

A Latin star-list for Toledo.

Fritz S. Pedersen

A star list found in ms. Cambridge, Trinity Coll., O.8.34, 4v ("Ct") will be briefly examined in the following. The manuscript is written in one or a few southern hands, perhaps Italian, of the 12th or the early 13th century. There is a horoscope diagram on f. 1r, marked "aragonensis", but explicit indications of place or date seem to be absent.

The star-list, printed overleaf, is part of a collection of Toledan tables. It contains 50 stars, with longitudes, latitudes, and several other constants, some of which appear to be computed for Toledo. The latitudes are those of the Almagest, whereas $14^{\circ}55'$ have been added to all the longitudes.

In the transcript I add: the Baily-numbers (for eventual comparison with Kunitzsch 1986, not carried out here); the modern references of the stars; the magnitudes according to the Almagest (tr. Manitius); and where each star is listed in Types (A-C), see below. The last column of the table is hidden in the binding, and I cannot read it on my microfilm. The numbers in question, and others that are incomplete or illegible, are represented by dots. Values corrected against Ct are underscored. In the apparatus, references such as (f25) point to the column marked (f) below the table, for star number 25.

Three other Latin star-lists, sharing some or all their values with Ct, are already known to occur together with the Toledan tables. Below I summarize the findings of Kunitzsch 1966, 1980, and of Toomer 1968, *qq.v.* for further references. I have also had the benefit of Prof. Kunitzsch's opinion on the present list; I quote from it freely, and any over-simplifications are mine. The cognate star-lists are:

(A) Type XII (Kunitzsch 1966; 82 Toomer): 40 stars, with longitudes and latitudes only. This list is common in the older manuscripts of the Toledan tables; Ct contains a copy too (25v). The longitudes are $14^{\circ}7'$ greater than in the Almagest. There exist some close cognates in Arabic, associated with the *Saphea* of Azarchel: one such list, with 37 stars showing the same longitudes as in (A), carries a dating to AH 459, or AD 1066-7 (Kunitzsch 1980, 197). This is here cited as (A0). The date suggests that these tables reflect Azarchel's own work.

(B) Type XIII (82a Toomer): 35 stars, with longitudes, latitudes, declinations, and mediations. This is common in a branch of the Toledan tables of the late 13th century. The longitudes are generally $14^{\circ}55'$ greater than those of the Almagest. A dozen are, however, revised so as to be $15^{\circ}7'$ greater. These may have been taken from (A) and up-dated by the round value of 1° . If this corresponds to the Albatenian precession in common use, it would advance the date of (A) by 66 years, taking it to AH 525. In fact, our list carries a dating to AH "577"; a likely correction is AH 527, or AD 1132-33, as concerns the revised values.

(C) Type XIV: 32 stars, with longitudes and latitudes only. This type appears in two manuscripts of the 1270s. The longitudes are uniformly $14^{\circ}55'$ greater than those of the Almagest. The heading has "... in civitate Toleti, anni (!) Alexandri 1422, secundum Azarchelem". The dating corresponds to AD 1110-11.

To judge from the star-names (Kunitzsch), all the Latin tables, including Ct, are translated from the Arabic independently of each other. Thus, where required, the symbols above will be used for the respective Arabic originals, now mainly lost.

Ct is most closely related to (B) and (C), since all share the same basic set of longitudes and latitudes (except the revisions in (B), which are secondary, as will be seen). I shall try to show that Ct is close to the common ancestor of (B) and (C), or at least closer than are (A A0). This may be made plausible from the arrangement of stars, and from the values.

Inventory and arrangement of stars. All the stars found in the other types of star lists can be

recognized in Ct. An exception might be no. 8 (β Leonis): indeed, (B) shows such an item, but it is last in the list and has the unexpected latitude of $25^{\circ}10'$. However, the declination is the same as in Ct, and the name *adarfa* corresponds to *assarfah*, used for β Leonis in (A0), in (C), and in the A-type table of ms. Ct (f. 25v). I will thus assume that this is in fact meant to be β Leonis in (B) too; for other possibilities see Kunitzsch 1966, 94 n. 35.

