Re-editing the tables in the *Ṣābi’ Zīj* by al-Battānī

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Summary

Between 1899 and 1909, Carlo Alfonso Nallino published his monumental study of the *Ṣābi’ Zīj*, an important Arabic astronomical handbook with tables compiled around AD 900 by Abū ‘Abd Allāh Muḥammad ibn Jābir ibn Sinān al-Battānī. Nallino’s work has remained one of the most important publications on Islamic astronomy up to this time. However, his transliterations of al-Battānī’s tables turn out to be frequently unfaithful to the only source that was available to him, the unique complete manuscript of the *Ṣābi’ Zīj* in the Escorial library. In this article we explore the reasons for these deviations and present a critical edition of some of al-Battānī’s tables based on a range of Arabic, Castilian and Latin sources.

1. Introduction

Abū ‘Abd Allāh Muḥammad ibn Jābir ibn Sinān al-Battānī (d. 929) was famous for the accuracy of the astronomical observations that he carried out in Raqqa in present-day Syria between 877 and 918.[1] Besides an astrological history, his most important extant work is an astronomical handbook with tables,[2] often referred to as the *Ṣābi’ Zīj* after the Sabian religion to which his ancestors adhered. Al-Battānī’s *zīj* is the earliest surviving one that is almost purely based on Ptolemaic astronomy, since the *Mumtaḥan Zīj* by Yaḥyā ibn Abī Manṣūr (d. c. 830) and the *Damascene Zīj* by Ḥabash al-Ḥāsib (c. 870) still show much clearer traces of Indian material. The *Ṣābi’ Zīj* was influential in the Islamic East, where its parameters were adopted by various later astronomers such as Kūshyār ibn Labbān (fl. 1025) and Abū Ja‘far Muḥammad al-Ṭabarī (fl. 1100), as well as in the West, where it was translated into Castilian and Latin and many of its tables were widely distributed as part of the *Toledan Tables*.

A full study of the only surviving complete Arabic manuscript of al-Battānī’s *zīj*, kept in the Escorial Library near Madrid, was published by the Italian Arabist Carlo Alfonso Nallino (1872 – 1938) as (Nallino 1899 – 1907). This monumental work includes a Latin translation of the text of the *zīj* in vol. I, a transcription of the tables in

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[1] More information on al-Battānī’s life and works can be found in (Hartner 1970, van Dalen 2007).

[2] The standard work on Islamic astronomical handbooks with tables, in Arabic and Persian called *zīj*es, is still (Kennedy 1956). A new survey of Islamic astronomical tables is currently being prepared by the first author. This will also include information on almost 100 works that have become known only during the last fifty years.

vol. II, and an edition of the Arabic text in vol. III. Half of vols. I and II is taken up by extensive commentaries that explain the numerous technical issues connected with the text and the tables of the *zīj* and relate these to various other sources that NALLINO had available.

Having been given such excellent scholarly treatment at a rather early time, AL-BATTĀNĪ’S *zīj*, and in particular the Escorial manuscript, may in more recent times not have received the attention they deserve. Parts of the *zīj* have been used for topical studies (see, for instance, SWERDLOW 1973, KUNITZSCH 1974, RAGEP 1996), but no new critical assessment has been made of the text and the tables as a whole. Since NALLINO had only the Escorial manuscript at his disposal, and the criteria for establishing the tabular values in his transcription are partly obscure and appear to be inconsistent, a fresh look at the tables in the *Ṣābi’ Zīj* is in fact highly desirable. In some cases NALLINO’S transcription turns out to differ so much from the manuscript tradition, and therewith in all probability from AL-BATTĀNĪ’S original table, that it cannot be reliably used to either establish direct interrelations with other sources or carry out a mathematical analysis of the underlying parameters and methods of computation.

The purpose of this article is to make an inventory of the problems attached to NALLINO’S transcription of AL-BATTĀNĪ’S tables and to pave the way for a possible new, critical edition that takes into account all relevant additional sources, in particular some later Arabic and Persian *zījes* that adopted tables from AL-BATTĀNĪ, the Castilian translation of the *Ṣābi’ Zīj* prepared around 1260 for ALFONSO X (1221–1284), and the Latin tradition of the *Toledan Tables*. For this purpose we shall present an edition of AL-BATTĀNĪ’S table of the solar declination and full apparatuses for a number of other tables, each with its own peculiar features. For each of the tables we shall discuss the types of errors that they contain, specify our own criteria for establishing the tabular values, and comment on the policy followed by NALLINO for his transcription.

Since medieval Latin manuscripts turn out to play an important role in our re-edition of some of AL-BATTĀNĪ’S tables, it is a great pleasure for us to be able to present this research in a *Festschrift* for Prof. Menso FOLKERTS, who has dedicated most of his career to such manuscripts. We would like to acknowledge the kind assistance of the curators of the Escorial library and the other libraries listed below in supplying us with microfilms of manuscripts from their collections.

1.1 Sources

Edition

N = (NALLINO 1899–1907, vol. II), NALLINO’S transcription of the tables from AL-BATTĀNĪ’S *zīj*, which is the only available publication of the tables. This is not a critical edition in the modern sense of the word. It rests on one Arabic manuscript, the unique complete copy of the *zīj* from the Escorial Library (E below), which NALLINO, often tacitly, corrected in various ways, in particular by means of recomputation and by adopting values from PTOLEMY’S *Almagest* and *Handy Tables* where these can be seen to have been AL-BATTĀNĪ’S ultimate source (cf. vol. I, p. vi; all such references without explicit indication of a publication will be to NALLINO 1899–1907). Only for tables that cannot be recomputed, such as the geographical table and the star catalogue, does NALLINO promise to cite the Arabic manuscript consistently (*ibid.*). Also for the Ptolemaic tables for planetary visibility he gives complete variant readings from a number of sources.

Manuscripts

For our critical edition and apparatuses of sample tables we have used the following manuscripts or parallel sources:

E = Escorial, ms. árabe 908. Described in (NALLINO 1899 – 1907, vol. I, p. lxi). In Western Arabic script from the late 11th or early 12th century. This is the only complete Arabic manuscript of AL-BATTĀNĪ'S work, and the only manuscript used by NALLINO throughout.

A = Paris, Arsenal, ms. 8322. Described in (NALLINO 1899 – 1907, vol. I, pp. lvii–lx; vol. II, pp. vii–viii). In Castilian, writing of the late 13th century, prepared for king ALFONSO X, incomplete. Translation of a version of the text and tables that is quite similar to E. This manuscript did not become available to NALLINO until his transcription of the tables had been printed (vol. II, p. vii). He excerpted it to some extent for his commentary on the tables, though not for the tables to be discussed here. The text of the Castilian translation of the *Ṣābi' Zīj* was published in (BOSSONG 1978).

O = Oxford, Bodleian Library, ms. Savile 22. In Latin, mid 13th century.

C = Cambridge, University Library, ms. Kk.I.1 (1935). In Latin, mid 13th century.
O and C represent a version ("class {k}") of the *Toledan Tables* that preserves Battanian readings much more faithfully than the mainstream versions of these tables (cf. PEDERSEN 2002, pp. 19 and 858; TOOMER 1968, pp. 12 – 13). O and C are closely related to each other and seem largely independent of E and A. In evaluating the evidence for readings in AL-BATTĀNĪ'S tables we shall normally count O and C as a single source.

T = *Toledan Tables*. Unless otherwise specified, the readings given by us are the mainstream ones, established from manuscripts representing the "archaic" and "early vulgar" classes ({a0} and {a1}, see PEDERSEN 2002, p. 868). This excludes readings peculiar to mss. O and C above. As a result, some of the values here cited for T are not the same as those printed in the edition in (PEDERSEN 2002).

We have not included tables derived from PTOLEMY'S *Almagest* or *Handy Tables*, since NALLINO'S transcriptions of these usually do not present many problems. For the lunar equation of anomaly we have adduced Arabic and Persian *zījes* that adopted tables from AL-BATTĀNĪ, in particular the *Mufrad Zīj* by Abū Ja'far Muḥammad AL-ṬABARĪ and the *Īlkhānī Zīj* by Naṣīr al-Dīn AL-ṬŪSĪ. Details of the manuscripts used for these works can be found in Section 3.5. Note that the 12th-century Latin translation of AL-BATTĀNĪ'S *zīj* by PLATO OF TIVOLI (12th c.), which was printed twice in the 16th and 17th centuries, included only the text.

Constructed values

We have adduced three types of "constructed values" for judging the plausibility of manuscript readings. These comprise:

r = Modern recomputation for the standard Ptolemaic formula and the parameter(s) indicated. Although the exact historical method of computing any one table is not generally known in detail, a modern recomputation can in most cases be assumed to give a fair approximation to AL-BATTĀNĪ'S original tabular values. Various of the tables discussed here include parts with systematic larger deviations from the recomputation, which may, for instance, be due to the use of interpolation; this is indicated for each individual table.

d = A value that makes the surrounding pattern of first-order differences highly regular, i. e., either constant or alternating between two adjacent values in a regular fashion (for example, 2, 2, 3, 2, 2, 3, 2, 2, 3). This type of constructed value will be applied only to tables of linear functions (such as the sub-tables of mean motion tables except those for extended years and months), and to tables that were clearly computed by means of linear interpolation between certain nodes.

s = A value that can be derived in a trivial way (e. g., identity, linear transformation) from a value elsewhere in the table and can be expected to be the same as the present value by virtue of some symmetry or antisymmetry, as described in each case. This type of constructed value will only be applied to cases where the symmetry was obviously used by the compiler of the table.

