Toledan tables in the "Toledan Tables"

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(1) The core "Toledan tables" comprise a set of tables for planetary mean motions and another set for mean syzygies for the sun and moon, computed for the meridian of Toledo (Toomer 1968 no. 28-36 and no. 52-55; see section (2) below). These generally occur inside larger collections of tables serving various purposes; conventionally, then, any such collection is called "Toledan tables" as a whole. The collections turn out to be of different types; a sketch of the common forms is given below. Most of the tables contained in the collections are obvious translations from Arabic compilations of older authors, mainly from the 8th-9th century, with the latest items dating perhaps from about AD 1100; but the collections are only known in Latin manuscripts, datable to the end of the 12th century or later.

Within these "Toledan" collections, one may find five or six more tables that are computed for Toledo, as can be verified from their values. Their parameters are tolerably uniform, and it is likely that all of them are late Hispano-Arabic work, like the mean motion tables mentioned above. None of them are found throughout the manuscript tradition; on the contrary, their distribution to some extent reflects the behaviour of the tradition as a whole. Thus perhaps the tables that are specific for Toledo are not a unity but have found their way into the tradition more or less independently of each other.

In the present pages, these Toledo-specific tables will be listed and their pertinence discussed. It is a more general question which other tables are late Arabic work, and whether such tables can be ascribed to Azarchel, Sâ'id al-Andalusi or others. This question will not be touched on here; indications may be found, e.g., in Toomer 1968, Richter-Bernburg 1987, Samsó 1992, and in my forthcoming edition of the Toledan Tables. These works may also be consulted for the evidence on points that have been left as postulates here.

The tradition of the Toledan table collections may, I believe, be roughly summarized as follows: There is a mainstream type, which has many features in common with what is known about the Alkhwarizmian version of the

Sindhind, though in all cases this is much mixed up with matter from Albattani.[1] Of the manuscripts in question, some archaic ones of the late 12th or early 13th century (="class {a0}") show few or no Christian innovations.[2] Others contain some Christian features, mainly in the calendrical tables, and are here termed "the **vulgate**". Among these again, one may distinguish between an older, less developed group from the first half of the 13th century ("{a1}"),[3] and several later, innovative groups {a2, e, x, p...}.[4] The vulgate corresponds to the common canons "Quoniam cuiusque" ("Cb").

Another type of collections, here designated {k},[5] are chiefly made up of material from Albattani, and show characteristic differences from the preceding in many respects, even down to tabular values.[6] It appears to be English, and its structure roughly corresponds to the less common type of canons "Scito quod annus" ("Ca"). A third type, {d}, comprises some collections that look rather disorganized, mainly containing Albatenian material too, but including some late Arabic tables that are rare elsewhere; two examples of the latter are among those listed below. Most of these manuscripts are Italian.[7]

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1 This mixture has often been noted, e.g., by Toomer 1968 p. 6. It is reflected in the archaic canons in Oo = Oxford Merton Coll. 259, where the components are still to some degree separate; see Pedersen 1992 for a partial edition of these canons with discussion.

2 The manuscripts are disparate in many respects, and there may in fact be several sub-versions. A distinguished ms. is Ct = Cambr. Trinity Coll., O.8.34, 2r-48v, early 13th c., found by Gingerich (see Gingerich / Welther 1977, p. 157 no. 13). Some of its peculiar items have been treated by North (1995) and by the present writer (1993, 1994). Below I also quote ms. Cq2 = Cambr. Gonv. & Caius 456/394 part II p. 75-118, early 13th c.

3 Typical ms., e.g., Xa = Paris BN lat. 16209, 2r-41r.

4 The largest of these groups ("{x}") is Parisian, from the last quarter of the 13th and the beginning of the 14th century. Typical manuscript, e.g., Xg = Paris BN, nal 3091.

5 They comprise: Cn = Cambr, UL Mm.III.11, 81r-106r, 14th c.; Co = Cambr. UL Kk.I.1, 144v-176v, mid 13th c.; Eg = Erfurt WAb CA Q 363, 1r-32r, late 13th c.; Eh = Erfurt WAb CA Q 364, 32r-123v, 13th-14th c.; Lw = Leiden BRu Scal. 64, 1r-132v, 13th-14th c.; Ou = Oxf. Bodl.L. Savile 22, 12r-81r, mid 13th c.

