Biographical Encyclopedia of Astronomers

al-Khwarizmi Khwarizmi: Muhammad ibn Musa

Born circa 780

Died circa 850

Khwarizmi was a well-known astronomer and mathematician who spent most, if not all, of his scholarly life in Baghdad, in close connection with the Abbasid court, particularly during the caliphate of Ma'mün (reigned: 813–833). There is some confusion about his origins. The 10th-century bibliographer Ibn al-Nadim claimed that Muhammad ibn Musa was from Khwarizmi in Central Asia, whereas the historian Tabari reported that Khwarizmi was also known as al-Qurabbuli, a name associating the scholar with a town not far from Baghdad rather than with the Central Asian region of Khwarizmi (Toomer, p. 358). Tabari added that he was also called al-Majushi, a designation that indicates that Khwarizmi was a Zoroastrian rather than a Muslim Ibn al-Nadim also stated that he was attached to the Bayt al-hikma, the caliphate library. What this means exactly is unclear since there is considerable modern controversy about this institution and whether it should be regarded simply as a library or as a translation bureau and scientific research institution.

Ibn al-Nadim lists four astronomical works: the *Zij al-Sindhind* (an astronomical handbook according to the *Sindhind*), a treatise on the sundial, and two works on the astrolabe. Of these, the first is no longer extant in Arabic but is available in Latin translation; the second seems to be extant as fragments of a work on the astrolabe. Rosenfeld and Ihsanoğlu list 20 astronomical works in all. Among Khwarizmi's nonastronomical works, at least two are mathematical: a book on Indian arithmetic and one devoted to algebra (A book on "addition and subtraction" is also attributed to him.) He also has a *Book on Geography*, which is extant, and a *Book on History*, which is not but was quoted by later authors. The *Algebra* and the *Zij* were dedicated to Caliph Ma'mūn. The treatise on Indian arithmetic, in its extant Latin translation, mentions the Algebra and was therefore produced later. Khwarizmi also wrote a description of the Jewish calendar, which was written not before 823/824 because one of its examples is carried out for that year. The other texts offer no clue for dating them.

Khwarizmi's *Zij al-Sindhind* confirmed the place of pre-Islamic Indian astronomical models, functions, and parameters in the scholarly community of Baghdad, which had been multicultural since the second half of the 8th century. Before him, several "Zījāt al-Sindhind" are said to have been compiled based on Arabic translations of Indian astronomical handbooks (Pingree 1970, p. 105). Indeed, the astronomer Ibn al-Adamī described Khwarizmi's *Zīj* as an abridgment, prepared for Mamün, of Fazārī's (second half of the 8th century) handbook *al-Sindhind* (Pingree 1970, p. 106). Khwarizmi's tables were known to astronomers not only in Baghdad, but also in Central Asia in the east and in Andalusia on the Iberian Peninsula in the west. A number of authors who compiled their own handbooks relied on it Two examples are the already mentioned Ibn al-Adami in Baghdad, in his nonextant astronomical handbook *Nazm al-'iqd*, and Ibn Mu'adh in Andalusia, whose handbook is extant in its Latin translation

Tabulae Jahen. Others commented on Khwarizmi's tables, often criticizing the methods used, such as Ahmad ibn Kathir al-Farghānī (9th century) in Baghdad, Ibn al-Muthannā (10th century?) in Andalusia, 'Abdallah ibn Masrür al-Hasib al-Nasrānī in Baghdad (9th/10th century), and Abū Rayhan al-Bīrūnī in Ghazna. Bīrūnī devoted three treatises to Khwarizmi's Zīj. In one of them, he defended Khwarizmi against attacks by Ahmad ibn al-Husayn al-Ahwāzī (10th century) (Muhammad ibn Mūsā 1983, p. 21). It is believed that as late as the 19th century, tables connected to Khwarizmi's *Zij* were copied in Egypt (Goldstein and Pingree 1978; Pingree 1983).