1.2 Apparatuses

For each of the tables discussed in Sections 2 and 3 we present an apparatus of variants that is intended to illustrate the manuscript evidence for each reading, to justify our choice of values, and to assess the rationality of NALLINO’S choices when editing from E alone. In establishing the tabular values, we shall give preference to E and A, since these are the only sources actually ascribed to AL-BATTĀNĪ, and primarily to E, since A seems to share some readings with the mainstream *Toledan Tables*. Generally, an apparatus does not list all variants in all manuscripts; however, the readings from E and A and the readings accepted by us are listed wherever they differ from N, so that E and A can be reconstructed by the reader who compares NALLINO’S table to the apparatus.

Scribal errors and easy corrections

Nearly every source for every single table discussed in this article is distorted by a large number of scribal errors. Many of these are caused by similarities between the Arabic letters used in the *abjad* notation with which most numbers in Arabic mathematical and astronomical tables are written, or between the Roman or Hindu-Arabic numerals as used in medieval Latin manuscripts. Which mistakes are particularly likely in a given source depends to a large extent on the type of writing of the original. In particular, due to a number of differences in the *abjad* notation between Eastern and Western Arabic writing, some mistakes are likely to occur only with an Eastern original and others only with a Western original. Most of the scribal errors in the Castilian and Latin manuscripts that we have used can be seen to derive from their Arabic originals (cf. NALLINO’S discussion of scribal errors in vol. II, pp. v–vi).

Some of the most frequent obvious scribal errors are the following (here “t” denotes any number of tens and “u” any number of units unequal to zero; “etc.” indicates that also compounds starting with the same numerals may be confused):[3]

Arabic: 0 ↔ 5, t2 ↔ t4, t2 ↔ t7, t3 ↔ t4, t3 ↔ t8, t4 ↔ t5, t4 ↔ t6, t4 ↔ t7, t6 ↔ t7,
7 ↔ 50, 9 ↔ 20, 1u ↔ 3u, 1u ↔ 5u, 17 ↔ 40, 3u ↔ 5u, 4u ↔ 5u, 40 ↔ 47,
50 ↔ 55, various other confusions of the form $t_1u \leftrightarrow t_2u$ (also with $t_1 = 0$),
80 ↔ 100 etc. Only for Eastern Arabic sources: 60 ↔ 300 etc.
Only for Western Arabic sources: 60 ↔ 90 etc.

Latin: Roman notation: I (1) ↔ L (50), X (10) ↔X̍ (40); N (9) ↔ II (2); miscounting of strokes, e. g. IIII (4) ↔ III (3). Hindu-Arabic notation: no typical errors.

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[3] Unlike the practice in most other Arabic and Persian *zījes*, in the Escorial manuscript of the *Ṣābi’ Zīj* angles that occur as arguments of planetary equations and other functions are always written as total numbers of degrees from 0 to 360 rather than as zodiacal signs plus a number of degrees from 0 to 29. This leads to different patterns of scribal errors from what is found in many other sources.

Our sources also frequently contain other types of scribal mistakes, such as slides of large parts of a column, a number of consecutive tabular values whose degrees have all been set to a particular number, mistaken digits which can only be explained by assuming that they were copied from an erroneous location, etc. When establishing our accepted readings we shall consider all plausible corrections of obvious scribal errors (to which we shall refer as “easy corrections”) for tabular values with apparent mistakes. For instance, in a table with deviations from the recomputation of generally less than 1″, we shall consider the possibility that the reading 7″ is a scribal mistake for 50″ if the other witnesses attest to 49, 50 or 51″. In particular in the Escorial manuscript, readings are not always easy to distinguish on the microfilm that we have used (nor possibly in the manuscript itself). In cases where the reading is ambiguous (e. g., if the dots on an Arabic letter are not strictly speaking correct for any possible number), we shall often give the manuscript the benefit of the doubt and shall not indicate a variant reading in the apparatus.

Apparatus entries
An apparatus entry has the following form:

69 56;0,54 [∗6° O; 5′ E]: AOC; 56″ E, 53″ TNrd.

Here 69 (in boldface) is the argument of the tabular value concerned, and 56;0,54 is our accepted value. This notation is shorthand for 56°0′54″, where the degree sign stands for units, also in cases where the variable is not an arc, and ′ and ″ for minutes and seconds. In this case the accepted value is found in the manuscripts AOC,[4] whereas we have rejected two other readings for the seconds, namely 56″ in E and 53″ in T. The latter reading is also given by NALLINO following the recomputation and/or a construction on the basis of tabular differences. The variant readings in the degrees and minutes printed between square brackets are considered irrelevant in this connection; they indicate that the value actually found in O is ∗6;0,54, where the asterisk stands for an illegible digit, and that the value in E is 56;5,56. Note that for the present purpose we ignore the exact layout of the tables and scribal mistakes in the arguments, and limit ourselves to variant readings in the tabular values as such.

Classes of apparatus entries
In each apparatus there are four basic classes of entries, namely, *Scattered evidence*, *Outliers*, *(Practically) certain values*, and *Remaining scribal errors in E and/or A*. These classes may have somewhat varying titles due to the particular circumstances of each table, and they may be supplemented by further classes to illustrate specific points, mostly related to the way NALLINO dealt with certain tabular values.

The basic classes are specified in terms of “likely values” or “likely readings”. These are defined as readings that fit the available constructed values (r, d, s) satisfactorily according to the circumstances of each case. Depending on the overall accuracy of a table, we may allow deviations from recomputed values of 1, 2 or 3 units in the final sexagesimal position. For tables with systematic larger deviations on certain intervals, we shall say that a value is likely if it “fits in its surroundings”, i. e., if it differs from the recomputation by roughly the same amount as its neighbours. For example, in Table 4 the value 5;0,45 for argument 97 with an error of −11″ fits in its surroundings because the neigh-

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[4] Only in exceptional cases will there be no actual witness for the value that we accept. Occasionally the only witness may be a recomputed (“r”) or symmetrical (“s”) value.

bouring errors are −12″ and −10″. The decision which likely value we accept in each case depends on the particular circumstances of the table and will be detailed under the heading *Criteria*. In the case of close calls between likely values we generally give priority to E and then to A.

In general, whenever N differs from our accepted value, we shall include a full entry in the apparatus. Not included in the apparatus at all will be cases where there is only one likely reading, and EAN (*before* any easy correction of scribal errors) agree about it. If any one present of (OC) or T has a variant reading in such cases, or if they have variant readings that differ among themselves and appear paleographically unrelated to each other, such readings are rejected tacitly.

The four main classes of apparatus entries are specified in the following general terms:

Scattered evidence: Cases where there is evidence for several likely readings.

Outliers: Cases where there is no evidence for any likely reading, even when applying easy corrections of obvious scribal errors as explained above.

(Practically) certain values: Cases where there is only one likely reading but a minority of the witnesses, after the correction of obvious scribal errors, attests to a different value.

Remaining scribal errors in E and/or A: All remaining cases where EAN differ among each other. In practice these are cases where we have accepted the value from N, and E and A differ from N only due to obvious scribal mistakes (in other words, NALLINO has rightly corrected the scribal errors in E). For this class we use a briefer notation indicating only the deviations from N (or, equivalently, from our accepted value). For each entry included, incidental variant readings from any other witnesses are also recorded. Cases where both E and A have a scribal error in the final sexagesimal position will be listed in a separate class *Values with scribal errors in the seconds in both E and A*, or else under *(Practically) certain values*. A combined entry in the section *Remaining scribal errors* … occasionally summarizes errors in a range of consecutive tabular values (e. g., "**122–126** 27–25–22–19–17′ (minutes all one too large) A"). Any further entries for arguments within such a range are preceded by a plus sign in order to facilitate the construction of the complete tabular values as they are found in the manuscripts.

Interrelationship of manuscripts

It may be said that we cannot determine the overall interrelationship of our manuscripts in any reliable way. The two AL-BATTĀNĪ witnesses E and A are each quite faulty, and they also have many errors in common. O and C are closely related. For certain variant readings, E may join OC whereas A joins T, such that neither of the readings in question is an obvious error. It is thus unwise to posit a common archetype, not to speak of postulating that this archetype reflects AL-BATTĀNĪ'S intention. Probably the Battanian manuscript tradition is a continuum generated by piecemeal corrections and cross-copying (for a possible instance of a table that occurs in more than one version, see Section 3.2).

Terminology

We shall use the following terms without further explanation. An *error* (other than a scribal error) is a deviation from the recomputation as specified for each table. Whenever a signed numerical value for an error is given, it is calculated as "tabular value minus recomputation". An exact value is a value without error, i. e., equal to the recomputation. Due to lack of space we cannot include full explanations of all astronomical functions and other basic concepts of Ptolemaic astronomy discussed in this article. For further information we refer the reader to (Kennedy 1956, Pedersen 1974, Neugebauer 1975, van Dalen 1993).

2. Re-edition of the table for the solar declination

al-Battānī based his table for the solar declination on the highly accurate obliquity value 23°35′, which had already been observed earlier in the 9th century and was confirmed by his own observations. The table is essentially different from any other declination table in early Islamic sources.[5] It contains a large number of errors of two seconds and more that cannot be explained as scribal errors. Since these errors show only very few regular patterns, most of them cannot be due to, for example, the use of linear or quadratic interpolation and they most plausibly stem from inaccuracies in the process of calculation. Nallino states in his commentary (vol. II, p. 221) that, besides correcting obvious scribal errors into plausible values, he corrected every declination value with an error of two seconds or more into a value recomputed by the Italian astronomer Giovanni Virginio Schiaparelli (1835–1910) (in some cases Schiaparelli's correction differs from our own recomputation by a second, probably due to small computational mistakes or intermediate rounding). As a result, the table that Nallino prints is very different from what we may assume about al-Battānī's original table. In Table 1 we provide our own edition of the declination table, in which we have tried to stay as close as possible to the tables in our only two witnesses, the Arabic and Castilian versions of the *Ṣābi' Zīj*.

