TRACES OF A TENTH-CENTURY SPANISH-ARABIC ASTROLABE*

PAUL KUNITZSCH**

The astrolabe was handed down to the Arabs from late Antiquity. The earliest stages of its invention and development cannot yet be safely established. The oldest extant texts describing the planispheric astrolabe as we know it are by Philoponus (6th century, Alexandria), in Greek, and by Severus Sebokht (around AD 660, northern Syria), in Syriac[1]. Arabic texts on the astrolabe exist in greater number, from the ninth century on.

There has survived one Greek astrolabe, but it dates from a relatively late period, AD 1062[2].

The oldest extant dated Eastern Arabic astrolabe was made by Nasṭūlus and is dated 315 H = AD 927-28[3].

The oldest known surviving astrolabes from the Islamic West are by Muḥammad ibn al-Ṣaffār, one incomplete, made in Cordoba and dated

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** Davidstraße 17, D-81927 München, Fed. Rep. of Germany.

[1] For a short survey of the instrument's early history and the research literature cf. P. Kunitzsch, *Glossar der arabischen Fachausdrücke in der mittelalterlichen europäischen Astrolabliteratur*, Göttingen 1983, 461f.

[2] Now in the Museo dell' Età Cristiana, Brescia. Cf. O.M. Dalton, The Byzantine Astrolabe at Brescia, *Proceedings of the British Academy* 12 (1926), 133-146.

[3] Now in the Dar al-Athar al-Islamiyyah, Kuwait. See D.A. King, Early Islamic Astronomical Instruments in Kuwaiti Collections, in A. Fullerton and G. Fehérvári (eds.), *Kuwait, Arts and Architecture, A Collection of Essays*, Kuwait 1995, 76-83.

417 H = AD 1026-27[4], the other one complete, made in Toledo and dated 420 H = AD 1029[5].

The knowledge and practice of the astrolabe were then taken over from the Arabs by European scholars in the late tenth century in Catalonia, north-eastern Spain, and – more intensively – in the course of the great translation movement from Arabic into Latin in Spain in the twelfth century.

The oldest Latin texts on the astrolabe from the late tenth century show that those Christian scholars had at their disposal both Arabic texts and instruments and, as it seems, also the help of native speakers of Arabic. Portions of the *Sententie astrolabii*[6], one of those oldest texts, have been identified as being translated from a treatise on the use of the astrolabe by al-Khwārizmī (9th century, Baghdad)[7] and from the Arabic version of Ptolemy's *Planisphaerium*, the well-known text on the projection of the sphere onto a plane, which was generally understood – and mostly in the West – as the basic text for the construction of the planispheric astrolabe[8].

One of the manuscripts carrying scattered portions of the *Sententie astrolabii* and other related texts is MS Paris, BN lat. 7412. Fol. 1r-23v of the manuscript date from the middle of the 11th century and were written by two French hands, probably in Reims[9]. The last nine

[4] Now in the Royal Scottish Museum, Edinburgh. For these two instruments cf. the forthcoming catalogue of Islamic astrolabes by D.A. King (cf. his preliminary report in *Bulletin of the Scientific Instrument Society*, No. 31 (1991), 3-7).

[5] Kept in the Staatsbibliothek, Preussischer Kulturbesitz, Berlin. Cf. F. Woepcke, *Über ein ... arabisches Astrolabium*, Berlin 1858; repr. In F. Sezgin (ed.), *Arabische Instrumente in orientalistischen Studien*, vol. ii (Frankfurt/Main, 1991), 1-36.

[6] The *Sententie astrolabii* and several other related texts were edited by J.M. Millás Vallicrosa, *Assaig d'història de les idees físiques i matemàtiques a la Catalunya medieval*, Barcelona 1931.

[7] See P. Kunitzsch, Al-Khwārizmī as a Source for the Sententie astrolabii, *From Deferent to Equant: A Volume of Studies... in Honor of E.S. Kennedy*, New York 1987 (Annals of the New York Academy of Sciences, vol. 500), 227-236.

[8] See P. Kunitzsch, Fragments of Ptolemy's *Planisphaerium* in an Early Latin Translation, *Centaurus* 36 (1993), 97-101.

