From: Thomas Hockey et al. (eds.). *The Biographical Encyclopedia of Astronomers, Springer Reference*. New York: Springer, 2007, pp. 188-189

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science+business media

http://dx.doi.org/10.1007/978-0-387-30400-7_223

Būzjānī: Abū al-Wafāʾ Muḥammad ibn Muḥammad ibn Yaḥyā al-Būzjānī

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Born **Būzjān (Būzhgān, Khurāsān, Iran), 10 June 940**

Died **Baghdad, (Iraq), 997 or 998**

Būzjānī was one of the leading astronomers and mathematicians of the Middle Ages, with significant contributions in observational astronomy. His achievements in trigonometry paved the way for more precise astronomical calculations.

Būzjānī was born in Būzjān, in the region of Nīshāpūr. The town is now a deserted land in the vicinity of the small town of Torbat-i Jām, located today in the Iranian province of Khurāsān. He was from an educated and well-established family. He is said to have studied arithmetic under both his paternal and maternal uncles.

Būzjānī flourished in an age of great political upheavals. The Būyids (945 to 1055), a family originally from the highlands of Daylam in northern Iran, had built a new dynasty that soon extended its rule over Iraq, the heart of the ʿAbbāsid caliphate, reducing the caliph's rule to a mere formality. Under the Būyids, who were great patrons of science and the arts, many scientists and scholars were attracted to Baghdad to enjoy the benefits of the new rulers' patronage. The change in the political climate had brought with it a great cultural revival in the eastern Islamic lands promoting literary, scientific, and philosophical activities on a grand scale.

At the age of 20, Būzjānī moved to Baghdad, the capital of the ʿAbbāsid caliphate, where he soon rose to prominence as a leading astronomer and mathematician at the Būyid court, conducting observations and research in the *Bāb al-Tibn* observatory. The decade following 975 seems to have been his most active years in astronomy, during which he is said to have conducted most of his observations. Later, to comply with the wishes of Sharaf al-Dawla, the Būyid Amīr (Regent), who was himself a learned man with keen interest in astronomy, Būzjānī became actively involved in the construction of a new observatory in Baghdad. His collaborator was **Kūhī**, another celebrated astronomer from the northern part of Iran who at the time was unrivaled in making astronomical instruments. The astronomical work of Būzjānī and his colleagues in Baghdad mark the revival of the “Baghdad school,” a tradition with much vitality in the preceding century.

Bīrūnī, the renowned astronomer and scientist living in Kath (in central Asia), tells us of his correspondence with Būzjānī, who was in Baghdad. This correspondence, and the exchange of astronomical data and measurements between them, signifies not only their mutual recognition as the leading astronomers of the time, but also the vigor with which astronomical observations were carried out in those days. According to Bīrūnī, in 997 the two astronomers prearranged to make a joint astronomical observation of a lunar eclipse to establish the difference in local time between their respective localities. The result showed a difference of approximately 1 hour between the two longitudes – very close to present-day calculations. In addition to this, Bīrūnī makes numerous references to Būzjānī's measurements in his various works.

Būzjānī's principal astronomical work, and his sole extant writing on the subject, is *Kitāb al-Majisṭī*. The book consists of three chapters: trigonometry, application of spherical trigonometry to astronomy, and planetary theory. An incomplete manuscript of this work exists in the Bibliothèque nationale, Paris.

A misinterpretation of a part of this book led Louis A. Sedillot (the French scientist) to claim that credit for discovering the variation (the third inequality) of the Moon's motion belonged to Būzjānī, and not to **Tycho Brahe**. This gave rise to a long-lived debate in the French Academy of Science from 1837 to 1872. The case was finally resolved by Carra de Vaux, the prominent historian of science in Islam, who, after a thorough study of the manuscript in 1893, reasserted Brahe's right to this discovery.

Although Būzjānī's *al-Majisṭī* – at least judging from the extant portion – did not introduce considerable theoretical novelties, it did contain observational data that were used by many later astronomers. More importantly, its section on trigonometry was a comprehensive study of the subject, introducing proofs in a masterly way for the most important relations in both plane and spherical trigonometry. Būzjānī's approach, at least in some instances, bears a striking resemblance to modern presentations.

In *al-Majisṭī*, Būzjānī introduced for the first time the tangent function and hence facilitated the solutions to problems of the spherical right-angled triangle in his astronomical calculations. He also devised a new method for constructing the sine tables, which made his tables for sin 30′ more precise than those of his predecessors. This was an important advance, since the precision of astronomical calculations depends upon the precision of the sine tables. The sine table in Būzjānī's *Almagest* was compiled at 15' intervals and given to four sexagesimal places. In the sixth chapter of *al-Majisṭī*, Būzjānī defines the terms tangent, cotangent, sine, sine of the complement (cosine), secant and cosecant, establishing all the elementary relations between them. Then assuming the radius of the (trigonometric) circle $R = 1$, he deduces that the tangent will be equal to the ratio of the sine to the sine of complement, and the inverse for the cotangent (identical to our present terminology). Later, Bīrūnī, inspired by Būzjānī and for simplification, uses this norm of $R = 1$ instead of $R = 60$ which was up until then commonly used in compiling the tables.

Būzjānī's contributions to mathematics cover both theoretical and practical aspects of the science. His practical textbook on geometry, *A Book on Those Geometric Constructions Which Are Necessary for a Craftsman*, is unparalleled among the geometrical works of its kind written in the Islamic world. Būzjānī wrote a practical textbook on arithmetic as well. The book is entitled *Book on What Is Necessary from the Science of Arithmetic for Scribes and Businessmen*. This is apparently the first and only place where negative numbers have been employed in medieval Islamic texts.

On the basis of works attributed to him, Būzjānī seems to have been a prolific scholar. He is said to have written 22 books and treatises. These include works on astronomy, arithmetic, and geometry, as well as translations and commentaries on the algebraic works of past masters like Diophantus and **Khwārizmī**, and a commentary on Euclid's *Elements*. Of all these works, however, only eight (as far as we know) have survived. Of his astronomical works, references were made to a *Zīj al-wāḍiḥ*, an influential work that is no longer extant.

Historical evidence, as well as the judgments of Būzjānī's colleagues and generations of scholars who came after him, all attest to the fact that he was one of the greatest astronomers of his age. He was also said to have been a man with great moral virtues who dedicated his life to astronomy and mathematics. His endeavors in the domain of science did not die with him. In fact, the data Būzjānī had gathered from his observations were used by astronomers centuries after him. Furthermore, the science of trigonometry as it is today is much indebted to him for his work. In his honor and to his memory, a crater on the Moon has been named for Būzjānī.

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