Apparatus
Edition: N pp. 57–58. *Manuscripts*: E ff. 177v–178r; A ff. 43r–43v. *Constructed values*: r = recomputation for an obliquity of the ecliptic of 23°35′.

Criteria: A likely value is any value differing from the recomputation by at most 3″. Whenever E and A, or any easy corrections of them, agree on a likely value, we accept it. If either E or A attests to a likely value, we likewise accept it. If E and A attest to two different likely values, we tend to accept the value from E.

Commentary: Where E and A agree, if necessary after correcting obvious scribal errors, they show numerous deviations of 2″ and more from the recomputation. Only some of these errors occur together in smaller groups and may hence be related, for example due to the use of interpolation. Five scattered errors larger than 8″ appear to be completely unrelated to any others and are here listed separately under *Outliers*. As Nallino states in his commentary (vol. II, p. 221), he corrected all values in E that differ from Schiaparelli's recomputed values by 2″ or more (in fact, occasionally by only 1″) to those recomputed values. It is unclear to which extent he actually used paleographical considerations in

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[5] The Escorial manuscript of the *Mumtaḥan Zīj* by Yaḥyā ibn Abī Manṣūr contains a declination table for the obliquity value 23°33′ observed under al-Ma'mūn, whereas the tradition of the *Toledan Tables* includes al-Khwārizmī's table for the Ptolemaic value 23°51′ and a table for the typical Zarqalian value 23°33′30″. The declination tables in the Leipzig manuscript of the *Mumtaḥan Zīj* (see van Dalen 2004) and in the Istanbul and Berlin versions of the *zīj* of Ḥabash al-Ḥāsib are for obliquity 23°35′, but were all calculated by different methods, partly involving a heavy use of linear interpolation.

Solar declination							
arg.	accepted	error	Nallino	arg.	accepted	error	Nallino
1	0;24, 0			46	16;43,33	–1	
2	0;48, 0			47	17; 0,47	–3	17; 0,50
3	1;11,59			48	17;18, 0	+12	17;17,48
4	1;35,57			49	17;34,30	+2	17;34,29
5	1;59,54			50	17;50,52	+2	17;50,51
6	2;23,49			51	18; 6,55	+2	
7	2;47,41			52	18;22,36	–1	
8	3;11,31			53	18;38, 5	+3	18;38, 2
9	3;35,15	–3	3;35,17	54	18;53, 7		
10	3;59, 1	–1		55	19; 7,52	+1	
11	4;22,42	+1		56	19;22,18	+2	19;22,16
12	4;46,18	+1	4;46,17	57	19;36,19		
13	5; 9,49			58	19;50, 2	+1	19;50, 1
14	5;33,16	+1		59	20; 3,21		
15	5;56,37			60	20;16,20		
16	6;19,53			61	20;28,41	–16	20;28,57
17	6;43, 4	+1		62	20;41,11		
18	7; 6, 7	+1		63	20;52,54	–8	20;53, 2
19	7;29, 4	+1	7;29, 3	64	21; 4,27	–3	21; 4,30
20	7;51,53			65	21;15,36	+1	
21	8;14,36			66	21;26, 9	–8	21;26,17
22	8;37,12	+1		67	21;36,34		
23	8;59,37			68	21;46,28	+1	
24	9;21,56	+1		69	21;55,58	+2	21;55,56
25	9;44, 5	+1		70	22; 5, 0		
26	10; 6, 5	+1		71	22;13,41	+2	22;13,39
27	10;27,55	+1	10;27,54	72	22;21,45	–8	22;21,52
28	10;49,34			73	22;29,42		
29	11;11, 3			74	22;37, 3	–1	22;37, 5
30	11;32,22			75	22;44, 3	+1	22;44, 2
31	11;53,29			76	22;50,33		
32	12;14,25			77	22;56,38		
33	12;35,10	+1		78	23; 2,16		
34	12;55,42	+2	12;55,40	79	23; 7,29		
35	13;15,59			80	23;12,15	+1	
36	13;36, 9	+5	13;36, 4	81	23;16,34	+1	
37	13;55,59	+3	13;55,56	82	23;20,24	–1	
38	14;15,37	+3	14;15,35	83	23;23,50	+1	
39	14;35, 2	+4	14;34,58	84	23;26,48	+1	
40	14;54, 8			85	23;29,18	+1	
41	15;13, 2			86	23;31,19	–2	23;31,21
42	15;31,41	+1		87	23;32,55	–2	23;32,56
43	15;50, 3			88	23;34, 2	–3	23;34, 5
44	16; 8, 9	–1		89	23;34,43	–3	23;34,46
45	16;26, 0			90	23;35, 0		

Table 1: Table of the solar declination, with the values accepted by us on the basis of manuscripts E and A, differences from the recomputation, and Nallino’s values if different from ours.

those cases where he corrected scribal errors into paleographically likely readings, because in a majority of the relevant cases the paleographically likely readings are equal to recomputed values.[6]

Scattered evidence (E and A, or any easy corrections of them, attest to two different likely values): **19** 7;29,4: A; 6″ E, 3″ Nr. **21** 8;14,36: ENr; 37″ A. **29** 11;11,3: ENr; 2″ A. **47** 17;0,47: A; 8″ E, 50″ Nr. **53** 18;38,5: E; 4″ A, 2″ Nr. **82** 23;20,24: EN; 25″ Ar. **87** 23;32,55: 35″ E, 54″ A, 56″ N, 57″ r.

Outliers (scattered errors of 8″ and more that do not fit into any patterns and were corrected by NALLINO into recomputed values):[7] **48** 17;18,0 [16′ E, 58′ A]: EA; 17′48″ Nr. **61** 20;28,41: A; 21″ E, 57″ Nr. **63** 20;52,54: A; 14″ E, 53′2″ Nr. **66** 21;26,9: EA; 17″ Nr. **72** 22;21,45: EA; 52″ N, 53″ r.

Other corrections by NALLINO *into recomputed values* (E, or any easy correction of it, differs by 2″ or more (in three cases by only 1″) from values recomputed by SCHIAPARELLI): **9** 3;35,15: A; 55″ E, 17″ N, 18″ r. **12** 4;46,18 [36′ E]: 5″ E, 58″ A, 17″ Nr. **27** 10;27,55: A; 19″ E, 54″ Nr. **34** 12;55,42: EA; 40″ Nr. **36** 13;36,9 [56′ A]: EA; 4″ Nr. **37** 13;55,59: EA; 56″ Nr. **38** 14;15,37: A; 17″ E, 35″ N, 34″ r. **39** 14;35,2: EA; 34′58″ Nr. **49** 17;34,30 [36′ E]: EA; 29″ N, 28″ r. **50** 17;50,52: EA; 51″ N, 50″ r. **56** 19;22,18: E; 58″ A, 16″ Nr. **58** 19;50,2: A; 50″ E, 1″ Nr. **64** 21;4,27: EA; 30″ Nr. **69** 21;55,58: A; 18″ E, 56″ Nr. **71** 22;13,41 [2*° E]: EA; 39″ Nr. **74** 22;37,3: EA; 5″ N, 4″ r. **75** 22;44,3: EA; 2″ Nr. **86** 23;31,19: EA; 21″ Nr. **88** 23;34,2: EA; 5″ Nr. **89** 23;34,43: E; 13″ A, 46″ Nr.

Values with scribal errors in the seconds in both E and A: **14** 5;33,16: N; 6″ E, 56″ A, 15″ r. **16** 6;19,53 [59′ A]: Nr; 33″ EA. **24** 9;21,56: N; 16″ EA, 55″ r. **52** 18;22,36: N; 6″ EA, 37″ r. **57** 19;36,19: Nr; 43″ E, 59″ A. **59** 20;3,21: Nr; 11″ EA. **62** 20;41,11: Nr; 31″ E, 0″ A.[8] **78** 23;2,16: Nr; 4″ E, 56″ A. **79** 23;7,29: Nr; 9″ E, 39″ A. **85** 23;29,18: N; 48″ E, 38″ A, 17″ r.

Remaining scribal errors in E and/or A: **1** 31° A; 31″ E. **7** 46′ E. **10** 54′ E. **11** 32′ A. **15** 50″ E. **17** 54″ E. **20** 43″ E. **22** 17′ A; 52″ E. **31** 25″ E. **32** 54′ A. **35** 55′ A; 15″ E. **41** 3′ E; 53′ A. **43** 55′ A. **46** 53′ E. **60** 56′ A. **65** 55′ A. **80** 55″ A. **84** 27′ E.

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[6] For six of the ten values with scribal errors in the seconds in both E and A, and for five of the eight values with scribal errors in the seconds in either E or A, the value accepted by us on paleographical grounds is equal to the recomputation; in all other cases it differs from it by only 1″.

[7] E and A are in agreement for three of the five values listed here; only for arguments 61 and 63 is the accepted value somewhat uncertain.

[8] Note that the error in A may be dependent on that in E: read 0  for 31 لا. In fact, the abjad forms for 0 and 31 in the Escorial manuscript are so close that confusion is certainly possible. NALLINO (vol. II, pp. vi and 271) interprets the abjad numeral 31 found instead of zero on seven occasions in the Escorial manuscript as the Arabic negation *lā*.

