Al-Zarqali (or Azarquiel), Abu Ish?aqibrahim Ibn Yah?ya Al-Naqqash | Encyclopedia.com

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AL-ZARQāLī (OR AZARQUIEL), ABū ISḤāQIBRāHīM IBN YAḤYā AL-NAQQāSH

(d. Córdoba, Spain, 15 October 1100),[1]

astronomy.

During his lifetime al–Zargāli was known in Spain as Azarquiel: the correct form of this word, al–Zārqiyal, was preserved by Ibn al–Qifti[2] The name is composed of the Arabic article al, the adjective *zarqā*ʿ ("blue" ; "the blue–eyed one"), and *elluslel,* the diminutive form in Spain.

The few known facts of al–Zarqali's life can be established from the autobiographical passages in his works. He must have been born in the first quarter of the eleventh century to a family of artisans[3] His manual skill led him to enter the service of Cadi Ibn Sāʿ id of Toledo[4] as a maker of the delicate instruments needed to continue the astronomical observations begun about 1060–possibly to emulate those carried out by Yahya ibn Abi Mansur–perhaps by order of al–Maʿ mun of Toledo. Al–Zarqali's intelligence encouraged his clients to supply him with the books he needed to educate himself; and around 1062 he became director. He constructed the water clocks of Toledo, which al–Zuhri[5] has described; and they must have aroused great admiration, for Moses benʿ Ezra (d. ca. 1135) dedicated a poem to them that begins; "Marble, work of Zarquiel. "The clocks were in use until 1133, when Hamis ibn Zabara, having been given permission by Alfonso VII to try to discover how they worked, took them apart and could not reassemble them. They constituted a very precise lunar calendar and were, to some extent, the predeces sors of the clocks or planetary calendar devices that became fashionable in seventeenth–century Europe.

Al–Zarqāli lived in Toledo until the insecurity of the city, repeatedly attacked by Alfonso VI, obliged him to move to Córdoba sometime after 1078. There he determined the longitude of Calbalazada (Regulus) in 1080 and the culmination of the planets a year later; in 1087 he carried out his last observations. This fact has led some writers to establish 1087 as the year of his death. Very little is known about his students, who included Muhammad ibn Ibrahim ibn Yahya al–Sayyid (d. 1144). Considerably more is known about his indirect influence on such later authors as Ibn al–Kammad, al–Bitruji, Abuʿ l–Hasan ʿAli, Ibn al–Banna, and Abraham Ibn' Ezra.

We shall consider seven works definitely known to be by al–Zarqali.[6] The first is the Toledan Tables. The original Arabic version has been lost, but two Latin versions have survived; one by Gerard of Cremona and one by an unknown author, perhaps John of Seville, who presents a shorter text than Gerard's. It deals only with a collective work directed by Cadi Ibn Sā' id, in which al–Zarqali participated and of which he wrote the definitive account. The Latin version, analyzed by Delambre in the nineteenth century and by Millas–Vallicrosa more recently, deals with a combination of processes and methods.[7] It follows the table of al–Khwarizmi in the determination of the right ascensions, and the equations of the sun and moon and of the planets; al–Battani's table in the oblique ascension, ascendant, parallaxm eclipses, and the setting of planets; Hermes' table in the equation of houses; and Thābit ibn Qura's table in the theory of trepidation or accession and recession. Such Indian processes as the *Kardaga* are used side by side with the sine, cosine, tangent, and cotangent. The table of stellar positions is apparently based on an older one corrected in precession[8] The Toledan Tables were extraordinarily successful in the Latin world; the Marseilles Tables (ca. 1140) were based on them, and by the twelfth century they were used throughout Europe, ultimately displaced only by the Alfonsine Tables. They also influenced the Islamic West, in the works of Ibn al–Kammād, for example.

Almanac of Ammonius[9] was elaborated by al–Zarqali in 1089, using material that predated 800, as M. Boutelle[10] has demonstrated. Millas–Vallicrosa identified the Aumenius Humeniz in various texts with Ammonius, son of Hermias, a disciple of Proclus, who restored the Platonic school of Alexandria in the late fifth and early sixth centuries. Study of the tabular values, unique in the medieval Arabic literature, shows that the *Almanac* deals with the combination of planetary values and Ptolemaic parameters with the Babylonian doctrine of the limit years, calculated according to the linear system A by Nabu–Rimannu, as van der Waerden[11] has demonstrated. Drawing on the works of Hipparchus and Ptolemy,[12] al–Zarqali's *Almanac* was known in Europe as part of al–Bitrūjī 's *corpus* until the fifteenth century.

The trigonometrical portion of the *Almanac* presents the same minglings of sources and contains tables of sines, cosines, versed sines, secants, and tangents. The work was translated into Latin (John of Pavia, 1154; William of Saint Cloud, 1296), Hebrew (Jacob ibn Tibbon, 1301), Portuguese, Catalan, and Castilian. Regiomontanus may be considered one of the last to express al–Zarqali's views.

