

900th Birth Anniversary of Bhāskarācārya: A Brief Report

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Bhāskarācārya alias Bhāskara or Bhāskara II, had a great reputation for his contribution in mathematics and astronomy in India. He was born in 1114AD in Bijapur in Modern Karnataka. He wrote the medieval classic, *Siddhānta Śīromani* on mathematics and astronomy. It is divided into four parts *Līlāvati* (arithmetic), *Bījgaṇita* (algebra) *Grahaṇita* (mathematics of planets) and *Golādhyāya* (spheres) which are also sometimes considered as four independent works. He also wrote another treatise called *Karaṇakutuhala*. Bhāskara's works has been edited and translated with commentaries and notes by almost hundred medieval scholars. A few of them are: Edition on *Līlāvati* by Bapudeva Sastri (1883), Sudhakar Sarma with his own commentary (1878), Ed. with notes by Sudhakar Dvivedin (1912); English translation of *Līlāvati* by John Taylor (1816) Colbrooke (1817) and Hindi translation by Lakhanlal Jha (v. s. 2018) and an edition with commentary *kriyākramakarī* by K.V. Sarma (1975) and others. *Bījgaṇita* is edited by Sudhakar Divedin (1888), ed. with commentary *Navankuru* by Krishna Daivajna (1930). The editions and commentaries on *Siddhānta Śīromani* (astronomical portions only) include edition by Bapudeva Sastri (1929), *Grahaṇitadhyaya* with commentary by Dattatreya Apte (1939), edition on *Golādhyāya* with *vāsanabhāṣya* by Girijaprasad Dvivedin; English exposition and annotation of *Siddhānta Śīromani* by Arka Somayaji and commentary by Sumatiharsha (1901). Commentaries on *Karaṇakutuhala* by Sudhakara Divedi (1881) and editions and translation by Balachandra Rao are well known.

Bhaskara himself wrote a commentary *Vāsanabhāṣya* on his own work *Siddhānta Śīromani*.

Two national seminars and two international seminars were organised to celebrate 900th Birth Anniversary of the savant. National Workshop at Rashtriya Sanskrit Vidyapeetha, Tirupati (08-12, December 2014) was sponsored by the Department of Science and Technology (DST), New Delhi. Its objective was to have an insight into glorious work of Bhāskarācārya and to motivate the young research scholars of mathematics interested in ancient Indian mathematics. The emphasis was to correlate Bhāskarācārya's mathematical work wherever possible utilising the present day advance in science and technology. The second national seminar by K.V. Sarma Research Foundation, Chennai (28-29 January 2015) was held in Collaboration with P.S. Educational Society, Mylapore, Chennai, Indian Institute of Technology, Mumbai & Vivekananda Educational Society, Chennai. It focussed on Bhāskara's contributions to mathematics and astronomy and its impact on school and college students of India.

The International Conferences at Savitribai Phule University, Pune (27-30 November 2014) focussed on history and development of mathematics. The theme included symposia on Bhāskara's works and panel discussions on relevance of his work for our times and the role of history of Mathematics in the curriculum. The prominent speakers included Kim Plofker (USA), Clemency Montelle (Newzeland), J.V. Narlikar (India) among others.

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The second international seminar was organised by Vidya Prasarak Mandal, Thane during 19-21 September 2014. The themes of the conference revolved around the life and works of Bhāskara. They included Bhāskara as a Poet, limitations of critical editions, translations and commentaries, and Pedagogical importance of Bhāskara's works. Each of themes had plenary speakers speaking on each of the above mentioned theme.

Dr. Vijay Bedekar, Chairman, Vidya Prasarak Mandal delivered a welcome speech during the inaugural function and Prof. S. R. Sarma, Düsseldorf, Germany described the background of the conference and expressed his wish that the deliberations would pave a way to long term collaboration among the academicians interested in the life and work of Bhaskarācārya. The chief guest for the ceremony Dr. Anil Kakodkar, a well known nuclear scientist of India, congratulated the Vidya Prasarak Mandal Thane, for taking the lead in arranging an international conference.

The first day proceedings of the conference began by a key note address by Prof. S. G. Dani, President Indian Association of the History of Mathematics (IAHM). Prof. Dani referred to a long tradition of Mathematics in India and described Bhāskara as a gem in this tradition. He emphasised that how Bhāskara has contributed to the growth of mathematics through his profuse writing in 12th century. Delivering the first plenary talk entitled "*Līlā in the Līlāvātī*" K Ramasubramanian (IIT, Mumbai) stressed that Bhāskara's emphasis was on teaching mathematics by solving practical examples of day to day life. The problems are presented in verse form making retention easier for a longer time and they have the ability to process our mind and creative faculty. The last plenary lecture by Prof. Sita Sundar Ram (Kuppuswamy Sastri Research Institute, Chennai) focussed on Bhāskara's *Bījagaṇita*. Using a variety of verses from the book, she tried to show how

Bhāskara was ahead of his contemporaries in the field of Algebra. The session on *Līlāvātī* included speakers like Prof. Takanori Kusuba (University of Economics, Osaka, Japan) on *Ankapakṣa*, Dr K Ramakalyani (Kuppuswamy Sastri Research Institute, Chennai) on Gaṇeśa Daivajōa's *Upapattis*, Prof. SR Sarma on legend of *Līlāvātī* and SMR Ansari on Persian translation of Bhāskara's works. Professor Sarma questioned the notion of text *Līlāvātī* being attributed to daughter of Bhāskara. The Session on *Bījagaṇita* included papers on *Sūryaprakāśa* of Suryadāsa by K Vidyuta (Kuppuswamy Sastri Research Institute, Chennai), Bhāskara's method of *Vargaprakṛiti* by VS Deore and Manisha Acharya (M. D. College & Bhavan's H. Somani College, Mumbai) Algorithms in *Karaṇiṣavidha* by Sriaram M (Dept. of Mathematics, Amolakchand College, Yavatmal, Maharashtra), Bhaskara's Kummaka method by Manish Acharya (Bhavan's H. Somani College, Mumbai), Malayalam commentaries on *Līlāvātī* by NK Sunderashan & PM Vrinda (University of Calicut) and *Līlāvātī* and Kerala school of mathematics by P Rajsekhar and V Lakshmi (Calicut).