(A0) and (A) show a standard series of stars, based on magnitude and longitude (cf. Kunitzsch 1966, 87-88). Ct renders this series as no. 1-38, with a few displacements of its own. It adds no. 39-50, of which at least the Ptolemaic "nebulous" stars (no. 44-48) may have been added simultaneously, since they show an ordering by ascending longitudes. Some identifications are not straightforward: see the apparatus for no. 41, 43, 47.

Both (B) and (C) may now be viewed as selections from Ct. *Type (B)* preserves the order of Ct (apart from no. 8, above), and shares Ct's no. 40, 45, and 46, not found elsewhere. *Type (C)* was selected independently of (B), comprising simply the first 32 stars of Ct in the order found there, including the displacement of β Aur relatively to (A0 A). Thus I will assume that both (B) and (C) are derived from an Arabic table ordered like Ct.

Longitudes and latitudes. I have corrected the longitudes and latitudes of Ct from a comparison with the declinations and altitudes, see below. The values often disagree in detail with those expected from the *Almagest* (tr. Manitius); these cases are noted in the apparatus.

Most values (including the deviations from the *Almagest*) are comparable to (A) when (A)'s longitudes are incremented by $48'$. The incompatible readings in (A) are: (10) $+31^{\circ}30'$ A; (33) Tau $1^{\circ}2'$ A (thus $1^{\circ}50'$ expected in Ct); (48) (Sgr $25^{\circ}58'$, $+0^{\circ}42'$) A; (49) Sgr $16^{\circ}28'$ A. In (10), (A) agrees with the *Almagest*; in (48,49) Ct does, except for an independent error; and in (33), neither does.

Alm: Almagesti libb. 7-8, Manitius 1913. -- Alm: longitudines Alm'i cum augmento 14°55'. -- B: Versio (B), ed. Kunitzsch (ms. Basil. O.II.7, 161v). -- B*: longitudines quaedam versionis B, deductis 12'. -- C: versio (C), ed. Kunitzsch (ms. Par. lat. 7198, 90v). -- X: lectio quae ex ceteris huius tabulae numeris derivari potest.*

(08) cum no. 35 versionis B fortasse correspondet (v. textum), lectiones hic non afferuntur. (14) = δ Peg. (34) = β Tau. (35) = ξ Gem. (41) aut ρ Persei (*Alm*: Ari $27^{\circ}40' \rightarrow$ Tau $12^{\circ}35'$, $+21'$, mag. 4) aut θ Persei (*Alm*: Tau $4^{\circ}10' \rightarrow 19^{\circ}5'$, $+12'$, mag. 3-4). (43) aut ϵ Leonis (*Alm*: Cnc $24^{\circ}10' \rightarrow$ Leo $9^{\circ}5'$, $+9^{\circ}30'$, mag. 3-2) aut λ Leonis (*Alm*: Cnc $21^{\circ}10' \rightarrow$ Leo $6^{\circ}5'$, $+7^{\circ}30'$, mag. 4). (47) G Scorpionis (*Alm*: Sgr $1^{\circ}10' \rightarrow 16^{\circ}5'$, $-13^{\circ}15'$, *nebul.*; δ ἑπόμενος τῷ κέντρῳ νεφελοειδῆς) *potius quam* ν Scorpionis (Sco $27^{\circ} \rightarrow$ Sgr $11^{\circ}55'$, $-13^{\circ}30'$, mag. 4).