[9] I owe these indications to a detailed description of the manuscript kindly supplied to me by Prof. A. Borst, Konstanz, who is currently preparing a critical edition of Hermann the Lame's (d. 1054) scientific writings. A collation

pages of this section in the manuscript contain drawings of a complete astrolabe – the rete, three plates (with front and back) and the *mater* (with front and back). Most of the inscriptions of this astrolabe were copied by the Latin draftsman; but these inscriptions are *in Arabic*. He even copied (on the back of the mater) the maker's name, Khalaf ibn al-Muʿādh. No date is mentioned on the instrument, but from the general situation – date of the manuscript, state of transmission of the texts in it, the contents of the astrolabe itself – it can be concluded that the Arabic astrolabe here copied was older than the two oldest extant Andalusian astrolabes by Muḥammad ibn al-Ṣaffār and that it dates perhaps from a time around AD 1000 or earlier. For us, it is therefore the oldest specimen of a Spanish-Arabic astrolabe. It can be seen that the style of writing on the original instrument is the well-known Andalusian kufi found also on the surviving Spanish-Arabic astrolabes. Of course, the Latin draftsman who did not know Arabic himself and who simply copied the model as good as he could, committed many errors in the composition of the Arabic words. But what there is, fully suffices to recognize the contents of the inscriptions on Khalaf ibn al-Muʿādh's astrolabe. The maker's name, Khalaf ibn al-Muʿādh, is not mentioned by Ṣāʿid al-Andalusī in the lists of Spanish-Arabic astronomers in his *Ṭabaqāt al-umam* (AD 1068). But the elements of which the name is composed are well attested elsewhere in al-Andalus and therefore appear to be genuine.

The series of drawings begins on fol. 19v with the drawing of the rete. The rete has pointers for 27 stars. The Arabic names of the stars are added in more or less corrupted Latin transliteration. To each name is added a letter or another symbol, and at the bottom of the page variant spellings of each name are given according to these letters and symbols[10]. The same 27 stars were also assembled in a star table, with coordinates, in the text *De mensura astrolabii* (Inc. *Philosophi quorum sagaci studio...*) which belongs to the milieu of the *Sententie astrolabii*[11]. The signs of the zodiac are divided in steps of 6 degrees (cf.

of the contents of MS 7412 was also given by M. Destombes, *Archives Internationales d'Histoire des Sciences* 15 (1962), 41-43, and by E. Poulle (footnote 15), 900 (note 3).

[10] The names in both forms were edited by P. Kunitzsch, *Arabische Sternnamen in Europa*, Wiesbaden 1959, 90f.

[11] See the edition in Millás (footnote 6), 301f. It is the star table of "Type III" in P. Kunitzsch, *Typen von Sternverzeichnissen in astronomischen Handschriften des zehnten bis vierzehnten Jahrhunderts*, Wiesbaden 1966, 23ff.

also the almucantars), and to each sign is added its name in Arabic and in Latin.

Fol. 20r shows the plate for the 7th climate [Fig. 1]. In this astrolabe the plates were made for the latitudes of the seven climates and not for specific localities, which may be regarded as another sign pointing to the antiquity of the instrument. It shows the circles of Cancer, Aries-Libra and Capricorn, the almucantars (in steps of 6 degrees – the astrolabe therefore was of the *sudsī* type; cf. also the zodiac on the rete) and the curves of the seasonal hours. Inscribed, in Arabic, are the numbers of degrees of the almucantars (from 6° to 90°, in *abjad* notation), the names of East (*al-mashriq*) and West (*al-maghrib*), the name of the lower vertical line (*khaṭṭ al-zawāl*) and the numbers – in words – of the twelve (seasonal) hours, *al-ūlā* (the first) to *al-thāniya ʿashara* (sic; the twelfth). Below the center is written *al-iqlīm al-sābiʿ ʿarḍuhu mḥ lb, nahāruhu al-aṭwal yw sāʿa* ("the seventh climate, its latitude is 48°32', its longest day is 16 hours").