3. Apparatus for selected other tables

3.1 Sine

AL-BATTĀNĪ’S sine table has an unusual format, displaying values for every 30′ of arc rather than for every 15′, such as ḤABASH’S table derived from PTOLEMY’S *Almagest*, or 1° as most other early Islamic sine tables. Apparently it thus followed the format of PTOLEMY’S table of chords, which likewise presents values for every 30′ of arc. The values of AL-BATTĀNĪ’S sine table are not related to those in any other Islamic *zījes* that we have checked. The only witnesses for this table are therefore the Arabic and Castilian versions of the *Ṣābi’ Zīj* and the manuscript tradition of the *Toledan Tables*. Since our reconstruction of the archetype shows only 32 deviations from the recomputation (29 of which are +1″ or −1″), NALLINO’S strategy to replace doubtful values by recomputed ones (vol. II, pp. 220–221) in this case leads to a generally correct recovery of the original table.

Apparatus
Edition: N pp. 55–56. *Manuscripts*: E ff. 176v–177r; A ff. 28r–28v; O ff. 18r–19r;[9] C ff. 164r–164v.[10] *Constructed values*: r = recomputation for radius of the base circle 60. The readings in the mainstream *Toledan Tables* (see PEDERSEN 2002, pp. 957–959) differ so frequently from the Battanian tradition that we do not consider their inclusion to be useful.

Criteria: A likely value is any value that lies within 1″ of the recomputation. Whenever E and A, or any easy correction of them, agree on a likely value, we accept this value. If E, A and at least one of OC agree on any value, we likewise accept it. If E and A attest to two different values (not necessarily likely) in the neighbourhood of the recomputation, none of which is supported by O or C, we accept the value that is closer to the recomputation; if both values are equally close, we accept the value from E.

Commentary: AL-BATTĀNĪ’S sine table as we have reconstructed it shows 32 deviations from the recomputation, in only three cases larger than 1″. Of the latter the error 44″ (for 49″) at argument 88 is the only one attested by all three manuscript sources. Our accepted values differ from NALLINO at arguments 4, 11½, 51½, 69, 87, and 87½. NALLINO corrected 55 values from E, mostly for obvious scribal errors, on the basis of PTOLEMY’S table of chords, Abū ‘Alī al-Ḥasan AL-MARRĀKUSHĪ’S sine table for every 15′ of arc, and a recomputation (vol. II, pp. 220–221). Only 14 of these corrections were *not* into exact sine values, twelve of which obviously for paleographical reasons (the only two exceptions being the outliers 51½ and 88).

Scattered evidence (E, A and (OC), or any easy corrections of them, attest to two or three different likely values): **7** 7;18,44: OCNr; 32″ corrected to 42″ (?) E, 45″ A. **12½**

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[9] In O the seconds for arguments 45½ to 60 were mistakenly copied into the values for arguments 15½ to 30. As a result, readings for the seconds for arguments 15½ to 30 are to be considered missing.

[10] In O and C the minutes of the values for arguments 51–56½ have slid upwards by three rows. As a result, the readings for 51, 51½ and 52 are to be considered missing.

12;59,11: AOCNr; 10″ E. **24½** 24;52,54: EOCNr; 55′ A. **51** 46;37,44 [(no minutes) OC]: OCNr; 46″ E, 45″ A. **52½** 47;36,4 [46′ E, 33′ O]: EANr; 5″ OC. **60½** 52;13,17 [33′ A]: EOCNr; 16″ A. **73½** 57;31,45 [56° A]: AOCNr; 44′ E. **76** 58;13,4: EOCNr; 3″ A. **77** 58;27,44: ENr; 45″ A, 14″ OC. **78½** 58;47,44: EOCNr; 45″ A. **87** 59;55,4 [54′ A]: AOCr; 3″ EN.

Outliers (three scattered values differing from the recomputation by 2″ or more): **29½** 29;32,45: EN; 44″ A, 43″ Cr. **51½** 46;57,25 [(minutes missing) OC]: EA; 24″ OCN, 23″ r. **88** 59;57,44: EAC; 49″ ON, 48″ r.

Reasonably certain values (two or three of E, A and (OC), or any easy corrections of them, agree about a likely value, whereas any alternative readings are not likely): **4** 4;11,8: EAOC; 7″ Nr. **4½** 4;42,27: AOCNr; 25″ E. **11** 11;26,55 [36′ E]: ANr; 35″ E, 14″ O, 9″ C. **11½** 11;57,43 [*6′ E]: AOCr; 55″ E, 44″ N. **25½** 25;49,50: ENr; 7″ A, 51″ C. **39** 37;45,34: EAN; 32″ OC, 33″ r. **39½** 38;9,53: EONr; 13″ A, 54″ C. **44½** 42;3,16 [4′ E]: ENr; 56″ A, 17″ OC. **47** 43;52,53: EON; 33″ A, 54″ C, 52″ r. **69** 56;0,54: AOC; 56″ E, 53″ Nr. **86½** 59;53,17: ECNr; 54″ A, 18″ O.

Values with scribal errors in the seconds in both E and A: **24** 24;24,15 [26′ E]: CNr; 35″ E, 25″ A. **42½** 40;32,8: CN; 28″ EA, 4″ O, 7″ r. **48** 44;35,19: OCNr; 49″ E, (seconds blank) A. **80** 59;5,19 [0′ A]: OCN; 59″ A, 39″ E; 18″ r. **87½** 59;56,35: OCN; 55″ EA; 34″ r.

Remaining scribal errors in E and/or A: **1** 1′ A. **1½** 35′54″ A. **2** 6′ EA, *8″ E. **5** (26″ corrected into *6″) E. **5½** 8″ A. **6** 36′38″ E. **9½** 42″ E. **10** 35′ E. **10½** 36′ E; 4″ OC. **12** 37′0″ E. **14** 15° EA. **14½** 12″ E. **15** 41″ E. **16½** 12′ E. **18** 24″ E. **18½** 38″ A. **20** 36″ E. **21** 55″ A. **21½** 55″ E. **26** 38′ E, 28′ A. **27** 34′ E, 44′ A. **27½** 38″ E. **28** 32′ E. **29** 0′ A. **33½** 18″ E. **35½** 55′ A. **36** 56′ A. **36½** 32″ E. **40** 35′ E. **43** 52″ A. **46** 58″ E. **46½** 0″ A. **47½–48½** 45° A. **+47½** 54′52″ A. **49** 56′ A; 18″ EOC. **49½** 23″ E. **50½** 57′ A. **52** 56′55″ A, 50″ OC. **53** 14′ E; 0″ A. **53½** 33′ A. **54** 12′ E. **54½** 55′ A. **55½** 27′31″ E, 36′ C. **56** 52″ E. **56½–58** 55° A. **+57** 59′ A. **+57½** 46′52″ E. **+58** 19″ E. **59** 35′ A. **61** 18′ OC; 18″ E. **63** 26′ EOC. **64** 54′ E. **64½–66** 55° A. **+65½** 34′ E; 12″ OC. **+66** 16″ E. **67** 33′ A. **69½** 30″ E. **72–75** 56° A. **+73½**: see under *Scattered evidence*. **75½** 0′ A. **77½** 35′ EA. **79** 31″ A. **79½** 53″ E. **81½** 38″ E. **82** 35′ A; 18″ EOC. **85** 49″ E, 59″ OC. **86** 54″ A.

3.2 Cotangent for a gnomon length of 12 parts

Al-Battānī's shadow table with values to minutes for a gnomon length of 12 parts is different from similar tables in other early Islamic works such as the *zījes* of Abū ʻAbd Allāh Muḥammad ibn Mūsā al-Khwārizmī (first half of 9th c.) and Kūshyār and the Almanac of Azarquiel (late 11th c.). It shares with these sources two typical errors in the cotangents of 1 and 2°, but it has its own characteristic errors for arguments 18 and 36. Ten errors of ±1′ in the Escorial manuscript of the *Ṣābi'Zīj* are not found in the other witnesses for al-Battānī's cotangent table, namely, the Castilian version of the *zīj* and the tradition of the *Toledan Tables*. This may point to the existence of two different versions of this table.

Apparatus
Edition: N p. 60. *Manuscripts*: E fol. 179r; A fol. 44v; O fol. 19v; C fol. 163v;[11] T pp. 991–993.[12] *Constructed values*: r = recomputation for gnomon length 12.

Criteria: A likely value is any value within 1′ of the recomputation. In nearly every single case a clear majority of the witnesses attests to one particular value, likely or not, which we consequently accept (only for argument 36 do two or more witnesses give values rejected by us). However, for a group of apparently interrelated errors of ±1′ in E, which (with two minor exceptions) do not occur in any of the other sources, we accept the value from E (cf. below). We include in the apparatus full entries for all values corrected by NALLINO and, under the heading *Possible indications …*, for the group of apparently interrelated errors in E. As elsewhere, OC have quite a large number of scribal errors in common that do not appear in any of the other sources; these are not listed here, but can be found in (PEDERSEN 2002, pp. 991–993).

Commentary: AL-BATTĀNĪ’S cotangent table for gnomon length 12 as we have restored it from the available sources has 19 deviations from the recomputation, 16 of which are only ±1′. NALLINO corrects eight of the errors to exact values, including all three larger ones. He mentions the typical errors in the cotangents of 1° and 2° in his commentary (vol. II, p. 221) and explains them from the use of sine values rounded to three sexagesimal places (12 · 59;59,27 / 1,2,50 = 687;25,41,13,… and 12 · 59;57,48 / 2;5,38 = 343;38,51,33,…). All sources for AL-BATTĀNĪ’S cotangent table have two characteristic errors in common, namely those for arguments 18 (−2′) and 36 (−3′). The Escorial manuscript has ten errors of a single minute on the interval 71 to 89°, where, with two minor exceptions, the Castilian translation and the tradition of the *Toledan Tables* have exact values. This makes it plausible that two versions of AL-BATTĀNĪ’S cotangent table existed in the western Islamic world (cf. the somewhat similar situation for the excess of half daylight in Section 3.3, for which only the *Toledan Tables* include more accurate values for two out of three intervals with larger deviations from the recomputation).