(a) nomina ut in Ct inveni exhibeo. @ (b-g): adsunt Ct, Alm, B partim, C partim. @ (b-f 13) Psc 4 21 55 23 C. (c10) 11: Ct, Alm*, B; 21 C. (c12) 17: Ct B* C; 18 Alm*. (c17) 5: Ct C; 8 Alm*. (c41) 9: Ct; 12 Alm* (si pro ρ Sco). (c49) 20: Ct; 21 Alm*. (d04) 55: Ct Alm* C; 57 B. (d07) 25: Ct Alm* C; 45 B*. (d12) 48: Ct B C; 45 Alm*. (d14) 25: Ct B C; 45 Alm*. (d17) 15: Ct C; 55 Alm*. (d26) 40: Ct B C; 35 Alm*. (d29) 48: Ct B C; 45 Alm*. (d30) 25: Ct C; 45 Alm*. (d33) 48: Ct; 45 Alm*. (d36) 25: Ct B; 45 Alm*. (d37) 8: Ct B; 15 Alm*. (e13) 23: Ct B; 20 Alm. (e24) 3: Ct B C; 4 Alm. (e26) 23: Alm B C; 28 Ct. (e29) 26: Alm B C; 25 Ct. (e34) 8: Ct B; 5 Alm. (e36) 36: Alm B; 56 Ct. (e40) 63: X; 64 aut 63 *codd.* *Almagesti*; 68 Ct; 66 B. (e41) 12: Ct; 21 Alm (si pro ρ Sco). (e43) 7: Ct; 9 Alm (si pro ρ Leo). (e45) 13: Alm B; 12 Ct. (f02) 50: Ct B C; 30 Alm. (f03) 50: Ct B C; 30 Alm. (f10) 50: Ct B C; 30 Alm. (f13) 0: Ct B; 20 Alm. (f17) 50: Ct C; 30 Alm. (f18) 40: Ct; 30 Alm; 0 B C. (f19) 15: Alm B C; x < . > Ct. (f20) 50: Ct C; 30 Alm. (f21) 50: Ct C; 30 Alm. (f23) 30: Ct C; 50 Alm. (f35) 50: Ct B; 30 Alm. (f37) 50: Ct B; 30 Alm. (f39) 7: Ct; 20 Alm; 0 B. (f45) 50: Ct B; 30 Alm. (f47) 50: Ct; 15 Alm. (g36) mer B (*codd.*) (g46) mer B (*codd.*). @ (h-k): adsunt Ct, B partim. @ (h36) 13: B X; 18 Ct. (h40) 46: Ct X; 36 B. (j25) 33: B X; 53 Ct. (j40) 34: Ct X; 33 B. (h47) 36: X; 56 Ct. @ (L-o): adest Ct. @ (L17) 53: X; 52 Ct. (L24) 27: X; 26 Ct. (m03) 20: X; 2 Ct. (m25) 33: X; 32 Ct. (m23) 76: Ct; 85° fere X. (n44) 31 Ct, ex voce Arabica quae 'non' significat prave transcriptum, cf. Nallino II p.271. (n50) 31 Ct, cf. (n44). @ (p-q): adsunt Ct, B partim. @ (p13) 334: Ct; 354 B. (p17) 57: Ct; 66 fere X. (p22) 219: Ct; 211 fere X. (p24) 234: Ct; 134 B. (p50) vacat Ct. (q11) 4: Ct; 20 B. (q27) 50: Ct; 51 B. (q28) 41: Ct; 21 B. (q31) 30: Ct; 39 B. (q40) 3: Ct; 4 B. (q50) vacat Ct. @ (r-u): adest Ct. @ (r44) 31 Ct, cf. (n44). (r50) 31 Ct, cf. (n44). (t44) 31 Ct, cf. (n44). (s06) < . > v Ct. (t06, 08, 23-24, 36, 38-39) male leg. Ct. (t50) 31 Ct, cf. (n44). (u1-50) Ct non vidi.

Declinations and meridian altitudes. The declinations presuppose an ecliptical obliquity of about $23^{\circ}33'$. Such a value is at the basis of some of the common Toledan tables (see, e.g., Toomer 1968 p. 36). Perhaps the value of $23^{\circ}33'30''$, ascribed to Azarchel, was intended, but the differences in the results are too slight to be conclusive. I have used the value of $23^{\circ}33'$.