Fol. 20v shows the plate for the 6th climate. The circles, curves and lines are drawn as on fol. 20r, but most of the text is not repeated here. Below the center is written *al-iqlīm al-sādis ʿarḍuhu mh ', nahāruhu al-aṭwal yh l* ("the sixth climate, its latitude is 45° 1', its longest day is 15,30 [hours]").

The plate for the 5th climate follows on fol. 21r. It is drawn as the two preceding plates, but with very few Arabic notations. Below the center we find *al-iqlīm al-khāmis ʿarḍuhu m yw, nahāruhu al-aṭwal yh* ("the fifth climate, its latitude is 40°16', its longest day is 15 [hours]").

Fol. 21v shows the plate for the 4th climate. The inscription reads *al-iqlīm al-rābiʿ ʿarḍuhu lw w, nahāruhu al-aṭwal yd l* ("the fourth climate, its latitude is 36°6', its longest day is 14,30 [hours]").

Next follows the plate for the 3rd climate, on fol. 22r. The inscription runs *al-iqlīm al-thālith ʿarḍuhu l kb, nahāruhu al-aṭwal* ... ("the third climate, its latitude is 30°22', its longest day is ...[12]").

Fol. 22v shows the plate for the 2nd climate. Below the center it has *al-iqlīm al-thānī ʿarḍuhu kj yw, sāʿāt nahārihi al-aṭwal yj l* ("the second climate, its latitude is 23°16', the hours of its longest day are 13,30").

The earliest form of this star table seems to appear in MS 7412, fol. 5v; cf. the remarks in Kunitzsch (footnote 1), 482f. (note 15[b]), on an inadequate edition by W. Bergmann.

[12] The number (14 hours) is not visible on the photocopy.

On fol. 23r there is the drawing of the mater with the limb (divided, anticlockwise, into 360°, marked in maghrebi *abjad* notation in steps of 5 degreees, from 5° to 360°). The interior of the mater carries the circles, curves and lines for the 1st climate. Below the center is written *al-iqlīm al-awwal ʿarḍuhu yw kz, nahāruhu al-aṭwal yj sāʿa* ("the first climate, its latitude is 16°27', its longest day is 13 hours").

In the drawing of each plate the number of the climate is also added in Roman numerals: VII, VI, V, IIII, III and I (II is not visible on the photocopy).

The values given here for the latitudes (of the middle of each) of the seven climates are found identically in a text from the milieu of the *Sententie astrolabii*. In this text the legends for each climate appear twice, in an upper line in Arabic (in Latin transliteration) and in the line below in Latin[13]. These values are basically identical with those given by Ptolemy in *Almagest* ii,13 (with three minor differences: in V Ptolemy has 40°56', in IV 36° and in II 23°51').

Finally, on fol. 23v we have the drawing of the back of the mater. In the outer rim it has the graduation of the four quadrants, with *abjad* notation (in the maghrebi style) in steps of 5 degrees, from 5° (at the horizontal line) to 90° (on top and at the bottom). Next follows the zodiac, with *abjad* notation for each sign, again in steps of 5 degrees, from 5° to 30° (written out only in Taurus and Gemini and left blanc in the other signs). The names of the signs are written down both in Arabic and Latin. The innermost system shows the calendar with the Julian month names both in Arabic and Latin (the Latin names are mostly abbreviated; the Arabic names are *ynyr*, *fbryr*, *mrs*, *'bryl*, *m'yh*, *ywnyh*, *ywlyh*, *'ghst*, *stnbr*, *'ktwbr*, *nwnbr*, *djnbr* – almost fully dotted). The innermost ring indicates the months' days, adding *abjad* notation for each 5 days in a month. In the lower right quadrant there is a shadow square graduated from 1 to 12 in *abjad* notation along the horizontal and the vertical scales. Diagonally inside the shadow square, towards the center, runs the maker's signature, truly copied by our Latin draftsman: *ʿamal Khalaf ibn al-Muʿādh*, "The work of

[13] See the edition of the text in Millás (footnote 6), 290-292. It appears also in our MS 7412, fols. 8v (defective) and 10r (complete), In a derived text (*De utilitatibus astrolabii*, Inc. *Quicumque astronomice discere peritiam discipline* ...; usually ascribed to Gerbert or one of his disciples) the numbers of the latitude values were often corrupted; cf. the edition by N. Bubnov, *Gerberti postea Silvestri II papae Opera Mathematica*, Berlin 1899, 141f.; see also E. Honigmann, *Die sieben Klimata* ..., Heidelberg 1929, 189-191.