Corrections by NALLINO *not supported by EA(OCT)*: **1** 687;26 [387° A]: EAOCT; 29′ Nr. **2** 343;39 [693° E, 383° A]: EAOCT; 38′ Nr. **15** 44;46: EAOCT; 47′ Nr. **18** 36;54: EAT; 14′ OC, 56′ Nr. **36** 16;28: EA; 38′ OC, 30′ T, 31′ Nr. **46** 11;34: EAOC; 35′ TNr. **67** 5;6: AOCTNr; 3′ E.

Corrections by NALLINO *supported by A(OCT)*: **60** 6;56: AOCTNr; 57′ E. **62** 6;23′ ATNr; 24′ E, (minutes missing) OC. See also **71** and **72** under the category *Possible indications …*.

Possible indications for the existence of a revised Battanian table (ten values for arguments on the interval 71–87 for which E has deviations from the recomputation of +1′ (twice) or −1′ (eight times), whereas A (with one exception) and OCT (with one exception

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[11] In OC the minutes of the values for arguments 61–87 have slid upwards by three rows; as a result, readings of the minutes for arguments 61–63 are to be considered missing.

[12] The mainstream version of T is very close to AL-BATTĀNĪ and includes his two characteristic errors for arguments 18 and 36 (but not the ten errors towards the end of the table that are not contained in AOC either).

for T) give exact cotangent values; of these ten values, NALLINO corrected only those at 71 and 72 into recomputed values): **71** 4;9: E; 8′ AOCTNr. **72** 3;55: ET; 54′ AOCNr. **76** 2;59 [3° E]: EN; 3°0′ AOCTr. **78** 2;32: EN; 33′ AOCTr. **79** 2;19: EN; 20′ AOCTr. **80** 2;6: EN; 7′ AOCTr. **84** 1;15: N; 35′ E, 16′ AOCTr. **85** 1;2: EN; 3′ AOCTr. **87** 0;37: EN; 38′ AOTr, 48′ C. **89** 0;12: EAN; 13′ OCTr.

Remaining scribal errors in E and/or A: **5** 136° E, 134° OC. **13** 19′ E. **17** 55′ EA. **21** 56′ EA. **23** 56′ E. **40** 58′ A. **43** 32′ E. **48** 28′ E. **59** 53′ A. **61** 29′ E, (minutes missing) OC. **63** 50′ E, (minutes missing) OC.

3.3 Half excess of longest daylight as a function of geographical latitude

This table displays, for every half degree of geographical latitude up to 60, the maximum equation of daylight, i. e., half the difference between the length of the longest day and 12 hours, expressed in equatorial degrees. It can be used for the calculation of oblique ascensions at arbitrary latitudes as explained in Chapter 13 of the *Ṣābi' Zīj* (vol. I, pp. 27 (translation) and 187–189 (commentary); vol. III, p. 39 (Arabic)). The standard method by which the half excess of longest daylight can be computed is explained in Chapter 9 of the *Ṣābi' Zīj*, although the present table is not explicitly mentioned. We have not found other copies of this table in early Arabic *zījes*, so that the only available witnesses are the Arabic and Castilian versions of AL-BATTĀNĪ's *zīj* and a branch of the tradition of the *Toledan Tables*. Whereas more than half of the tabular values that we accept are highly accurate, three intervals show groups of larger systematic errors, two of which were adjusted to more or less exact values in the *Toledan Tables*.

Apparatus
Edition: N p. 59. *Manuscripts*: E fol. 178v;[13] A fol. 44r; T pp. 1128–1129.[14] *Constructed values*: r = recomputation for an obliquity of the ecliptic of 23°35′; d: as explained in the introduction.

Criteria: A likely value lies within 1′ of the recomputation or, in the case of values within one of the three intervals with systematic deviations from the recomputation, fits in its surroundings, if possible in such a way that the tabular differences become regular.[15] If E and A, or any easy corrections of them, agree on a likely value, we accept it. If, on the third interval of inaccurate values, neither E nor A has a likely value (e. g., for arguments 52, 54 and 57½), we tend to accept E.

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[13] In E the arguments and degrees for arguments 2½–11½ have slid downwards by one row, making the degrees for arguments 2½, 5, 7, 9, and 11½ one too small.

[14] This table is not innate in the mainstream tradition of the *Toledan Tables*; it occurs only in manuscript Oo and class {d} (cf. PEDERSEN 2002, p. 1128) and may be an accidental loan. It differs systematically from the archetype of EA on the following intervals: 5½–10, 48½–49½ and 51½–55½, 58–59½. Consequently, on these intervals T has not been given the same weight as a witness for the Battanian table, and its values are cited between parentheses.

[15] The second part of this definition applies only to argument 6½, since no further problematic values appear in the first two intervals with systematic deviations, and the errors on the third interval are so irregular that all values for which E and A differ fall under the category *Scattered evidence*.

Half excess of longest daylight							
lat.	accepted	error	diff.	lat.	accepted	error	diff.
15	6;43		0;14	23	10;43	+2	0;16
15½	6;57		0;14	23½	10;59	+2	0;17
16	7;11		0;14	24	11;16	+4	0;17
16½	7;25	–1	0;15	24½	11;33	+4	0;18
17	7;40		0;14	25	11;51	+6	0;17
17½	7;54	–1	0;15	25½	12; 8	+7	0;16
18	8; 9		0;14	26	12;24	+6	0;17
18½	8;23	–1	0;15	26½	12;41	+7	0;16
19	8;38	–1	0;15	27	12;57	+6	0;17
19½	8;53	–1	0;15	27½	13;14	+6	0;16
20	9; 8	–1	0;15	28	13;30	+5	0;17
20½	9;23	–1	0;16	28½	13;47	+4	0;16
21	9;39		0;16	29	14; 3	+3	0;17
21½	9;55	+1	0;16	29½	14;20	+2	0;16
22	10;11	+1	0;16	30	14;36		
22½	10;27	+2	0;16				

Table 2: Fragment of the table of the half excess of longest daylight as a function of geographical latitude, with the values accepted by us, differences from the recomputation, and first-order tabular differences.

Commentary: AL-BATTĀNĪ’S table deviates in a systematic fashion from the recomputation on three intervals: for arguments 5–10½ with a maximum error of +5′; for arguments 21½–29½ with a maximum error of +7′; and for arguments 52–55½ with a maximum error of −5′. The very regular pattern of tabular differences up to argument 45 points to a heavy use of linear interpolation. The first two “dents” can thus be explained by only two incorrect values at interpolation nodes.[16] Of the three “dents”, the version of this table in the manuscript tradition of the *Toledan Tables* has only the second one; instead of the first and third dent it has (almost) exact values. Since three quarters of the tabular values in the *Toledan Tables* agree with AL-BATTĀNĪ, we may nevertheless assume that the two tables are interdependent. It cannot at present be decided with certainty whether the version in the *Toledan Tables* corrected the dents resulting from incorrect linear interpolation in

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[16] The first-order differences within the first two intervals with systematic deviations from the recomputation are highly regular between the nodes 4–8–11 and 21–25–30 (to explain the table fully from linear interpolation between these nodes, we need to assume that a minor mistake was made between arguments 21 and 25, resulting into tabular differences 16, 16, 16, 16, 16, 17, 17, 18). As a result, if linear interpolation is carried out using the incorrect tabular values for arguments 8 and 25 (for the latter, cf. Table 2), the Battanian table can be reproduced almost exactly.

al-Battānī's archetype (this possibility may be more probable), or the version extant in the Arabic and Castilian versions of the *Ṣābi' Zīj* incorrectly patched some more or less exact parts of an archetype surviving in the *Toledan Tables*. Nallino (vol. II, p. 224) states that his transcription of this table was emended by Schiaparelli. It turns out that, at the first and second dents with their very regular tabular differences, he only corrected scribal errors. At the third, much more irregular, dent he changed various values into recomputed ones without any obvious system.

Scattered evidence (E and A, or any easy corrections of them, attest to two different likely values, or neither E nor A has a likely value): **4** 1;45: ATNrd; 44′ E. **6½** 2;54: ANd; 55′ E, (52′ T), 51′ r. **14** 6;15: ATNrd; 16′ E. **31½** 15;31: ATrd; 32′ EN. **47** 27;55: ETNr; 54′ A. **52** 33;56: E; 54′ A, 57′ N, (34°1′ T), 58′ r. **54** 36;53: EN; 57′ A, (55′ T), 56′ r.

Reasonably certain values (E and A, or any easy corrections of them, agree on a likely value, or either E or A agrees with T on a likely value whereas the third witness does *not* provide a likely value): **11** 4;51: EA; 53′ N, 52′ Tr. **39** 20;42: ATrd; 45′ E, 40′ N. **39½** 21;5: ATrd; 13′ E, 3′ N. **50** 31;22: ATN; 24′ E, 21′ r. **53** 35;22: EA; (26′ T), 24′ Nr. **53½** 36;7: EA; (10′ T), 9′ Nr. **54½** 37;39: EA; (42′ T), 43′ N, 44′ r. **55** 38;29: EA; (32′ T), 34′ Nr. **55½** 39;22: EA; (25′ T), 26′ Nr. **57** 42;16: AT; 56′ E, 14′ Nr. **57½** 43;17: ET; 14′ A, 15′ Nr. **59½** 47;45: EA; 49′ (T)N, 50′ r.

