From: Thomas Hockey et al. (eds.). *The Biographical Encyclopedia of Astronomers, Springer Reference*. New York: Springer, 2007, pp. 133-134

Courtesy of Springer science+business media

http://dx.doi.org/10.1007/978-0-387-30400-7_164

Biṭrūjī: Nūr al-Dīn Abū Isḥāq [Abū Jaʿfar] Ibrāhīm ibn Yūsuf al-Biṭrūjī

Julio Samsó

Alternate name

Alpetragius

Flourished **Andalusia (Spain), 1185–1192**

Biṭrūjī was a famous Andalusian (Arab) cosmologist who wrote an astronomical work that was quite influential in Latin Europe, where he was known as Alpetragius. Little is known of his life. He was probably a disciple of the philosopher **Ibn Ṭufayl** (died: 1185/1186), who was already dead when Biṭrūjī wrote his *Kitāb fī al-hay'a*. On the other hand, an anonymous treatise on tides (Escorial MS 1636, dated 1192) contains ideas seemingly borrowed from Biṭrūjī's work. A more definitive guide to dating is **Michael Scot**, who finished his Latin translation of Biṭrūjī's work in Toledo in 1217. His book was also translated into Hebrew by Mosheh ben Tibbon in 1259, and one of the manuscripts of this Hebrew translation states that he was a judge. A late 15th-century Moroccan source calls him *faqīh* (jurist). His name, al-Biṭrūjī, may be a corruption of al-Biṭrawshī, derived from Biṭrawsh, a village in Faḥṣ al-Ballūṭ (Cordova province).

Biṭrūjī's only extant work bears the title *Kitāb [murtaʿish] fī al-hay'a* (A [revolutionary] book on cosmology), which is extant in two Arabic manuscripts, the Latin translation of Scot, the Hebrew translation of ben Tibbon, and the Latin by Calo Calonymos (1286–*circa* 1328) from the Hebrew. A modern English translation and commentary can be found in Goldstein (1971).

Biṭrūjī's book is the final result of the efforts made by Andalusian Aristotelian philosophers of the 12th century (**Ibn Bājja**, **Ibn Ṭufayl**, **Ibn Rushd**, and **Maimonides**) to overcome the physical difficulties inherent in the geometrical models of **Ptolemy**'s *Almagest* and to describe the cosmos in agreement with Aristotelian or Neoplatonic physics. It is a book on *hay'a* (theoretical astronomy/cosmology). Earlier Andalusian work in this genre include two books by **Qāsim ibn Muṭarrif al-Qaṭṭān** (10th century), who followed the line of Ptolemy's *Planetary Hypotheses*, and an anonymous Toledan author of the second half of the 11th century who seems to represent the earliest Andalusian attempt to criticize the *Almagest* from a physical point of view. Despite these precedents in the Islamic west, Biṭrūjī seems to be the first to present alternatives to Ptolemy's models. His knowledge of the astronomical literature, though, was limited; he had probably read the *Almagest*, but he does not seem to have understood it completely. According to Biṭrūjī, Ptolemy was the archetypical mathematical astronomer who created imaginary models that were successful in their ability to predict planetary positions but were totally unreal.

Besides Ptolemy, Biṭrūjī may have read **Theon of Alexandria**'s *Commentary to the Almagest*. He also was well acquainted with the treatise on the motion of the fixed stars by **Zarqālī**. Furthermore, he quotes **Jābir ibn Aflaḥ**'s *Iṣlāḥ al-Majisṭī* (Revision of the *Almagest*) regarding the problem of the order of the planets in the Solar System but rejects Jābir's proposal to put both Mercury and Venus above the Sun, opting instead to make only Venus a superior planet. Jābir had argued that proposal on the basis of a lack of records of Mercury or Venus transits, but Biṭrūjī suggested that this might be because of both Mercury and Venus being self-luminous.