Sumo reference al movimiento del sol has been lost.[13] Its subject is known, since the identically entitled work of Thābit ibn Qurra, written about two centuries earlier, is extant, and al–Zārqalī refers to the latter work in his *Tratado… de las estrellas fijas.* It is based on twenty–five years of observations in which he discovered the proper motion of the solar apogee, which he set as 1 every 299 common years (12.04″ annually) counted in the same direction as the zodiacal signs. This discovery is shown in the Marseilles Tables (ca. 1140), and Abu' l" Hasan 'Ali (fl. 1260) attempted to explain it by means of an epicycle, which he sought to provide.[14]

Tratado relativo al movimiento de las estrellas fijas is preserved in the Hebrew translation by Samuel ben Yehuda (called Miles of Marseilles)[15] Known by Ibn Rushd,[16] the *Tratado* sought to demonstrate mathematically the trepidation theory according to which the movement of the sphere of the fixed stars is determined by the movement of a straight line that joins the center of the earth with a movable point on a base circle or epicycle. Comparing his observations with those of earlier authors, al–ZarqālĪ explained the trepidation theory according to three models that situate the epicycle (1) in a meridian plane, (2) in the plane of the ecliptic, and (3) with two equal epicycles centered in the mean equinoctial points normal to the equator. He always took the beginning of Aries as a movable point on the epicycle and referred its motion to the vernal equinox. He thus justified the accession and retrocession of the fixed stars, studied and calculated their longitudinal movement, and determined the dimensions of the epicycle (radius) and period of trepidation in the three models. Having critically studied the results to which the three models led him, al–ZarqāĪconcluded that the third conforms most to the observational data and, relying on it, he constructed tables of mean movement at the beginning of Aries in Christian, Arab, and Persian years. In the same work he studied the variation in the obliquity of the ecliptic by the action of two small circles, one concentric to an equator of 23˚ 43' diameter and the other with its center in a point of the first, 10' in diameter.

Tratado de la azafea[17] concerns the *azafea* Al–Zarqāli constructed one superior to the universal sheet of˓ Ali ibn Khalaf.[18] The latter, which exerted only limited influence in the Muslim world–and none in the Latin world–contained the stereographic projection of the sphere on a plane normal to the ecliptic that cuts it along the solstitial line Cancer–Capricorn. In his *Tratado de la azafea (al–safiha)* al–Zarqāli presented the stereographic projections of the equatorial circle and of the circle of the ecliptic at the same time.

The construction of the apparatus and the formulation of the corresponding rules occurred in several stages. Before 1078 a draft of the *Tratado* was dedicated to al–Ma˓ mūm of Toledo *(azafea ma˓ muniyya);* it was not transmitted to Alfonso X. The *azafea ˓abbādiyya* (dedicated to al–Mu tamid ibn ˓Abbād) subsequently appeared in two versions; the major one, comprising 100 chapters, was translated into Castilian at the court of Alfonso X[19] and exerted little influence in the Latin world; the minor one, of sixty–one chapters, was transmitted through Jacob ibn Tibbon, Moshe Galino, and William the Englishman to influence Gemma Frisius, Juan de Rojas (fl. 1550), and Philippe de La Hire[20].

The back of the copy of this instrument, at the Febra Observatory of Barcelona,[21] presents the orthographical projection of the sphere and, in the fourth quadrant, a representation of sines that Millas–Vallicrosa called the quadrant *retustisimto* ("very ancient"), which is believed to date from the mid–tenth century in the Iberian Peninsula[22].

Arabic treatises on the *azafea* frequently contain a description of the *azafea shakāziyya,* which is not now known. It was the forerunner, however, of the *shakazi*[23] quadrant invented by Ibn Tibūgā (1358-1447), who used the same projection system on its face as in al–ZarqālĪ's *azafea,* the only difference being the omission of the ecliptic projection and the major circles of longitude and the minor circles of latitude. Also, there was an alteration of the quadrant of the umbra, which was at the back of the *azafea* and was determined by an arc of extensive or convex umbras parallel to the arc of altitude. There was an ordinary zodiacal calendar on the back, another of right ascension, and the projection of the fixed stars that made it possible to determine, by means of the alidade, the equatorial coordinates of any fixed star through simple reading. The projection system used seems to be the polar stereographic one of the ordinary astrolabe.