Remaining scribal errors in E and/or A: **3** 39′ E. **7½** 32′ E, (18′ T). **13** 40′ E. **14½** 25′ E. **15** **′ E. **15½** 54′ A. **16** 51′ A. **18½** 28′ A. **19** 33′ A. **19½** 58′ E. **21** 19′ E. **22** 51′ A. **24** 56′ A. **25½** 81′ (sic!) A. **27½** 54′ A. **30½** 24′ E, 55′ T. **31** 53′ A. **32** 55′ A. **34** 4′ E. **36½** 11′ E. **37** 53′ A. **37½** 3*′ E. **38** 37′ E. **38½** 59′ A. **46** *2′ E. **51½** 38′ A, (20′ T). **56½** **′ E. **58** 59′ E, (20′ T). **60** 50′ A.

3.4 Mean motion of the northern lunar node for the Arabic calendar

Al-Battānī includes in his *zīj* two sets of planetary mean motion tables, one for the Arabic calendar, the common calendar in the Islamic world, and one for the Byzantine or Syrian calendar, which was more frequently used in the region where al-Battānī lived and worked. Both sets cover a range of many centuries and are based on new parameters which were apparently derived from the observations that al-Battānī made in Raqqa between 877 and 918. Although the mean motion tables present straightforward linear functions, they are not usually error-free. Occasionally the sub-tables contain systematic errors that make it impossible to reliably determine the underlying parameter for the daily mean motion and to decide between readings differing by one or two seconds. We present a full apparatus for the table of the motion of the ascending lunar node in the Arabic calendar and reproduce in its entirety the particularly problematic sub-table for extended years from this table. We have determined the underlying values for the daily mean motion by means of the least number of errors criterion,[17] omitting from the analysis all uncertain values as listed under the category *Nontrivial variants*.

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[17] For a discussion of the least number of errors criterion, see (van Dalen 1993, 60–62). A fully explained application of the criterion can be found in (van Dalen 2000).

Apparatus
Edition: N pp. 19 – 23. *Manuscripts*: E ff. 164v – 166v; A ff. 36v – 38r. *Constructed values*: r = recomputation for a daily mean motion of 0;3,10,37,24,5,57 °/day; d: as explained in the introduction.

Criteria: In general, a likely value is a value that differs by at most 1″ from our recomputation. For inaccurate and irregular sub-tables (in particular, the extended years and days) a likely value is a value that produces a roughly regular pattern of tabular differences. We shall usually accept any likely value on which E and A, or any easy corrections of them, agree. In cases where E and A attest to two different likely values, we accept the value which is closest to our recomputation or, in the case of less accurate sub-tables, fits best in its surroundings. Values constructed on the basis of tabular differences (indicated by “d”) will be included in the apparatus only for purely linear sub-tables, i. e., not for the extended years and months.

Commentary: Nallino’s values for collected years are all correct for the indicated parameter. However, in the manuscripts the degrees have suffered from great distortions: in E those for the last ten values are 40° too low, and in A most of those for arguments 331 – 871 are 20° too high. On the other hand, the extended years, reproduced in Table 3, cannot be satisfactorily recomputed for any parameter value (the minimum number of errors in this sub-table is 15) and cannot be plausibly restored either. Also the sub-table for days has a large number of deviations from the recomputation due to an extremely irregular pattern of first-order differences.[18]

Nontrivial variants: **Collected years** (1, 31, 61, …, 871 Hijra): **241** 57;7,34 [4′ A]: ENrd; 35″ A. **841** 155;33,13 [115° E, 175° A]: Nrd; 48″ E, 10″ A. **Extended years**: **3** 56;17,12 [57′ E]: N; 52″ E, 13″ Ar. **6** 112;34,25: Ar; (seconds illegible: 1 or 30?) E, 24″ N. **7** 131;22,17: Ar; 15″ EN. **9** 168;51,37: A; 34″ E, 36″ N, 38″ r. **10** 187;39,29: Ar; 27″ EN. **23** 71;32,57 [38′ E, 33′ A]: N; 17″ E, 14″ A, 33′0″ r. **26** 127;53,20 [58′ E]: (perhaps most likely on paleographical grounds[19]); 9″ EAN, 24″ r. **29** 184;10,34 [174° A; ∗∗′ (21′ ?) E]: N; 24″ EA, 36″r. **30** 202;55,14: AN; ∗∗″ E, 17″ r. **Months**[20]: Shawwāl 15;37,14: Ar; 54″ E, 15″ N. Dhu ’l-Ḥijja 18;44,41: ANr; 45′15″ E. **Days**: **21** 1;6,44: A; 45″ EN, 43″ r.[21] **Hours**: -.

Remaining scribal errors in E and/or A: **Collected years**: **1** 213° E. **31** 47′ A. **151** 48° E. **301** 152° A. **331 – 571** and **661 – 871** (all degrees 20 too high except where noted) A. **601 – 811** (all degrees 40 too low except where noted) E. **+631** 165° A; 56″ E. **+691** 172° E, 241°57′ A. **+781** 120° A; 50″ E. **871** 218°…50″ E. **Extended years**: **4** 12″ E. **5** 48″

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[18] As for all mean motions, there are only minor differences between the sub-tables for days and hours in al-Battānī’s tables for the Arabic calendar and those in his tables for the Byzantine calendar.

[19] A sound correction on the basis of a recomputation or tabular differences is here basically impossible. Acceptable alternatives are also 19″ and 21″.

[20] To the sub-tables for months of all mean motion tables for the Arabic calendar Nallino has added an extra calculated entry for Dhu ’l-Ḥijja in a leap year, which is absent from the manuscripts; cf. (vol. II, p. 204, note to pag. 21).

[21] The correction into 44″ is mentioned by Nallino in his commentary (vol. II, p. 204). The basically identical sub-table for days in the table for Byzantine years shows the corrected value.

Mean motion of the northern lunar node in extended Arabic years							
arg.	accepted	error	Nallino	arg.	accepted	error	Nallino
1	18;44,41			16	300;13,53	–1	
2	37;32,32			17	318;58,34	–1	
3	56;17,12	–1		18	337;46,25	–1	
4	75; 1,52	–1		19	356;31, 6	–1	
5	93;49,43	–2		20	15;15,46	–2	
6	112;34,25		112;34,24	21	34; 3,36	–3	
7	131;22,17		131;22,15	22	52;48,17	–3	
8	150; 6,56	–1		23	71;32,57	–3	
9	168;51,37	–1	168;51,36	24	90;20,48	–4	
10	187;39,27	–2		25	109; 5,28	–4	
11	206;24, 8	–2		26	127;53,20	–4	127;53, 9
12	225; 8,49	–2		27	146;38, 2	–2	
13	243;56,39	–3		28	165;22,43	–2	
14	262;41,20	–2		29	184;10,34	–2	
15	281;26, 2	–1		30	202;55,14	–3	

Table 3: Sub-table for extended Arabic years from the table of the motion of the lunar node, with the values accepted by us, differences from a recomputation for a daily mean motion of 0;3,10,37,24,5,57 °/day, and Nallino’s values if different from ours.

E. **12** 59″ E. **13** 248° E. **15** 25′ EA. **16** 58′28″ E, 60°…23″ A. **17** 328°…24″ A. **19** 1′ E. **20** 35′ E. **22** 57″ A. **25** 0′ A. **27** 30′ E, 8′ A. **28** 48″ E. **Months**: Muḥarram 49″ E. Ṣafar 30′ E, 4′ A. Rabīʿ II 34′ E. Jumādā I 33′ E. Jumādā II 51″ E. Dhu ’l-Qaʿda 32′53″ E. **Days**: **4** 13′ E. **11** 35′50″ E. **13** 55″ E. **15** 60″ (sic!) A. **17** 34′ E. **18** 37′2″ E. **19** 43″ E. **25** 20″ A. **28** 19″ E. **30** 49″ E. **Hours**: **7** 1′ A. **16** 50″ E. **18** 33″ A.

3.5 Lunar equation of anomaly at apogee

Of the tables in the *Ṣābi’ Zīj* for the solar, lunar and planetary equations, al-Battānī can be assumed to have computed only very few. He calculated the solar equation on the basis of his new solar eccentricity 2;4,45^p, whose determination he describes in Chapter 28 of the *zīj* (cf. Nallino 1899 – 1907, vol. I, pp. 44 (translation) and 213 (commentary); vol. III, p. 223 (Arabic)). He computed the lunar equation of anomaly at apogee anew for the Ptolemaic epicycle radius but with values to seconds, and may have carried out his own calculation of the equation of centrum for Venus on the basis of the new maximum of 1°59′ which had been observed by Yaḥyā ibn Abī Manṣūr and the other astronomers involved in the compilation of the *Mumtaḥan Zīj* under the Abbasid caliph AL-MA’MŪN (c. 830).[22] Basically all other tables for the planetary equations in the *Ṣābi’ Zīj* were adopted from PTOLEMY’S *Handy Tables*, possibly through the intermediary of the earliest Arabic *zījes* with Ptolemaic planetary tables, of which the *Mumtaḥan Zīj* and the *Zīj* by ḤABASH AL-ḤĀSIB (c. 870) have survived.

