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Zarqālī: Abū Isḥāq Ibrāhīm ibn Yaḥyā al-Naqqāsh al-Tujībī al-Zarqālī

Roser Puig

Alternate name

Azarquiel

Died **Córdova, (Spain), 15 October 1100**

According to his biographer Isḥāq Israeli, Zarqālī was a renowned instrument maker in Toledo, where he taught himself astronomy. He worked for **Ṣāʿid al-Andalusī** and was a leading figure among Ṣāʿidʾs group of astronomers. An anonymous Egyptian 14th-century source (*Kanz al-yawāqīt*, Leiden Universiteitsbibliotheek, MS 468) quotes a passage from Ṣāʿidʾs lost work entitled *Ṭabaqāt al-ḥukamāʾ*, in which it is stated that Zarqālī constructed an astronomical instrument, called *al-zarqāla*, for al-Maʾmūn (1043–1075), the ruler of Toledo, in the year 1048/1049. It also says that Zarqālī wrote a treatise of 100 chapters on its use. Zarqālī left Toledo between 1081, the beginning of the reign of al-Qādir, and 1085, the date of the conquest of the city by Alfonso VI. He settled in Córdova, where he was protected by al-Muʿtamid ibn ʿAbbād (1069–1091), ruler of Seville.

There are many variations of the name of Zarqālī, known as Azarquiel in Latin. According to the *Ṭabaqāt al-umam* of Ṣāʿid al-Andalusī, he was known as *walad al-Zarqiyāl*, from whence came the Hispanicized form *Azarquiel*. The 13-century biographer al-Qifṭī maintains the expression *walad al-Zarqiyāl* in his *Akhbār al-ʿulamāʾ bi-akhbār al-ḥukamāʾ*. Other readings quoted in Andalusian sources are al-Zarqālluh, al-Zarqāl, or Ibn Zarqāl; readings such al-Zarqāla and al-Zarqālī (sometimes al-Zarqānī) seem to be classicized Eastern forms.

In his *Jāmiʿ al-mabādiʾ wa-ʾl-ghāyāt fī ʿilm al-mīqāt*, an encyclopedic work on astronomy, **Abū al-Ḥasan ʿAlī al-Marrākushī** (13th century) states that Zarqālī was making observations in Toledo in 1061. This testimony is confirmed by **Ibn al-Hāʾim al-Ishbīlī** (flourished: 1204/1205) in his *al-Zīj al-kāmil fī al-taʿālīm*, who attributes to Zarqālī 25 years of solar observations and 37 years of observations of the Moon. Al-Qifṭī says that his observations were used by **Ibn al-Kammād**.

One can generally classify the contents of Zarqālīʾs work under four main categories: astronomical theory, astronomical tables, magic, and astronomical instruments.

The following four works by Zarqālī deal with astronomical theory: (1) There is a treatise on the

motion of the fixed stars, written *circa* 1084/1085 and extant in Hebrew translation. It contains a study of three different trepidation models, in the third of which variable precession becomes independent of the oscillation of the obliquity of the ecliptic. (2) There is a lost work summarizing 25 years of solar observations, probably written *circa* 1075–1080. Its contents are known through secondary sources, both Arabic and Latin. The title was either *Fī sanat al-shams* (On the solar year) or *al-Risāla al-jāmiʿa fī al-shams* (A comprehensive epistle on the Sun). In this work Zarqālī established that the solar apogee had its own motion (of about 1° in 279 Julian years) and devised a solar model with variable eccentricity that became influential both in the Maghrib and in Latin Europe until the time of **Nicolaus Copernicus**. (3) There is an indirect reference to a theoretical work entitled *Maqāla fī ibṭāl al-ṭarīq allatī salaka-hā Baṭlīmūs fī istikhrāj al-buʿd al-abʿad li-ʿUṭārid* (On the invalidity of **Ptolemy**'s method to obtain the apogee of Mercury) mentioned by **Ibn Bājja**. (4) There is a reference in Ibn al-Hāʾim's work to Zarqālī's lost writing (*bi-khaṭṭ yadi-hi*, in his own hand) describing a correction to the Ptolemaic lunar model. Ibn al-Hāʾim understands this correction as a result of the displacement of the center of the lunar mean motion in longitude to a point on a straight line linking the center of the Earth with the solar apogee, and at a distance of 24'. This model met with some success, for we find the same correction in later Andalusian (Ibn al-Kammād) and Maghribī (**Ibn Isḥāq**, **Ibn al-Bannāʾ**) *zīj*es, although restricted to the calculation of eclipses and the New Moon. It appears also in the Spanish canons of the first version of the *Alfonsine Tables* and in a Provençal version of the tables of eclipses of *Gersonides*, although in these tables the amount is given as 29' (either a copying error or a new estimation).