6 Noted by Toomer 1968 (p. 12, 31, 32, 68, 72, 110) on occasion of ms. Ou (his "Sa").

7 Manuscripts: A = Firenze B. Med.-Laur. Ashb. 211, 196r-271r, 13th c.; Fd2 = Firenze B. Med.-Laur., S.M. 194, early 14th c.; Fj = Firenze BNC cs J.V.6, 15r-95v, 13th c., second half; Gr3 = Groningen BRu 102, 89r-133v, late 13th c.; Nc = New York, Columbia U.L., Smith W.6, 13th-14th c.; Pa = Paris Arsenal 877, 17r-77r, 13th c., second half; Pb = Paris Arsenal 879, 13th c., second half; Pv = Praha SK XIV.A.18, 13th-14th c.; Wj = Wien ÖNb 2385, 1r-41r, 14th c. -- The small collection Mh = Madrid BN 10053, 9r-18v (end of 13th c.) does not show the Toledan mean motion tables, but it contains most of the tables that are otherwise peculiar to group {d}. For one such (JA54) see Goldstein & all. 1994, esp. p.89. -- The following mss. have features in common with group {d}, in various ways: Vd = Vatican BAV Barb. lat. 296, 11r-44v, 14th c.; Lb = London Royal Astron.Soc., Add.1 Vol. 2, 1r-64r, 13th c.; Ok = Oxford BL, Can. misc. 51, 1r-71v, 14th c.; Op = Oxford BL, Digby 68, 25r-78r, mid 14th c.; C = Cambr. Gonville & Caius 141/191, p. 263-382, 14th c., first half.

I shall now list the tables I have found to be specific for Toledo, adding notes of some cognate tables and of some dubious ascriptions. Symbols such as "CA11" are those to be used in my edition. Symbols such as "T28" refer to the numbering in Toomer 1968.

(2) Tables that occur in all complete manuscripts.

As was mentioned, the tables for mean motions and mean syzygies ("CA..." and "GA..." below), being the core of the Toledan Tables, are present by definition.

CA01-81 (T28-36). Tables for finding the mean sidereal longitudes of the sun and moon, the anomaly of the moon, and the sidereal longitudes of the node and the five planets, for the meridian of Toledo. This location is stated in the table headings, and is confirmed from the radices.[8]

GA11-14 (T52-55). Tables for finding mean syzygies of the sun and moon. The values are derived from the mean longitude tables just mentioned.

Cognate:

DA* (Toomer p.45). Apogee longitudes of the sun and the five planets, one value for each. They are normally attached as notes to the mean motion tables, though (typically in group {k}) they are collected in a list (=DB11). The values are specific for the Toledan collections.

PA11 (T81:i): Table for the mean motion of the eighth sphere, for use in the trepidation scheme ascribed to Thabit b. Qurra. Occurs in almost all witnesses for the Toledan tables, occasionally accompanied by the tract "De Motu" attributed to Thabit; the table itself may, however, originate in the Toledan tables. Since the tabulated motion is a slow one, a location is not needed and is

8 As has been shown by Mercier (1996), the mean velocities and the radices can largely be derived from those of Albattani, such that only the solar motion need have been assessed independently. On this basis, the likely distance of Toledo from Albattani's location Aracca turns out to be just about 3 hours, or 45°, corresponding to the traditional longitudes of 28°30′ for Toledo and of 73°15′ or 73°36′ for Aracca. Thus there is no serious doubt that the mean motion tables have in fact been computed for Toledo.

mostly absent; still, some late witnesses, mainly of group {x}, locate the table to Toledo, no doubt in analogy with the CA* and GA* tables above.

Stray location:

JE21 (T61). Table for the size, duration and totality of lunar eclipses. Present generally, though eliminated in the late group {x}. Carries the label "Tabula Toletana", mainly in copies of group {a1}; this is sometimes combined with an ascription to Azarchel, which is found alone in a few further manuscripts. In fact the table is not dependent on location, and ultimately it is from Albattani. The immediate model for the copies found in the Toledan Tables is perhaps Azarchel's Almanac, which may explain the ascription to Azarchel[9] if not the location to Toledo.

(3) Tables that occur in the vulgate.

The two tables below are absent from group {k} but present in group {d}. In each case group {k} has tables from Albattani that may serve as alternatives.

BD11 (T18). Table of oblique ascensions. All the manuscript headings locate this table in Toledo, and a significant part of them state that the geographical latitude is 39°54′ and that the length of daylight is 14h 51m. The ecliptical obliquity inherent in the tabular values is about 23°33′, both for right ascensions and for differences of ascension.

HA11 (T63). Table of lunar parallax in longitude and latitude. Stated to be for Toledo, at latitude 39°54′, length of daylight 14h 51m, with insignificant exceptions. Probably computed by interpolation from the tables HB41 and HB51; see below.

Cognates:

HB41 (T66) and **HB51** (T67). Tables of lunar parallax, stated to be for the fourth and fifth climates, at latitudes 36°24′ and 41°44′. These values look as if corrupted from the Albatenian values (36°22′ and 41°14′). The latitudes that have

9 Seen by Toomer 1968 p. 94.

in fact been used for the computations are more likely to be the Ptolemaic ones (36°0′ and 40°56′), and in any case the probable ecliptical obliquity is about 23°51′ as in Ptolemy. These tables are proper to the older vulgate tradition of the Toledan Tables, though one or the other may be present in other branches. -- The values of HA11 appear to be calculated as the weighted sum (value_in_HB41 + 2*value_in_HB51)/3; in this way, indeed, half-a-dozen errors in either HB41 or HB51 have propagated into the corresponding values in HA11.

Stray location:

BH11 (T84). Table of astrological houses. Largely absent from groups {k} and {d}, but present in all of the vulgate; located to Toledo in almost all the headings, but the latitude is not stated. In fact the table is the same as in the Maslama version of Alkhwarizmi (Suter 1914 Tab. 79-90). This version is anonymous, but the latitude implied by the values is about 38°30′, which is valid for Cordoba,[10] the home of Maslama; so perhaps he is the author.