Tratado de la lamina de los siete planetas, dedicated to al–Mu tamid, was written in 1081 and surpasses the book on the sheets of the seven planets by Ibn al–Samh (d. 1035)[24] ; it is a predecessor of the *Aequatorium planetarium* of the Renaissance. The importance of the Arabic text lies in its clarification of one of the most debated passages in medieval astronomy, for in the graphic representation included in the Castilian translation ordered by Alfonso X (The Wise) the orbit of Mercury is not circular[25]. On this basis it has been alleged that al–Zarqāl̄i anticipated Kepler in stating that orbits–the orbit of Mercury in this case–are elliptical. Although the Arabic text merely states that an orbit is *baydi* ("oval"), it shows that al–ZarqālĪ treated Mercury in the same deductive way that Kepler dealt with Mars in his *Astronomis nova* Before establishing his first law, Kepler considered the possibility of elliptical orbits; it is not known whether he knew al–ZrāqlĪ's text[26].

Influencias y figuras de los planetas is an astrological treatise of no particular importance.

NOTES

1. Ibn al–Abbar, *Takmila,* Bel–Ben Cheneb, ed. (Algiers, 1920), no, 358, p. 169

2.*Tarikh al–hukamā,* J. Lippert, ed. (Leipzig, 1903), 57.

3. Ishaq Israeli, *Yesod olam* (Berlin, 1848), IV, 7.

4.*Tabaqat al–umām,* Luis Cheikho, ed, (Beirut, 1912), 74; French trans, by Régis Blachere (Paris, 1935), 138-139.

5. castilian trans, by J. M. Millás–Vallicrosa, *Estudios sobre Azarquiel* (Madrid–Granada, 1943-1950), 6-9.

6. The order of the works is that of Millas–Vallicrosa, op. cit. the fundamental work on the subject.

7. E. S. Kennedy, "A Survey of Islamic Astronomical Tables," in *Transactions of the American Philosophical Society,* n.s. **46** no, **2** (1956), no. 24.

8. Analysis in Millas–Vallicrosa, op, cit., 22-71.

9. Edition of the Arabic canons, Castilian trans., and corresponding tables, ibid., 72-237.

10. M. Boutelle, "The Almance of Azarquiel," in *Centaurus.***12** no, **1** (1967), 12-19.

11. "The Date of Invention of Babylonian Planetary Theory," in Archive for History of Exact Sciences, 5, no. I (1968),70-78.

12. Almagest, IX, 3.

13. See Millás-Vallicrosa, op. cit., 239-247.

14. This discovery must have been made by al-ZārgalĪ. See Willy Hartner, "Al-Battani," in DSB, 1,507-516.

15. Edition and Castilian trans. by Millás-Vallicrosa, op. cit. , 239-343.

16. See the Castilian trans. by Carlos Quirós Rodriguez, Compertdio de metcal'isica de Averroes(Madrid, 1919) : Kitab ma had al-tabiʿa (Hyderabad, 1945), 135-136 ; and esp. O. Neugebauer, "Thâbit ben Qurra, 'On the Solar Year' and 'On the Motion of the Eighth Sphere,'" in Proceedings of the American Philosophical Society, 106, no. **3** (1962), 264-299: B. R. Goldstein, "On the Theory of Trepidation," in Centaurus, **10** (1964), 232-247; and. I. D. North, "Medieval Star Catalogues and the Movement of the Eighth Sphere." in Archives internationales d'histoire des sciences, **20** (1967), 71-83.

17. See Millás-Vallicrosa, op. cit., 425-455.

18. The instructions for the construction and use of this instrument appear in Los libros del saber de astronomia, M. Ricoy Sinobas, ed., I I I (Madrid, 1864), 1-132.

19. lbid., 135-237.

20. Jacob ibn Tibbon, Tractat de l'assafea d'Azarquiel, ed. of the Hebrew and Latin texts and Catalan trans. by J. M. Millas-Vallicrosa (Barcelona, 1933) : E. Poulle, "Un instrument astronomique duns ('Occident latin: La 'saphea,' in A. Giuseppe Ernrini (Spoleto, 1970), 491-510: and F. Maddison, "Hugo Helt and the Rojas Astrolabe Projection," in Revista da Faculdade de ci~ncias, Uriversidade de Coimbra, **39** (1966) .

21. J. M. Millas-Vallicrosa, "Un ejemplar de azafea árabe de Azarquiel," in al-Amlalus, 9, no. I (1944), 111-119.

22. See J. Vernet, "La ciencia en el islam y occidente," in Xll Settitnane di studio clef certro italiano di studi sulfa/to nedioevo, 11 (Spoleto, 1965), 555-556.

23. See Julio Samso Moya, "Un instrumento astronómico de raigambre zargali: El cuadrante šakāzĪ de Ibn TĪbugā, in Memorias de la Real Academia de buenos letras de Barcelona, 13 (1971-1975), 5-31.

24. See Millás-Vallicrosa, op. cit., 111, 241-271.

25. lbid., 272-284.

26. See Willy Hartner, Oriens, Occidens (Hildesheim, 1968), 474-478. 486.

J. Vernet