There are two works by Zarqālī dealing with astronomical tables: (1) The *Almanac* is preserved in Arabic, Latin, and in an Alfonsine translation. It is based on a Greek work calculated by a certain Awmātiyūs in the 3rd or 4th century, although the solar tables seem to be the result of the Toledan observations. Its purpose is to simplify the computation of planetary longitudes using Babylonian planetary cycles (*goal years*). (2) The *Toledan Tables* are known through a Latin translation. They seem to be the result of an adaptation of the best available astronomical material (*i. e.*, **Khwārizmī** and **Battānī**) to the coordinates of Toledo that was made by a team led by Ṣāʿid and in which Zarqālī seems to have been a prominent member. The mean-motion tables are original and are the result of observations. Ṣāʿid does not mention these tables although they had been completed before the writing of the *Ṭabaqāt* in 1068.

The only known magical work by Zarqālī is entitled *Risāla fī Ḥarakāt al-kawākib al-sayyāra wa-tadbīri-hi* (On the motions and influences of planets), which is a treatise on talismanic magic using magic squares to make talismans. It is preserved in two Arabic manuscripts, which contain two different versions of the text. There is also a third one summarized in a Latin translation.

Finally, Zarqālī has several works on astronomical instruments: (1) There is a treatise on the construction of the armillary sphere, which is preserved in an Alfonsine–Castilian translation. The original Arabic has not survived. (2) There are two treatises on the construction (*circa* 1080/1081) and use (*circa* 1081/1082) of the equatorium, dedicated to al-Muʿtamid. Zarqālī's equatorium differs from the earlier Andalusian model designed by **Ibn al-Samḥ** (*circa* 1025/1026) in that it is an independent instrument that represents all the planetary deferents and related circles on both sides of a single plate, while a second plate bears all the epicycles. Mercury's deferent is represented as an ellipse. (3) Marrākushī attributes to Zarqālī a sine quadrant with movable cursor (*majarra*), which is a graphic scale of solar declination with the solar longitude as argument. It is similar to the quadrant *vetustissimus*, although in this quadrant the argument used is the date of the Julian year. (4) There are two treatises on two variants of the same astronomical universal instrument (*al-ṣafīḥa al-mushtaraka li-jamīʿ al-ʿurūḍ*): A 100-chapter treatise on the use of the *ṣafīḥa* (plate), called the *zarqāliyya*, and another treatise of 60 chapters on the use of the *ṣafīḥa shakkāziyya*. In both instruments the stereographic equatorial projection of the standard astrolabe is replaced by a stereographic meridian projection onto the plane of the solstitial colure. In fact, it is a dual projection corresponding to each of the Celestial Hemispheres, one of which had its viewpoint at the

beginning of Aries and the other at the beginning of Libra. The end result was obtained by superimposing the projection from Aries (turning it) onto the projection from Libra. The two variants of the *ṣafīḥa* differ slightly. The *zarqāliyya* has, on its face, a double grid of equatorial and ecliptical coordinates and a ruler horizon representing the horizontal ones. On its back, in addition to the features proper to the astrolabe, it shows an orthographic meridian projection of the sphere, a trigonometric quadrant, and a small circle (named "of the Moon") used to compute the geocentric distance of the Moon. The *shakkāziyya* is a simplification of the *zarqāliyya*, as Marrākushī states in his *Jāmiʿ*. On its front it bears a single grid of equatorial coordinates and a grid of ecliptical ones reduced to the ecliptic line and the circles of longitude marking the beginning of the zodiacal signs. The back of this kind of *ṣafīḥa* is the same as the back of the astrolabe. There is an Alfonsine translation of the treatise on the *zarqāliyya*, as well as several translations into Latin and Hebrew of the treatise on the *shakkāziyya*.

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