(4) Tables that occur in lesser groups of manuscripts.

These are absent from the vulgate (except for late copies, which may be stray ones). The first two items are focused in group {d}.

BH12 (T84a). Table of astrological houses. Present in some of group {d} (mss. Pa A Fj, plus Fc; see note above) and in group {p}.[11] Located to Toledo in all headings; the latitude is said to be 39°54′ and the length of daylight to be 14h 51m everywhere except in Fc. In fact the table is composed of several disparate parts, for different latitudes. One of these parts (for Aries until Cancer, and for Aquarius and Pisces) is indeed likely to be for the latitude of Toledo. If so, then the ecliptical obliquity used for right ascensions is about 23°35′, perhaps as in Albattani, and the obliquity for hour-lengths (i.e., for difference of ascension) is about 23°33′-35′, perhaps as in BD11.[12]

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10 Toomer 1968, 142-143.

11 Consists of ms. O = Oxford Bodl.L., Laud. misc. 644 (f. 42r-44v), and ms. Pd = Paris BN lat. 7198 (f. 91r-93v).

12 For these results cf. Toomer 1968, 146; North 1986, 17.

BK11 (not in Toomer). Table of length of daylight for Toledo. Quite well attested, since it occurs in group {a0} (mss. Ct Cq2), {d} (mss. Lb Pa A Fj Mh, plus Fc), {p} (ms.Pd), and three late mss. of group {x}. Located to Toledo in all headings except in Cq2. The headings state the location only. The maximum length of daylight apparent from the tabular values is 14h 51m, as is normal in other tables. The tabular values are compatible with the usual latitude of 39°54′ for Toledo, in which case the obliquity is likely to be 23°33′0". Thus the present table, too, may be compatible with BD11.

LA13a (Toomer 1968 p. 123). Star list with 32 stars, giving values for ecliptical longitudes and latitudes. Only in mss. O Pd of group {p}. In both, the values are said to be "verified in Toledo" and are dated to "anni Alexandri 1422", i.e., AD 1110-11. The location appears irrelevant, but may be justified by noting that the present table is likely to be an extract of table LA13 (see below), where the geographical latitude does come into play.

Cognate:

LA13 (not in Toomer; see Pedersen 1994). Star list with 50 stars, giving values for longitudes, latitudes, declinations, meridian altitude, etc. Only seen in ms. Ct (class {a0}). There is no heading, but the values imply a geographical latitude of 39°54′ and an ecliptical obliquity of 23°33′0"; so this table is certainly for Toledo. Table LA13a (above) shows the same values for ecliptical longitudes and latitudes, though the star names are in a different translation. Thus LA13a was excerpted from a copy that was still in Arabic.

(5) Observations:

The ecliptical obliquity used (where it is not the Albatenian value of 23°35′) may be 23°33′0" (same as the value ascribed to Yahya ibn abi Mansur in canons Cb) rather that 23°33′30" as ascribed to Azarchel in table BA21 (T14). There is no clear evidence that the latter has been used in the early part of our tradition, nor indeed by Azarchel himself in his Almanac.

Group {k} has the tables under (2) above, but does not show the other tables consistently, and is likely to have lacked them originally. This is in keeping with the impression that {k} is a selection from Albattani, with little foreign material

except as concerns the calendrical tables. In most cases it is obvious that the translation is different from both the main tradition and from {d}.

Group {d}, on the other hand, tends to contain late Hispano-Arabic tables that are never or only rarely met with elsewhere. Indeed, in group {k} and in the mainstream tradition, it is likely that the Toledan mean motion tables have been inserted into "matrix" collections that were standard and already extant; on the other hand, group {d} bears the stamp of being a conglomerate of material that happened to be available, including recent material for Toledo and for Cordoba.

The mean motion tables (in section (2) above) are for the meridian of Toledo and do not depend on the geographical latitude; so they can be used everywhere, given some banal rules for translating between meridians. On the other hand, the rest of the tables involve the latitude of Toledo (which is probably meant to be 39°54′ in all cases), so in principle they do not work at other latitudes. One might thus suppose that they were liable to be arbitrarily discarded as useless. This may indeed have happened to LA13, which is only in Ct, and to BK11, to judge from its scattered transmission; but in the rest of the cases, the transmission looks as regular as can be expected.

For similar reasons, it is unlikely that the present tables would have been introduced into a Latin tradition, since they were not needed there; so probably they have all been inherited from Arabic versions. Thus, although {d} may have drawn on a version like the mainstream one, the two tables from section (4) above represent a stage where {d} was still located at Toledo or a compatible place. Group {k}, as was noted above, is independent too. On the whole, then, as is also likely from other considerations,[13] the tradition of the "Toledan" table collections has been heterogeneous since the beginning.

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13 Such as the criticism of readings in the tabular values; see Toomer 1968 (note 6 above, to class {k}). One or two indications of the textual peculiarities of class {d} may be found in Pedersen 1999.

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