Biṭrūjī presented the first non-Ptolemaic astronomical system after Ptolemy, although he admits that the results are only qualitative. As a follower of **Aristotle**, his system is homocentric, the celestial bodies being always kept at the same distance from the center of the Earth. Despite this, Biṭrūjī employs mathematical eccentrics and epicycles, which are placed on the surface of the corresponding sphere and in the area of the pole. Apparently, he has adapted ideas derived from Zarqālī's trepidation models or perhaps from **Eudoxus**.

One of the most original aspects of Biṭrūjī's system is his proposal of a physical cause of celestial motions. Biṭrūjī uses the idea of *impetus*, originally put forth by **John Philoponus** (6th century) to deal with forced motion in the sublunar world, to account for the transmission of energy from a first mover that is placed in the ninth sphere. The motion of the ninth sphere, which rotates uniformly once every 24 hours, is transmitted to the inner spheres, and it becomes progressively slower as it approaches the Earth. The velocity of rotation of each sphere is used by Biṭrūjī to establish the order of the planets. It is noteworthy that Biṭrūjī is applying the same dynamics to the sublunar and the celestial worlds, contradicting the Aristotelian idea that there is a specific kind of dynamics for each world. Indeed, the force of the first mover reaches the sublunary world causing the rotation of comets in the upper atmosphere as well as the tides. Similar ideas can also be found in Ibn Rushd. Both Ibn Rushd and Biṭrūjī use another idea to explain this transmission of motion: the celestial spheres feel a "passion" or "desire" (*shawq*, *desiderium*) to imitate the sphere of the first mover, which is the most perfect one. Thus the spheres closer to the first mover are most like the ninth sphere and therefore move faster, while those farther away move slower. This use of *shawq* seems to derive from Neoplatonic notions developed by the philosopher Abū al-Barakāt al-Baghdādī (died: 1164), whose ideas may have been introduced into Andalusia by his disciple Abū Saʿd Isaac, the son of **Abraham ibn ʿEzra**.

Impetus and *shawq* were used by Biṭrūjī in his attempt to solve a puzzling problem: How can one explain that the unique first mover can produce both the daily east–west motion and the longitudinal (zodiacal) west–east motions in the planetary spheres? Biṭrūjī's explanation is that the motions in longitude can be explained as a "delay" (*taqṣīr*, *incurtatio*) in the perfect daily motion being transmitted by the first mover; this delay becomes progressively more noticeable in the planetary spheres further away from the first mover.

Biṭrūjī builds his geometrical models on this theoretical basis. *Taqṣīr* corresponds to the planetary motion in longitude while Biṭrūjī seems to identify *shawq* with the anomaly. In the case of the planets, each one of them moves near the ecliptic but its motion is regulated by the pole of each planet, placed at a distance of 90° from the planet itself. This pole rotates on a small polar epicycle whose center moves, as a result of *taqṣīr*, on a polar deferent. This use of a type of deferent and epicycle (within the context of homocentric astronomy) allows Biṭrūjī to explain, in a way similar to Ptolemy, the irregularities of planetary motions (direct motion, station, retrogradation). The problem is that Biṭrūjī also tries to explain, using the motion in anomaly (rotation of the pole of the planet on the polar epicycle), the changes in planetary latitude. This, however, does not really work since the periods of recurrence in anomaly and in latitude are not the same. Other problems result due to Biṭrūjī's ambiguity regarding the direction of motions and the fact that *shawq* does not diminish, as claimed, in the planetary spheres as they are further removed from the first mover. Thus, despite their ingenuity, Biṭrūjī's models are unable to provide the predictive accuracy of Ptolemy's models, and there are inconsistent aspects to them as well. In the case of the fixed stars, he proposes a model that results in a variable velocity in the precession of equinoxes, which echoes earlier Andalusian theories of the trepidation of the equinoxes. The geometrical model for the fixed stars is not easy to understand as preserved in the extant texts. A recent paper by J. L. Mancha (2004) gives a new and sophisticated interpretation, based on the Latin translation, which supports the hypothesis formulated by E. Kennedy in 1973 that Biṭrūjī's homocentric system is an updating and reformulation of the system of Eudoxus. For the motion of the fixed stars the Zarqālian tradition would be combined with aspects of Eudoxus's models, *i. e.*, he uses a Eudoxan couple that results in a hippopede. With Mancha's interpretation, Biṭrūjī's model for the fixed stars makes sense, but we have the problem of establishing which sources available to the Andalusian cosmologist gave him information on Eudoxus's models.