Khalaf ibn al-Mu'ādh" [Fig. 2]. The throne is indicated at the bottom (the entire plate is drawn upside down on the page).

The drawings in MS 7412 had not remained unnoticed. In 1931, foll. 19v and 23v were reproduced by A. van de Vyver[14]. E. Poulle reproduced foll. 19v, 20r, 23r and 23v in 1964 and added a short comment[15]. In 1980 W. Bergmann called the drawings on foll. 20r-23v "Zeichnungen zur Astrolabkonstruktion" (drawings for constructing an astrolabe)[16]. But none of these authors realized the historical importance of the drawings as the oldest available representation of a Spanish-Arabic astrolabe nor did any of them recognize the maker's name on fol. 23v.

There are known several other Latin manuscripts of the same period containing drawings of astrolabe plates with poor imitations of *abjad* notation in Arabic and in Latin transliteration. But MS 7412 is unique in presenting the full set of plates of a complete Arabic astrolabe including the inscriptions in a nicely readable kufi script.

[14] A, van de Vyver, Les premières traductions latines (X^{e}-XI^{e} s.) de traités arabes sur l'astrolabe, *1er Congrès International de Géographie Historique*, t. ii: *Mémoires*, Bruxelles 1931, 266-290; see Pl. I and III.

[15] E. Poulle, Le traité de l'astrolabe de Raymond de Marseille, *Studi medievali*, 3^{a} Serie, V,2 (1964), 866-900; see Pl. I-IV. For the comment, see p. 900. Poulle rounded off the latitudes on the plates to full degrees.

[16] W. Bergmann, Der Traktat "De mensura astrolabii" des Hermann von Reichenau, *Francia* 8 (1980), 65-103; see p. 85f.