For the tables that AL-BATTĀNĪ adopted from the *Handy Tables* we thus also have a number of earlier sources available. For the tables that were originally calculated by him, our main witnesses besides the Arabic and Castilian versions of the *Ṣābi’ Zīj* are the tradition of the *Toledan Tables* and incidental Arabic and Persian *zījes* that made use of AL-BATTĀNĪ’S work. For the lunar equation of anomaly, one of the tables for which NALLINO’S edition is furthest removed from what we may assume about AL-BATTĀNĪ’S original table, the witnesses include the *Mufrad Zīj* by Abū Ja‘far Muḥammad AL-ṬABARĪ (Persian, c. 1100, for Amul to the south of the Caspian Sea), and the *Īlkhānī Zīj* by Naṣīr al-Dīn AL-ṬŪSĪ (Persian, c. 1270, for Maragha).

Apparatus
Edition: N pp. 78 – 83. *Manuscripts*: E ff. 189v–192r; A ff. 52r–54v;[23] O ff. 48r–50v; C ff. 153r–154r; T pp. 1253 – 1258.[24] Also collated: F = *Mufrad Zīj*, ms. Cambridge University Library, Browne O.1, f. 105v; K = *Īlkhānī Zīj*, ms. Paris Bibliothèque Nationale de France, persane 163, ff. 34v–36r.[25] *Constructed values*: r = recomputation for epicycle radius 5;15^p.

Criteria: A likely value is a value whose error fits within its surroundings. In the parts of the table that were clearly computed by means of some form of interpolation (see below), this may include values with deviations of more than 10″ from the recomputation. Except in six cases of scattered evidence, a clear majority of the sources always favours a particular likely value, which we consequently accept.

Commentary: This table has numerous groups of five to ten consecutive errors of the same sign, in some parts of the table as large as 15″, which point to a heavy use of linear and/or quadratic interpolation. AL-BATTĀNĪ apparently adjusted the table around its maximum in order to obtain exactly the Ptolemaic maximum of 5;1,0°, whereas a correct calculation for the used epicycle radius 5;15^p would have led to a maximum of 5;1,11°. NALLINO states in his commentary (vol. II, p. 226) that he compared AL-BATTĀNĪ’S table to values recomputed by means of logarithms for every 6° and by means of interpolation in between. He notes some of the larger errors, in particular those of −12″ at argument 96 and of −11″ at argument 114, but, unlike his policy for some of the other tables here discussed, he refrains

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[22] Alternatively, the equation of centrum for Venus may simply have been rounded from the solar equation (cf. GOLDSTEIN and SAWYER 1967, pp. 167–168; TOOMER 1968, pp. 65 – 66), but there are two groups of deviations that do not support this assumption.

[23] In A the minutes of the values for arguments 71 – 87 and 104 – 107 have slid upwards by one row, so that readings of the minutes for arguments 71 and 107 are to be considered missing.

[24] On some intervals (28 – 40, 65 – 71, 88 – 89, 103, 130 – 145) T deviates significantly from the other sources, which may point to a systematic attempt to improve the Battanian table in parts where it has rather large errors. Accordingly, on these intervals T has been given less weight as a witness and is quoted between parentheses.

[25] The errors in F and K do not seem to depend on the errors in the other witnesses, nor to be correlated with the recomputed values.

Lunar equation of anomaly							
arg.	accepted	error	Nallino	arg.	accepted	error	Nallino
91	5; 0,26	–1		106	4;55,38	+4	
92	5; 0,44	–2		107	4;54,33	+4	4;54,34
93	5; 0,55	–5		108	4;53,20	+1	4;53,30
94	5; 0,59	–9		109	4;52, 0	–3	4;52,10
95	5; 1, 0	–11		110	4;50,33	–8	4;50,43
96	5; 0,57	–12		111	4;49, 2	–12	4;49,12
97	5; 0,49	–11	5; 0,45	112	4;47,26	–15	4;47,32
98	5; 0,37	–10		113	4;45,47	–15	
99	5; 0,21	–6		114	4;44, 6	–11	
100	5; 0, 1	–1		115	4;42,23	–4	4;42,24
101	4;59,32			116	4;40,31		
102	4;58,55	–1		117	4;38,31	+1	
103	4;58,11	–3		118	4;36,23	+1	
104	4;57,24	–2		119	4;34, 9	–1	
105	4;56,33			120	4;31,50	–1	

Table 4: Fragment of the lunar equation of anomaly at the farthest distance of the epicycle from the earth, with our accepted values, differences from the recomputation, and Nallino’s values if different from ours.

from correcting these errors in his transcription. In seven cases, here listed in a separate category, he omits to correct some rather obvious scribal errors, although he mentions three of these in his commentary. Between arguments 107 and 115, in the part of the table with the largest errors, four scribal errors in E caused him to introduce a number of corrections that can now easily be seen to be unjustified. Table 4 shows this most erroneous part of the table with the errors in al-Battānī’s tabular values and Nallino’s adjustments.

Scattered evidence (two likely readings each supported by two or more witnesses): **28** 2;11,4: E; 5″ ATN, 6″ OCK, 7″ F, 2″ r. **34** 2;36,43: EAKNr; 44″ OCF, 42″ T. **93** 5;0,55: ETFKN; 54″ AOC, 1′0″ r. **103** 4;58,11: AFKN; 51″ E, 12″ OCT, 14″ r. **122** 4;26,56 [27′ A]: EATN; 57″ OCFK, 58″ r. **167** 1;13,56 [14′ OC]: EKN; 57″ ATF, 53″ OC, 58″ r.

Practically certain values (a majority of the witnesses, or any easy corrections of them, agrees on a likely reading and at least one of the alternative readings is also likely but none of them is supported by two or more witnesses; this category also includes values for which the seconds in both E and A contain obvious scribal mistakes): **5** 0;24,7: AOCTKNr; 5″ E, 4″ F. **7** 0;33,44: AOCTFKr; 45″ EN. **25** 1;57,48: ETFKN; 4″ A, 47″ OC, 44″ r. **29** 2;15,26: OCFKN; 46″ E, 25″ A(T), 24″ r. **40** 3;1,4: EAOCFN; 3″ TK; 2″ r. **54** 3;51,7:

AOCTK; 30″ E, 4″ F, 6″ Nr. **55** 3;54,17: AOCTFK; 16″ ENr. **57** 4;0,24: AOCTFKr; 25″ EN. **62** 4;14,37: AOCTK; 36″ EN, 18″ F, 39″ r. **65** 4;22,24: EOCFN; 25″ A(T), 23″ Kr. **67** 4;27,7: EOCKN; 12″ A(T)r, 4″ F. **70** 4;33,54 [34′ OC]: AOCFK; 55″ EN, (51″ T), 52″ r. **87** 4;58,16: OCTFKNr; 56″ E, 26″ A. **97** 5;0,49: AOCTFK; 45″ EN, 1′0″ r. **126** 4;16,5 [17′ A]: AOCTFK; 6″ EN, 4″ r. **140** 3;26,57: OCFK; 7″ E, 56″ A, (52″ T), 58″ N, 27′0″ r. **158** 2;2,37: EOCKN; 36″ AT, 27″ F, 35″ r. **161** 1;46,44: AOTFKr; 45″ EN, 42″ C.

Scribal errors not corrected by NALLINO:[26] **35** 2;40,52: AOCT; 12″ EN, 50″ F, 51″ K, 53″ r. **36** 2;44,57: ACK; 45′17″ EN, 58″ O(T), 50″ F, 45′0″ r. **37** 2;49,2 [48′ C]: AOC(T)FK; 42″ EN, 4″ r. **41** 3;4,57: AOCTFK; 17″ EN, 56″ r. **61** 4;11,53: AOCTK; 33″ EN, 13″ F, 56″ r. **63** 4;17,18: AOCTFKr; 8″ EN. **73** 4;39,52: AOCTFKr; 38′ EN.

Other mistaken readings and corrections by NALLINO:[27] **19** 1;30,25 [26″ Fr]: EAOCTKFr; 31′ N. **107** 4;54,33 [(minutes missing) A]: AOCTFK; 24″ E, 34″ N, 29″ r. **108** 4;53,20: EAOCTK; 30″ N, 17″ F, 19″ r. **109** 4;52,0: EAOCTFK; 10″ N, 3″ r. **110** 4;50,33: AOCTFK; 13″ E, 43″ N, 41″ r. **111** 4;49,2: AOCTFK; 12″ EN, 14″ r. **112** 4;47,26: EAOCTK; 32″ N, 25″ F, 41″ r. **115** 4;42,23: AOCTFK; 34″ E, 24″ N, 27″ r.

Remaining scribal errors in E and/or A: **1** 55″ A. **13** 0′ A. **31** 26′ E; 9″ A, 30″ O, (1″ T). **45** 4″ A. **51** 56″ E. **52** 45′ E, 43′ C. **66** 25′ A; (51″ T). **69** 48″ A, (41″ T). **71** 34′ E, **′ A; (57″ T). **72** 36′ A. **82** 56″ E. **85** 59″ E. **101** 52″ A. **102** 59′ OC; 35″ E. **120** 7″ A. **121** 25′ E. **122–126** 27–25–22–19–17′ (minutes all one too large) A. **+122**: see under *Scattered evidence*. **+126**: see under *Practically certain values*. **139** 16″ E, (52″ T), 57″ F. **146** 53″ E. **151** 38′ OC; 39″ A. **154** 7″ E. **160** 51′ EOC. **163** 16″ E. **177** 4″, 13″ C.