Despite its scientific failings, the *Kitāb fī al-hay'a* was quite successful. The Latin translation by Michael Scot contributed to its European diffusion between the 13th and the 16th centuries. It was accepted in scholastic circles where it was considered a valid alternative to Ptolemy's *Almagest*. The work was also known in the Islamic East, perhaps introduced in Egypt by Maimonides. The Damascene astronomer **Ibn al-Shāṭir** mentions a certain al-Majrīṭī as having presented non-Ptolemaic models; this may be a corruption of al-Biṭrūjī's name.

Selected References

Abattouy, Mohammed (2001). "Au dessus ou au-dessous du Soleil: Prolégomènes sur la position de Mercure et Vénus dans la tradition astronomique andalouse." In *Science et pensée scientifique en Occident Musulman au Moyen Age*, edited by Bennacer El Bouazzati, pp. 19–42. Rabat: Faculty of Letters of Rabat.

Avi-Yonah, Reuven S. (1985). "Ptolemy vs al-Biṭrūjī: A Study of Scientific Decision-Making in the Middle Ages." *Archives internationales d'histoire des sciences* 35: 124–147.

Carmody, Francis J. (1952). *Al-Biṭrūjī: De motibus celorum*. Critical edition of the Latin translation of Michael Scot. Berkeley: University of California Press. (See review by E. S. Kennedy in *Speculum* 29 (1954): 246–251.)

Casulleras, Josep (1998). "The Contents of Qāsim ibn Muṭarrif al-Qaṭṭān's *Kitāb al-hay'a*." In *The Formation of al-Andalus, Part 2: Language, Religion, Culture and the Sciences*, edited by Maribel Fierro and Julio Samsó, pp. 339–358. Aldershot: Ashgate.

Cortabarría, Angel (1982). "Deux sources de S. Albert le Grand: Al-Bitruji et al-Battani." *Mélanges de l'Institut dominicain d'etudes orientales* 15: 31–52.

Forcada, Miquel (1999). "La ciencia en Averroes." In *Averroes y los averroísmos: Actas del III Congreso Nacional de Filosofía Medieval*. Zaragoza: Sociedad de Filosofía Medieval, pp. 49–102.

Goldstein, Bernard R. (1971). *Al-Biṭrūjī: On the Principles of Astronomy*. 2 Vols. New Haven: Yale University Press. (See the reviews by Kennedy and Lorch.)

Kennedy, E. S. (1973). "Alpetragius's Astronomy." *Journal for the History of Astronomy* 4: 134–136.

Lorch, Richard (1974). "Review of *Al-Biṭrūjī: On the Principles of Astronomy*" by Bernard Goldstein. *Archives internationales d'histoire des sciences* 24: 173–175.

Mancha, J. L. (2004). "Al-Biṭrūjī's Theory of the Motion of the Fixed Stars." *Archive for the History of the Exact Sciences* 58: 143–182.

Sabra, A. I. (1984). "The Andalusian Revolt against Ptolemaic Astronomy: Averroes and al-Biṭrūjī." In *Transformation and Tradition in the Sciences*, edited by Everett Mendelsohn, pp. 133–153. Cambridge: Cambridge University Press. (Reprinted in Sabra, *Optics, Astronomy and Logic*, XV. Aldershot: Ashgate, 1994.)

Saliba, George (1994). *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*. New York: New York University Press.

——— (1999). "Critiques of Ptolemaic Astronomy in Islamic Spain." *Al-Qanṭara* 20: 3–25.

Samsó, Julio (1992). *Las ciencias de los antiguos en al-Andalus*. Madrid: Mapfre, pp. 330–356.

——— (1994). *Islamic Astronomy and Medieval Spain*. Aldershot: Variorum.