No copy of Khwarizmi's *Zij* has survived, but Hebrew and Latin versions of various later texts connected with Khwarizmi's tables are extant. Ibn al-Muthannā in Andalusia set out to compose a commentary in order to rectify the obscurities of a critique of Khwarizmi's tables written by Farghānī. Both commentaries are lost But Hebrew and Latin versions of Ibn al-Muthanna's commentary are extant (Goldstein 1967, pp. 5–6; Pedersen, p. 32). The Latin translation of Ibn al-Muthanna's commentary was made by Hugo of Santalla (12th century) (Millás Vendrell, 1963). One Hebrew translation was produced by Abraham ibn Ezra (Goldstein 1967, p. 3). In the same century as Ibn al-Muthanna, and also in Andalusia, Maslama ibn Ahmad al-Majritī edited Khwarizmi's tables. Majritī's student, Ibn al-Şaffär, is believed to have continued his teacher's editorial work (Toomer, p. 358). This edition was translated into Latin in the 12th century, presumably by Adelard of Bath. Other Latin manuscripts contain texts that appear to combine extracts from Ibn al-Muthanna's commentary, Majriṭi's edition, and one or more Arabic compilations of material, translated and revised into Latin, from the tables of Khwarizmi, Yahya ibn Abi Mansür, Muhammad ibn Jabir al-Battani, Ibn al-Muthanna, and Majriṭi (Pedersen, pp. 31–46). The *Toledan Tables*, compiled around 1060 in Muslim Spain, contain several tables from Khwarizmi's *Zij*, some of which are not found in Majriṭi's revision. They are lost in Arabic but extant in several Latin versions (Van Dalen, p. 200).

The extant texts and tables follow in their presentation of the material; in their methods, rules, and models; and in several of their parameter values astronomical knowledge and practice as taught in several treatises written by Hindu scholars between the 5th and 7th centuries. They also use elements from Sasanian astronomical tables, incorporate borrowings from Greek astronomical writings (in particular Ptolemy's *Almagest* and *Handy Tables*), and include values determined by observations carried out during Mamūn's reign. A survey of the character of the tables in the Latin translation of Majrītī's revision of Khwarizmi's *Zij* has recently been given by Van Dalen (pp. 200-211). Khwarizmi's original Zij has been described as a similar mixture of elements by Ibn al-Adami, who, according to Ibn al-Qifṭi (1173–1248), reported that Khwarizmi had relied on the mean motions of the Indian tradition in his work, but differed from it in the equations and the declension. Ibn al-Adami also asserted that Khwarizmi followed Sasanian sources with regard to the equations and Ptolemy when dealing with the declension of the Sun (Pingree 1970, p. 106). According to McCarthy and Byrne, Khwarizmi's original handbook juxtaposed tables, which addressed the same kind of tasks, but came from different cultural origins. Examples illustrating the diverse components in the extant texts and tables and their modifications are the replacement of the Yazdagird calendar by the Hijra era, the addition of calendars alien to the traditions in India such as the ancient Egyptian, Seleucid, Roman, and Christian eras, the use of theorems (such as the Menelaus theorem) that were unknown to Hindu astronomers, the use of the value for the obliquity of the ecliptic as found in Ptolemy's *Handy Tables*, the use of the Ptolemaic value of 66% miles for a terrestrial degree, and the replacement of the latitude of Baghdad by the latitude of Cordova (Neugebauer, p. 19; Kennedy and Janjanian, pp. 73, 77; Goldstein 1967, pp. 7-8; Van Dalen, 1996, pp. 196, 240).

Khwarizmi's treatise on the Jewish calendar gives rules for determining the mean longitude of the Sun and the Moon based on this calendar and for determining on which day of the Muslim week the first day of the New Year shall fall. It also discusses the 19-year intercalation cycle and the temporal distance between the beginning of the Jewish era, *i.e.*, the creation of Adam and the beginning of the Seleucid era (Kennedy, 1964, pp. 55–59; Toomer, p. 360). The treatise on how to work with an astrolabe is only fragmentarily preserved, and opinions vary as to whether these fragments in their present form represent the genuine version of what Khwarizmi actually wrote. The treatise on how to construct an astrolabe seems to be lost. Khwarizmi's book on geography, *Kitāb Şūrat al-ard*, combines substantial parts of Ptolemy's *Geography* with many non-Ptolemaic coordinates and place names. His two writings on arithmetic, one in the tradition of oral reckoning and the other according to the Indian tradition of written reckoning using the decimal place-value system, are lost in Arabic. The latter survives in various Latin manuscripts. Khwarizmi's book on algebra is the first known in Arabic. It treats quadratic equations, the measurement of areas and volumes, commercial problems using four proportional quantities, and several types of Muslim inheritance mathematics. This text, too, was translated into Latin by at least two translators. Its influence on elementary algebra in Arabic, Persian, Ottoman Turkish, Latin, and European vernacular languages was substantial.

Finally, it is worth mentioning that Khwarizmi may have participated in a number of scientific expeditions, one to measure the size of the Earth, the other to explore the regions north of the Caspian Sea (Matvievskaya and Rozenfeld, 1983, Vol. 2: p. 41). The first, though, has recently been questioned (King, 2000).

Sonja Brentjes

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