3.6 Lunar latitude

AL-BATTĀNĪ used PTOLEMY'S standard method for calculating the lunar latitude based on the assumption that the Moon moves on a circle inclined to the plane of the ecliptic. He also used the Ptolemaic value for the maximum latitude, namely 5°. In some other Arabic and Persian *zījes* we find different methods of calculating the lunar latitude, such as the so-called method of sines, as well as different values for the maximum latitude, such as the *Mumtaḥan* value of 4°46′. Of the numerous Islamic tables for a maximum lunar latitude of 5°, none appear to be directly related to the table in the *Ṣābi' Zīj*. KŪSHYĀR displays values to minutes that were not simply rounded from those of AL-BATTĀNĪ, and the *Mufrad Zīj* includes a table whose values were computed by a different method and differ by up to 28″ from AL-BATTĀNĪ'S values for arguments around 40°. Our only other witnesses for this table are therefore found in the Castilian translation of the *Ṣābi' Zīj* and in the manuscript tradition of the *Toledan Tables*.

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[26] NALLINO mentions the errors for arguments 35–37 in his commentary (vol. II, p. 226), but not the others here listed. Only for arguments 35 and 36 do some of the witnesses attest to other likely values.

[27] The mistake at argument 19 is a misprint. NALLINO reports the mistakes for arguments 108–109 in his commentary as if they were readings in E (vol. II, p. 226). For arguments 107–115, see the sample values in Table 4.

Apparatus
Edition: N pp. 78–83. *Manuscripts*: E ff. 189v–192r; A ff. 52r–54v; O ff. 48r–50v; C ff. 153r–154r;[28] T pp. 1253–1258.[29] *Constructed values*: r = recomputation according to the standard formula $\beta(a) = \arcsin(\sin\beta_{\max}\cdot\sin a)$ for $\beta_{\max} = 5°$; s (for an argument a) = the symmetrical value (as accepted by us) for argument $180° - a$.

Criteria: A likely value is a value with a deviation of at most 2″ from the recomputation or, for parts of the table with larger errors, a value whose error fits within its surroundings. Except for seven values with scattered evidence, a majority of the witnesses for every value (and nearly always also the symmetrical value) agree on a likely reading, which we consequently accept.

Commentary: Al-Battānī’s lunar latitude table as we have restored it is rather accurate for arguments 0–10, 70–110 and 170–180, but shows groups of between five and ten consecutive errors of at most 5″ in all other parts of the table. Since consecutive errors usually have the same sign, it is plausible that these errors result from some kind of (quadratic) interpolation. The table has only three divergences from the symmetry $\beta(\lambda) = \beta(180° - \lambda)$, namely for arguments 15/165, 56/124, and 60/120; in two of these cases it concerns the highly common confusion of 6 and 7, in the third case the only slightly less common confusion of 4 and 6. For one pair of arguments, namely 61/119, the deviations in A and T are themselves symmetrical. Nallino states that he checked al-Battānī’s table against a recomputation by Schiaparelli (vol. II, p. 227). For his transcription he mainly corrected the obvious scribal errors in E, erring in six cases listed under *Practically certain values*. He somewhat unsuccesfully tried to improve the values for arguments 88–92 and those on the interval 131–138, but followed E faithfully in most other cases.

Scattered evidence: **61** 4;22,20 [21′ E]: EOCNs; 22″ AT, 18″ r.[30] **63** 4;27,14 [26′ EN]: TNrs; 54″ E, 19″ A, 15″ O, 16″ C. **89** 4;59,57: AOCrs; 54″ E, 58″ T, 56″ N. **91** 4;59,57: Ars; 54″ E, 52″ OC, 58″ T, 56″ N. **105** 4;49,44: ETNs; 45″ Ar, 42″ OC. **119** 4;22,20: EOCNs; 22″ AT, 18″ r.[31] **124** 4;8,36: EOCN; 37″ ATrs.

Rather certain values (a majority of the witnesses supports one likely reading, but one or more other readings are also likely): **36** 2;56,10: AOCTs; 11″ ENr. **60** 4;19,47: EOCTN; 46″ As, 44″ r. **149** 2;34,24 [35′ E]: AOCTs; 25″ EN, 22″ r. **158** 1;52,17: EOCTNs; 16″ Ar. **165** 1;17,34: EOCTN; 35″ A, 33″ r, 36″ s.

Practically certain values:[32] (the majority of the witnesses supports one likely reading, and any other readings can be explained as straightforward scribal mistakes): **15** 1;17,36: EAOCT; 33″ Nr, 34″ s. **25** 2;6,40: AOCTs; 17″ E, 37″ N, 39″ r. **28** 2;20,40: AOCTs; 5″

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[28] In OC the seconds of the values for arguments 41–54 have slid upwards by one row, so that a reading of the seconds for argument 41 is to be considered missing.

[29] The mainstream version of the *Toledan Tables* does not have significant systematic deviations from the version in the *Ṣābi’ Zīj*.

[30] A and T are symmetrical for arguments 61 and 119 in spite of these deviations; cf. argument 119.

[31] See the previous footnote.

[32] These are mostly scribal errors in E which were incorrectly restored by Nallino.

E, 39″ N, 42″ r. **88** 4;59,50: EOCTs; 5*″ A, 47″ N, 49″ r. **92** 4;59,50: EOCTs; 30″ A, 47″ N, 49″ r. **101** 4;54,28: AOCTrs; 23″ E, 27″ N. **103** 4;52,17: AOCTs; 40″ E, 16″ N, 18″ r. **164** 1;22,35: AOCTs; 30″ E, 34″ N, 36″ r.

Corrections by Nallino *on the interval 131 – 138*:[33] **131** 3;46,17: AOCTrs; 40″ E, 20″ N. **132** 3;42,49: EAOCTrs; 51″ N. **133** 3;39,17: AOCTrs; 40″ E, 20″ N. **134** 3;35,41 [34′ E]: EAOCTs; 51″ N, 40″ r. **135** 3;32,0: EAOCTrs; 10″ N. **136** 3;28,15: AOCTs; 55″ E, 35″ N, 16″ r. **137** 3;24,27 [25′ E]: EOCs; 26″ AT, 47″ N, 28″ r. **138** 3;20,35: AOCs; 30″ E, 36″ Tr, 55″ N.

Values with scribal errors or illegible digits in the seconds in both E and A: **29** 2;25,17: OCTNs; 57″ E, 14″ A, 18″ r. **115** 4;31,49: OCTNs; 4*″ E, 59″ A, 50″ r. **116** 4;29,34: OTNrs; **″ E, 59″ A, 39″ C. **117** 4;27,14: OCTNrs; **″ E, 19″ A.

Remaining scribal errors in E and/or A: **1** 53″ A, 14″ C. **5** 25′50″ E. **12** 36″ E. **19** 34′ E; 26″ O, 36″ C. **27** 12″ E. **30** 32″ A. **31** 35′ A. **32** 12″ A. **33** 57″ OCT. **35** 16″ A, 57″ T. **43** 25′ A; 26″ T. **44** 55″ E. **52** 56″ E. **53** 58″ E. **56** 9′ E. **58** 15′ E. **64** 30″ E. **65** 44″ E. **72** 44′ A. **79** 48″ E, 39″ OC. **81** 14″ E, 27″ OC. **82** 7″ E. **87** 19′ A. **99** 57″ E. **110** **′ E. **113** 37′ E. **121** 30″ A. **143** 2°58′ (sic!) E. **144** 3° A. **146** 46′ E. **147** 48′ A. **159** 46′ E. **161** 36′ E. **175** **″ E, 6″ T. **179** 53″ E.

4. Conclusion

Our sample edition and apparatuses for a number of tables from al-Battānī's *Ṣābi' Zīj* have shown a wide variety of tabular characteristics and editorial difficulties, and a corresponding variety of policies by Nallino to deal with these in his extensive study (1899 – 1907).

The tables discussed include highly accurate ones, such as the sine (Section 3.1) and the cotangent (3.2); generally accurate ones with incidental systematic deviations which may be due to erroneous interpolation, such as the half excess of longest daylight (3.3); rather inaccurate tables with irregular errors, such as the solar declination (Section 2); tables that are accurate in many parts but have irregular groups of errors in other parts, such as the lunar equation of anomaly (3.5) and the lunar latitude (3.6); and a sub-table of the table for the motion of the lunar node with relatively large but more or less regular errors (3.4).

Having to deal with these characteristics on the basis of the Escorial manuscript only, Nallino resorted to various strategies. Sometimes he explains these in his commentary, but in other cases we need to infer them from the values in his transcription of the tables. He appears to have had two basic policies for dealing with tabular values with larger errors, whether computational or scribal: correction into values recomputed by Schiaparelli, and correction into paleographically likely values. He applies corrections into recomputed values in particular in the tables for the solar declination (in which every error of 2″ or more is emended), the sine, and the cotangent. On the other hand, he does not correct the

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[33] Nallino introduces additional errors in an attempt to correct four scribal errors on the interval 131 – 138. Note that the symmetrical values for arguments 42 to 49 are basically correct.

larger errors in the tables of the lunar equation of anomaly and the lunar latitude. Especially in the table of the solar declination NALLINO mixes his two approaches: he corrects into paleographically likely values if these are at most 1″ removed from the recomputation, otherwise into recomputed values. In the lunar tables in particular, NALLINO introduces additional errors in an attempt to correct some unclear scribal errors in the Escorial manuscript. Also in various other cases a proper correction was simply impossible for him on the basis of the single source that he had available.

Even though the tables discussed here reflect some of the most obvious problems in NALLINO'S transcription, caution is required for many other tables as well. We may conclude that a new, critical edition of the tables from the *Ṣābi' Zīj*, taking into account in particular the Castilian translation of the *zīj* and the tradition of the *Toledan Tables*, is highly desirable. Until this is available, researchers interested in a more detailed comparison of AL-BATTĀNĪ'S tables with other sources or in an analysis of their mathematical properties are recommended to consult the manuscripts of the Arabic and Castilian versions of the *zīj* and the second author's edition of the *Toledan Tables* besides NALLINO'S monumental study.

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