



# ḤĀMED BAL-KEẒR AL-ḶOJANDI

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**ḤĀMED BAL-KEẒR AL-ḶOJANDI**, ABU MAḤMUD, mathematician and astronomer of the late 4th/10th century who, according to Heinrich Suter (p. 74, no. 173), died in around 1000 C.E. His *nesba* suggests that he originated from Ḷojand (Qojand) in Fergāna, on the Jaxartes (Syr Darya) river in present-day Tajikistan. He is the author of the *Ketāb fi ‘amal al-āla al-‘amma*, also called *Ketāb al-āla al-šāmela*, in which he presents a description of a “universal” or “comprehensive” observational instrument; however, it could only be used at one latitude. This instrument was improved upon by Hebat-Allāh b. al-Ḷo-sayn al-Baḡdādi (al-QeḶṯi, p. 339), who died in 534 /1139-40; indeed, one of the two extant manuscripts of the *Ketāb al-āla al-šāmela* was copied by Hebat-Allāh himself, who added an appendix (Sezgin, VI, p. 221).

Another of Ḷojandi’s works on instruments was his *Ketāb samt al-qebla*, which is referred to by Abu Rayḡān Biruni in his *Maqāla fi taṣṯiḡ al-šowar wa-tabṯiḡ al-kowar* (p. 91 Arabic; p. 51 English), and is probably the source upon which his teacher, Abu Naṣr Maṣur b. ‘Ali b. ‘Erāq, drew in his *Resālat dawā’er al-somut fi al-aṣṯorlāb* (pp. 3-9; Samsó, 1969, pp. 89-93, Spanish tr.). It is also probably the work referred to by Biruni in his *Ketāb esti‘āb al-wojuh al-momkena fi ṣan‘at al-aṣṯorlāb* (Wiedemann, 1970, II, p. 503).

In the last decade of the tenth century Ḷojandi was in Ray enjoying the patronage of the Buyid ruler, Faḡr-al-Dowla (r. 977-97). When Biruni visited



him there, after his flight from K̄vārazm, Ķojandi showed him his book “on nocturnal labors concerning the fixed stars” in which he set out his proof of sine theorem for solving spherical triangles, which he called the *qānun al-hay’a*, claiming to have discovered it himself (Biruni, 1985, pp. 100-103). This book was probably his *Ketāb fi’l-sā’āt al-māḍia men al-layl*, which is cited in the anonymous *Jāme’ qawānin ‘elm al-hay’a* (Sezgin, VI, p. 222). Ķojandi’s proof is provided *in extenso* by Biruni (1985, pp. 138-41), whose account of the several proofs of this theorem is in turn the source of a passage in Naṣir-al-Din Ṭusi’s *Ketāb šakl al-qattā’* (pp. 108-19, Arabic; pp. 139-54, French; al-Ķojandi’s proof is on p. 117, Arabic; pp. 151-52, French). There is a passage in the anonymous *Masā’el motafarreqa handasiya*, attributing a slightly different proof to Ķojandi (see Schoy, pp. 260-63). However, Debarnot (Biruni, 1985, p. 138, n. 1) has pointed out that this proof is derived from that of Guṣyār ebn Labbān, which is also described by Biruni in his *Ketāb maqālid* (pp. 142-45). Ķojandi is also cited by Moḥammad b. al-Ḥasan al-Ḥobubi for his work in spherical trigonometry (Sezgin, VII, pp. 414-15).

At the command of Faḵr-al-Dawla, Ķojandi built a massive sextant with a diameter of 80 cubits on the hill called Ṭabrūk north of Ray (Biruni, 1964, pp. 101-2; English tr., 1967, pp. 70-71); every degree of the sextant was divided into 360 equal parts, so that each interval was 10 seconds of arc. He described this instrument, which he called *al-suds al-faḵri*, and some of the observations he made with it, in a work entitled *Resāla fi taṣḥiḥ al-mayl wa-’arḍ al-balad* (ed. Cheikho; tr. Schirmer (into German); see also Wiedemann, 1984, I, pp. 406-8; II, 1180-81; Sayılı, pp. 118-21). Birūni quotes extensively from Ķojandi’s *Resāla* in his *Ketāb taḥdid al-amāken* (pp. 102-7; English tr., 1967, pp. 71-75), describing how he determined the noon solar altitudes before and after a summer solstice, on 5 and 6 Jumādā I in 384 A.H./16 and 17 June 994 (see also Biruni, 1954-56, II, p. 643), and before and after the following winter solstice, on 9 and 12 Dū’l-qa’da 384 /14 and 17 December 994. He determined the obliquity of the ecliptic to be  $23;32,21^\circ$  (see Biruni, 1954-56, I, p. 364). In comparing this result with other determinations of it, Ķojandi concluded that the obliquity was decreasing. Biruni, who did not believe in this diminution, explained Ķojandi’s result by recounting that he had been directly informed by him that the aperture above the arch of this huge instrument had slipped down by about a span, causing an error in his observation (Biruni, 1964, pp. 107-9; English tr., 1967, 75-77; 1954-56, I, 364). Ķojandi also calculated from the sun’s altitude at the summer solstice that the latitude of Rayy is  $35;34,39^\circ$  (Biruni, 1964, pp. 86-87; English tr., 1967, p. 56; he rounded this off to  $34;35^\circ$  in his *Qānun*, II, p.



612).

Toward the end of his *Resāla fi taṣḥīḥ* Ƙojandi says that he is making observations of the planets in preparation for composing an astronomical table (*zij*). Evidently he never completed this project, but there is in Tehran a manuscript of an anonymous Persian *zij* which may be based on parameters originally determined by Ƙojandi, though this matter has yet to be investigated; the epoch of this *zij* is 600/1231, at least 200 years after Ƙojandi's death (Kennedy, "Survey," p. 133, no. 60).

Finally, it should be mentioned that in a letter to Ƙojandi's contemporary, Abu Moḥammad 'Abd-Allāh b. 'Ali (Woepcke, pp. 301-24 and 345-56), Abu Ja'far Moḥammad b. al-Ḥosayn states that he has shown the falsehood of Ƙojandi's attempt to demonstrate that the sum of two cubes cannot be a cube (Woepcke, p. 301). This was the first of several attempts by Muslim mathematicians to demonstrate its impossibility (Rashed, pp. 82-83).

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