The meridian altitudes are for the latitude of $39^{\circ}54'$, the common value for the latitude of Toledo, usual in the Toledan tables (e.g., Toomer, *ibid.*)

On this basis, most declinations and altitudes can be found from the longitudes and latitudes with an accuracy of a few minutes. When not, textual corrections can mostly be made without assuming computational errors; only at no. 16 and 21 are there still discrepancies of 9 and 14 minutes, not enough to warrant corrections. To find the declinations, our calculator used a full trigonometrical rule throughout, rather than the simplistic one from the canons, i.e., to take the sum of the latitude and the declination corresponding to the longitude.

Thus the declinations are consistent with the longitudes and latitudes as they are found in Ct, including any deviations from other sources. Type (B) shows the same set of declinations, even if some of the corresponding longitudes appear revised and would no longer yield the declinations listed. So, most probably, an ancestor of (B) had values as in Ct, and the date shown by (B) is the date of the revision.

The rest of the values have been less easy for me to reproduce, so I have kept the readings of Ct everywhere, even those which are certainly wrong. In fact, the *half day-arc* can be found from the longitudes and latitudes within a few minutes, except in some 8 cases. Two serious deviations (no. 23 and 29) are noted in the apparatus. The "*mediation*" values, also attested by (B), are difficult to perceive as pertaining to the ecliptic. If in fact they build on the present longitudes and latitudes, they fit better as right ascensions (cf. Toomer p. 128 n.3). Even then, one fourth of them are more than 1° off calculation. I have noted the worst cases. *Co-risings and co-settings* have been left as in Ct, tacitly, and need a revision.

This re-calculation, though imperfect, makes it plausible that most of the non-ecliptical sub-tables in Ct have been calculated on one and the same occasion, and for all the stars in Ct. Indeed, the declination table of Ct seems uniformly well calculated from the longitudes and latitudes, with no exception for the stars peculiar to Ct against the other types. Of the tables specific for Toledo, which are in Ct alone, at least the table of half day-arc is pretty homogeneous, again with no exception for the peculiar stars. So I shall assume that all or most of the sub-tables in Ct were made by one calculator, who was either situated at Toledo or intended to make tables for that latitude.

To sum up: Each of Ct, (B), and (C), are translations of Arabic tables that descend from a model with $14^{\circ}55'$ added to the longitudes, probably for a date of about AD 1110. As for the *inventories of stars*, (B) and (C) share enough peculiarities with Ct to make it plausible that they are extracts of tables like Ct, apart from secondary revisions in the case of (B). Of the *sub-tables*, (C) shows longitudes and latitudes only, and does not allow conclusions as to the further contents of its source. On the other hand, (B) also had access to tables of declination and mediation; and if the exemplar of Ct was made as a whole on one occasion, then (B) saw most or all of the tables now shown by Ct, and chose to eliminate those specific to Toledo. So we may here have a case where a table made for Toledo, now preserved by Ct alone, has been almost lost in the tradition of "Toledan" tables, to emerge again in late witnesses, in a form no longer Toledan.

Baily, F. The catalogues of Ptolemy... *Mem. Roy. Astr. Soc.* 13 (1943), cf. Kunitzsch 1986+, I pp. 22, 181.
Kunitzsch, P. [1966]: *Typen von Sternverzeichnissen in astronomischen Handschriften des zehnten bis vierzehnten Jahrhunderts*, Wiesbaden.

Kunitzsch, P. [1980]: "Two star tables from Muslim Spain", *Journal for the history of astronomy* 11, 192-201
Kunitzsch, P. [1986+]: *Der Sternkatalog des Almagest I-III*, 1986-91.

Toomer, G. J. [1968]: "A survey of the Toledan Tables", *Osiris* 15, 5-174.