the angle without the tabled sine are enunciated first by Brahmagupta. But this credit has been wrongly given to Sripati.

भुजकोट्यंशोनगुणा भार्धांशास्तच्चतुर्थ-

भागोनैःपञ्चद्वीन्दुखचन्द्रैर्विभाजिता।

तज्ज्ये परमफलज्यासङ्गुणिता तत्फले विना ज्याभिः।

इष्टोच्चनीचवृत्तव्यासार्धं परमफलजीवा॥

इष्टज्यासङ्गुणिताः पञ्चकयमलैकशून्यचन्द्रमसः

इष्टज्यापादयुतव्यासार्धविभाजितं लब्धम्।

नवतिकृतेः प्रोह्यं पदं नवतेः संशोध्यशेषभागकलाः

एवं धनुरिष्टायाः भवति ज्याया विना ज्याभिः॥[5]

The Bijaganita (Algebra) was first found in Brahmasphuta Siddhanta only.

Bhaskara II of 12th century was one of the greatest mathematicians and astronomers of the world. There is no exaggeration in the words of Muneeshwara the ardent follower of BhaskaraII.

गूढं स्थूलं स्वसिद्धान्तं मत्वा यस्तच्छिरोमणिम्।

कृतवान् मनुजव्याजादसौ जयति भास्करः॥[6]

Muneeshwara firmly believes BhaskaraII is the incarnation of Lord Sun. Bhaskara undoubtedly deserves this praise. After the arrival of Bhaskara the name and fame of the other ancient Indian astronomers prior to and after him has been obscured. Siddhanta Shiromani of Bhaskara is regarded as the greatest astronomical work of Ancient India. This monumental treatise consists of four parts. Leelavati (Arithmetic) Bijaganita (Algebra) Goladhyaya (Spherical) and Grahaganitadhyaya. His poetic skills, mathematical excellence and pedagogy are clearly reflected in his work. Popularity of Leelavati can be gauged by the number of its commentaries and translations in several languages. It is firmly believed by traditional Indian astronomers that without the study of Siddhanta Shiromani the study of Ancient Astronomy is incomplete. Bhaskara wrote a lucid commentary named Vasana Bhashya to his own text Siddhanta Shiromani.

Udayantara a correction to be affected in planetary position due to the equation of time due to obliquity was first propounded by Bhaskara.

In the very next verse to the salutations to the Sun God with which Siddhanta Siromani begins, Bhaskara says -

कृती जयति जिष्णुजो गणकचक्रचूडामणिः।

जयन्ति ललितोक्तयः प्रथिततन्त्रसयुक्तयः॥[7]

In the Vasanabhashya of भगणाध्याय Bhaskara explains the method of Excel that blessed Brahmagupta the son of Jishnu who is hailed as the crest jewel of mathematicians. Bhaskara's quoting the name of Brahmagupta with reverence at the beginning of his work shows that he holds Brahmagupta at high esteem.

Computing the number of revolutions of the planets in a kalpa, Bhaskara quotes Brahmagupta in support of his theory. तथा **च आह ब्रह्मगुप्तः–**

ज्ञातं कृत्वा मध्यं भूयोऽन्यदिने तदन्तरं भुक्तिः।

त्रैराशिकेन भुक्त्या कल्पग्रहमण्डलानयनम्॥[8]

Bhaskara accepts the Agama of Brahmagupta and adopts the number of revolutions of planets in a Kalpa and such other astronomical constants as were adopted by Brahmagupta.

Bhaskara in the 16th verse of Spashtadhyaya explains rectification of the next H sine difference known as Bhogya Khanda Spashteekarnam.

यातैष्ययोः खण्डकयोर्विशेषः शेषांशनिघ्नो नखदृत् तदूनम्।

युतं गतैष्यैक्यदलं स्फुटं स्यात् क्रमोत्क्रमज्याकरणेऽत्र भोग्यम्॥[9]

The difference of the previous and the following H sine multiplied by the remaining degrees and divided by 20. The result is subtracted from the arithmetic mean of the previous and following H sine differences. The result is rectified next H sine. This formula is a re-statement of the formula enunciated by Brahmagupta.

गतभोग्यखण्डकान्तरदलविकलवधात् शतैर्नवभिरासैः

तद्युतिदलं युतोनं भोग्यादूनाधिकं भोग्यम्॥[10]

Bhaskara follows the Natakarma(नतकर्म), the correction to the planets propounded by Brahmagupta. In the Vasana Bhashya of 68th verse of स्पष्टाधिकार, Bhaskara quotes Brahmagupta and explains the theory. अथ ब्रह्मगुप्तोक्तम् उच्यते। This was accepted by Bhaskara as Agama enunciated by Brahmagupta. This correction is known in modern astronomy as correction due to astronomical refraction. This correction, named Natakarma really adds credit to Brahmagupta's observational skill.

In the Vasana Bhashya of 10th verse of Suryagraha-nadhikara Bhaskara explains the place of दृक्षेप of the Sun and the Moon. While explaining the two he takes the idea of Brahmagupta -

यथाह श्रीमान् ब्रह्मगुप्तः –

दृक्क्षेपमण्डले युक्ते अपमण्डलेन भानोश्चन्द्रस्य विमण्डलेन युते इति।

Whenever Bhaskara wants to prove his point, he never hesitates to quote from Brahmagupta. Further in the same chapter in the Vasana Bhashya of 19th verse he supports the method of computing parallax in latitude of Brahmagupta though it is approximate.