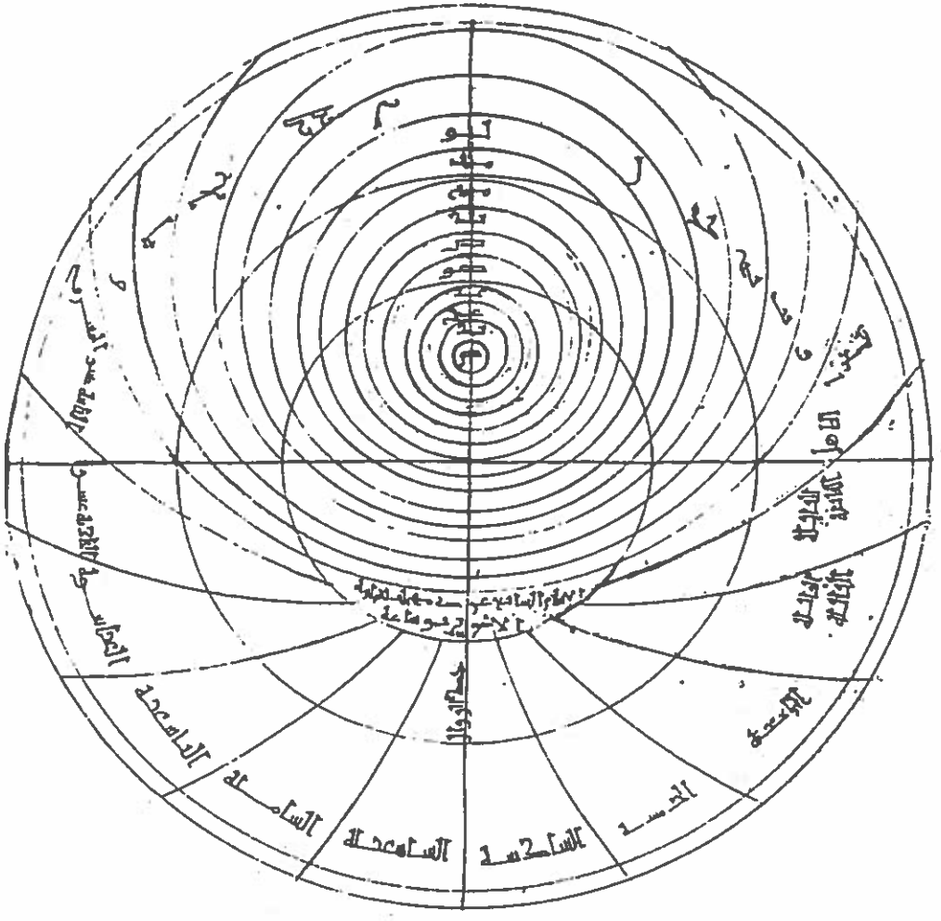

Figure 1: Plate for the seventh climate
MS Paris, BN lat. 7412, 20r

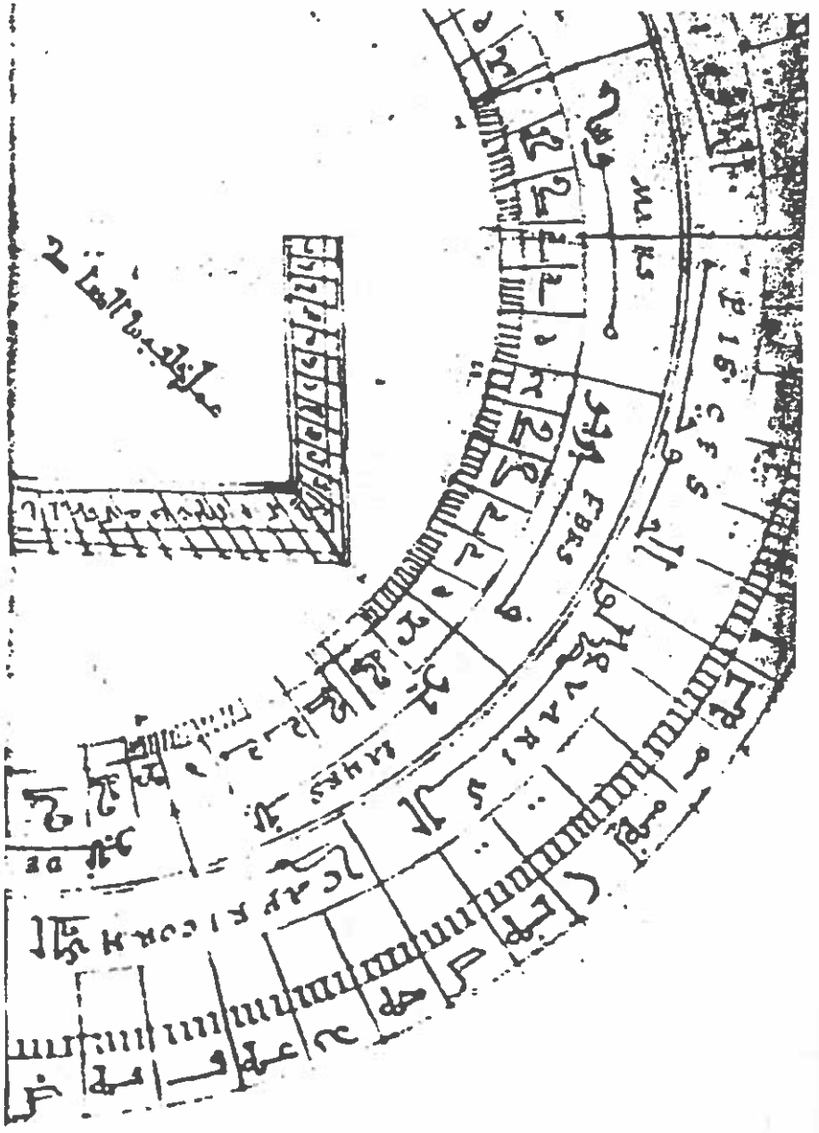

Figure 2: The back of the astrolabe.
The maker's name in the shadow square: *ʿamal Khalaf ibn al-Muʿādh*
MS Paris, BN lat. 7412, 23v