In the first plenary lecture on second day on Learning and patronage in 12-13th century, Dr A. P. Jamkhedkar (Director (retired), State Department of Archaeology and Museums Maharashtra, Mumbai) showed that strong patronage to the pursuit of knowledge was provided in ancient and medieval India. He presented an illustrative account of complete genealogy of Bhāskara and the Sāṅḍilya family. According to him, the royal family at Pattanapura of the Yādava period established a school (*maṭha*) in memory of Bhāskara to study and teach the treatises written by him. Bhaskara's own son Lakṣmīdhara was the Chief Astronomer of Yādava Jaitrṣpāla. His grandson, Caṅgadeva was honoured in A. D. 1207, by Yādava Siṅghana (II). Śrīpati, a brother of Bhāskara, succeeded him in the imperial court of Siṅghana. The inscriptions of Khandesh area describes different centres of

mathematics and also astronomy learning, within a perimeter of 100 kilometer. In the second plenary lecture Prof. Pierre-Sylvain Filliozat (Emeritus Professor, Department of Sanskrit, University of Paris, France) brought out the poetical face of mathematical and astronomical works of Bhāskara. The third plenary lecture of the day by Prof Sriram (University of Madras, Chennai) on *Grahagaṇitadhyāya* of Bhāskaracārya's *Siddhānta Śiromaṇi* dwelt on mathematical formulae related to the motion of the planets described by Bhāskaracārya in his famous book *Grahagaṇita*. Post-lunch had two parallel sessions focussing on *Bhāskara as a poet* and on *Karaṇakutuhala*. Paper by KK Geethakumary (University of Calicut) highlighted the contributions of *Līlāvati* to prosody, while MS Limaye (Mumbai) mentioned about the use of Bhūta-Saṅkhyās (Object Numerals) in *Līlāvati*. The session on *Karaṇakutuhala* had papers on concepts of transit & occultations and solar and lunar eclipses by V. Vanaja (Government First Grade College, Bengaluru) and Mohini Kulkarni & Arpita Deodikar (Joshi–Bedekar College of Arts and Commerce, Thane) respectively.

On third day and final day plenary lecture by Prof. Balachandra Rao (Gandhi Centre of Science and Human Values Bharatiya Vidya Bhavan, Bengaluru) threw light on importance of *Karaṇakutuhala* as an algorithmic handbook. The second plenary lecture by Prof. M. D. Srinivas (Centre for Policy Studies, Chennai) focussed on *Vāsanbhāṣya* of Bhāskaracārya, explaining and justifying the results and processes in mathematics and astronomy. The last plenary by Prof. S. R. Sarma on astronomical instruments mentioned in *Golādhyāya* of Bhāskaracārya's *Siddhānta Śiromaṇi* listed ten instruments for observation and time-measurement, namely Gola, Nāivalaya, Yaṣṭi, Śaṅku, Ghaṭī, Cakra, Cāpa, Turya, Phalaka, Dhī. He explained in detail the purpose of these instruments.

The session on *Siddhānta Śiromaṇi* included speakers from overseas countries as well. Michio Yano (Kyoto Sangyo University, Kyoto, Japan) in his paper described the concept of *Kṣayamāsa*, while Padmaja Venugopal (S J B Inst. of Technology, Bengaluru) and K Rupa (Global Academy of Technology, Bengaluru) presented the concepts of eclipses and heliacal rising of stars and planets mentioned in Bhāskara's works. Kim Plofker (Union College, New York, USA) described the concepts of *Siddhānta-Karaṇa* conversion (algorithms) mentioned in *Gaṇitadhyāya* of *Siddhānta Śiromaṇi* and *Karaṇakutuhala*. Clemency Montelle (University of Canterbury, New Zealand) examine the many links between twelfth century set of astronomical tables, the so-called *Brahmatulyasāraṇī* and *Karaṇakutuhala* and what they reveal about the computational procedures and techniques that practitioners from this period employed when executing and applying these astronomical algorithms. Setusuro Ikeyama (Kyotanabe-shi, Kyoto, Japan) presented an application of addition formula for Sine in Indian Astronomy.

Session on Bhāskara's pedagogical importance had papers by Ananya Mitra (K M Mahavidyalaya, Keshabpur), MW Barsagade (B. N. Bandodkar College of Science, Thane), SC Agarkar (VPM's Academy of International Education and Research Thane), and HP Koirala (Eastern Connecticut State University, Willimantic, Connecticut, USA) highlighting the importance of *Līlāvati* and contributions of Bhāskara's to modern mathematical concepts.

In the Concluding Ceremony Prof. SR Sarma summarised the proceedings of the conference highlighting its outcomes. Prof. Deepak Phatak, IIT Mumbai, Chief Guest for the ceremony reiterated the need to undertake serious studies in the field of history of science and mathematics in India.

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