Bhaskara quotes Brahmagupta in the chapter Patadhyaya.

भावाभावे गतैष्यत्वे पातस्य विदुषां भ्रमः।

पूर्वेषां यत्र वक्ष्येऽहं तत्साधनमपि स्फुटम्॥[11]

Bhaskara says even scholars get confused while computing the occurrence of Pata, unable to know whether it has already occurred or is going to occur. Finding of the occurrence of Pata is so tough that another astronomer of ancient times declares thus -

त्रिस्कन्धविद्याकुशलैकमल्लो लल्लोऽपि यत्राऽप्रतिभो बभूव।

यातेऽपि किञ्चिद्गणिताधिकारे पाताधिकारे मम नाधिकारः॥[12]

Patas are two in number called Vyatipata and Vaidhriti. When the Sun and the Moon have equal declinations being situated in opposite Ayanas but the same Gola, Vyatipata occurs. When the Sun and the Moon have equal declinations and being situated in the same Ayana but opposite Gola, Vaidhriti occurs. To know the declination of the Moon is not so easy. Here also Bhaskara follows the method of Brahmagupta though it is approximate but as it is easy for the students. He says "छात्राणां सुखार्थं स्थूलान्यपि पञ्चदश भागलभ्यानि क्रान्तिखण्डानि ब्रह्मगुप्ताद्यैः पठितानि तद्यथा -

"क्रान्तिकला द्विरसगुणास्त्रिखमुनयो द्विखदिशो वसुत्र्यर्काः।

वसुवसुविश्वे च खकृतमनवश्च क्षेपयुतवियुताः॥"[13]

Again, in the Vasana Bhashya of 14th verse of Patadhikara he thoroughly discusses the theory of Brahmagupta.

In the Vasana Bhashya of the 37th verse of छेद्यकाधिकार of गोलाध्याय Bhaskara again approves the opinion of Brahmagupta. He says **"अतो ब्रह्मोक्तिरत्र सुन्दरी"**

"स्वल्पान्तरत्वात् मृदुकर्मणीह कर्णः कृतो नेति वदन्ति केचित्"[14]

To those who ask for the reason for the omission o hypotenuse in the Manda process, Brahmagupta's logical and appropriate answer has been accepted by Bhaskara.

Bhaskara's undeterrable confidence in the scholarship of Brahmagupta clearly reflects in the Vasana Bhashya of 17th, 18th and 19th verses of गोलबन्धाधिकार of Siddhanta Shiromani where he discusses about the अयनांश precession of equinox.

"येऽयनचलनभागाः प्रसिद्धाः ते एव विलोमगस्य क्रान्तिपातस्य भागाः। मेषादेः पृष्ठतस्तावत् भागान्तरे क्रान्तिवृत्ते विषुवद्वृत्तं लग्नमित्यर्थः। न हि क्रान्तिपातो नास्तीति वक्तुं शक्यते। प्रत्यक्षेण तस्योपलब्धत्वात्। उपलब्धिप्रकारमग्रे वक्ष्यति। तत्कथं ब्रह्मगुप्तादिभिर्निपुणैरपि नोक्त इति चेत्। तदा स्वल्पत्वात् तैर्नोपलब्धः। इदानीं बहुत्वात् साम्प्रतिकैरुपलब्धः। अत एव तस्य गतिरस्तीत्यवगतम्। यद्येवमनुलब्धोऽपि सौरसिद्धान्तोक्तत्वात् आगमप्रामाण्येन भगणपरिध्यादिवत् कथं तैर्नोक्तः। सत्यम्। अत्र गणितस्कन्ध उपपत्तिमानेवागमः प्रमाणम्। तर्हि मन्दोच्चपातभगणा आगमप्रामाण्येनैव कथं तैरुक्ता इति न च वक्तव्यम्। यतो ग्रहाणां मन्दफलाभावस्थानानि प्रत्यक्षेणैवोपलभ्यते। तान्येव मन्दोच्चस्थानानि। यान्येव विक्षेपाभावस्थानानि तान्येव पातस्थानानि। किन्तु तेषां गतिरस्ति नास्ति वेति सन्दिग्धम्। तत्र मन्दोच्चपातानां गतिरस्ति। चन्द्रमन्दोच्चपातवदित्यनुमानेन सिद्धा। सा च कियती तदुच्यते। यैर्भगणैरुपलब्धिस्थानानि तानि गणितेनागच्छन्ति तद्भगणसम्भवा वार्षिकी दैनन्दिनी वा गतिर्ज्ञेया। नन्वेवं यद्यन्यैरपि भगणैस्तान्येव स्थानान्यागच्छन्ति तथा कतरस्या गतेः प्रामाणयम्। सत्यम्। तर्हि साम्प्रतिकोपलब्ध्यनुसारिणी कापि गतिरङ्गीकर्तव्या। यदा पुनर्महता कालेन महदन्तरं भविष्यति तदा महामतिमन्तो ब्रह्मगुप्तादीनां समानधर्माण एवोत्पत्स्यन्ते। ते तदुपलब्ध्यनुसारिणीं गतिमुररीकृत्य शास्त्राणि करिष्यन्ति।"[15]

Conclusion -

Bhaskara had quoted Brahmagupta at several places in his Siddhanta Shiromani. we made a humble attempt of showing a few examples how Bhaskara was inspired and influenced by the scholarship of Brahmagupta. There is no doubt that Bhaskara was a scholar of exceptional quality but the influence of Brahmagupta on him is undoubtable.

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