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STAR CATALOGUES AND STAR TABLES IN MEDIAEVAL ORIENTAL AND EUROPEAN ASTRONOMY*

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In mediaeval times, the knowledge of the fixed stars became manifest mostly in catalogues and tables of these stars. Apart from that, a major point of discussion, in this connexion, was precession which had been fixed at a rate of 1° in 100 years by Ptolemy, a value which was later improved to 1° in 66 or 70 years by Islamic astronomers.[1] In addition to precession, some astronomers also pursued the theory of trepidation which, however, was not accepted by Ptolemy and consequently not by most of the great astronomers in Islamic astronomy.

For convenience, in the following discussion we shall basically distinguish between star catalogues and star tables. Star catalogues will be the complete long lists of the fixed stars following the model of Ptolemy's catalogue in the *Almagest*, whereas star tables will be the smaller lists of fundamental or otherwise important stars, often devised for the astrolabe, and mostly containing from 20 to 70 or so stars.

The model for cataloguing the fixed stars had been set up by Ptolemy. In books vii and viii of the *Almagest* he had listed 1,025 fixed stars with their ecliptical coordinates and magnitudes, arranged in 48 constellations, for the epoch 137 A.D.[2] This catalogue of stars visible to the naked eye became the standard model for describing the fixed stars both in the Islamic Orient and in mediaeval Europe until the invention of the telescope, which led to a new view of the stellar sky and to the formation of new types of star catalogues.

Together with many other scientific works of ancient Greek and Hellenistic times, the *Almagest* was translated into Arabic several times from the late 8th to the late 9th centuries.[3] These Arabic versions of Ptolemy's work, called *al-majasṭī* by the Arabs[4] (and hence *Almagest* by the Europeans[5]), became of greatest influence in the development of scientific astronomy in the Arabic-Islamic civilization. Two

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of these translations have survived, in manuscripts form, till our times, the one by al-Ḥajjāj ibn Yūsuf ibn Maṭar, and the other by Isḥāq ibn Ḥunayn (with emendations by Thābit ibn Qurra). A critical edition of the star catalogue from these two Arabic translations is presently under preparation.[6]

All the succeeding star catalogues in the Islamic world imitated Ptolemy's catalogue in every detail—the numbers of the stars and constellations, their distribution, the nomenclature, and the coordinates and locations of the stars. The most famous star catalogues in the Islamic world are those of al-Battānī, al-Ṣūfī, al-Bīrūnī, and Ulugh Bēg, to which can be added Naṣīr al-Dīn al-Ṭūsī's recension of the *Almagest* completed in 1247 which again repeated the *Almagest* catalogue (in Isḥāq ibn Ḥunayn's translation).

The star catalogue of al-Battānī is prepared for the epoch 880 and uses a longitude value of ≪ Ptolemy + 11°10′ ≫ applying the improved Arabic precession constant of 1° in 66 years. Of Ptolemy's 1,025 stars, al-Battānī has retained only 533, that is slightly more than a half. The catalogue has been edited and incorporated in al-Battānī's complete astronomical work by Carlo Nallino,[7] who also added a modern Latin translation of his own. In mediaeval times, only the accompanying text had been translated into Latin, but not the star catalogue. However, an Old-Spanish translation made in the time of King Alfonso X of Castile also includes the star catalogue, and Nallino has incorporated in his edition two missing pages in the Arabic text from that Old-Spanish translation. Recently it has been found that Nallino committed a fundamental error in establishing the coordinates of al-Battānī's star catalogue; the reason was that at his time he had no full knowledge of the Arabic transmission of the *Almagest*. Therefore, erroneously, he emended many of the coordinates in the unique Arabic manuscript of al-Battānī's work according to the values found in some versions of the *Almagest* accessible to him. He failed to notice that al-Battānī had not followed those more recent versions. A few years ago, the evaluation of an Arabic critic of the transmission of the coordinates in Ptolemy's star catalogue by the Islamic scholar Ibn al-Ṣalāḥ of the first half of the 12th century[8] has proved that al-Battānī had used the so-called "old Arabic version" of the *Almagest* which has not survived in direct tradition.[9] Thus, it has become evident that most of the coordinate values found in al-Battānī's manuscript, which were emended by the editor Nallino according to more recent versions of the *Almagest*, were in fact correct and derived from the "old version" as cited by that 12th century author. The star catalogue in Nallino's edition, therefore, can no longer be regarded as reliable.

al-Ṣūfī, of Persian origin, is most famous for his *Book on the constellations of the fixed stars*.[10] For each of the 48 Ptolemaic constellations, this work contains first, a general description of the constellation and its individual stars including al-Ṣūfī's

criticism, especially with regard to star positions, or magnitudes; second, a section on the indigenous Arabic star names falling under the respective Greek constellation, and the identification of the indigenous Arabic names with the respective stars of Ptolemy's catalogue; third, two drawings of the constellation, one as it is seen in the sky, and one as it is seen on a celestial globe; and fourth, a table of the stars making up the constellation. These 48 tables together form a complete star catalogue. al-Ṣūfī also applies the Arabic precession constant of 1° in 66 years and uses, for his epoch 964, a longitude value of ≪ Ptolemy+12°42′ ≫. As explained in his own introduction, he did not follow one specific Arabic version of the *Almagest*, but rather drew upon all the versions available to him, because he had realized that the various versions were often in disagreement and so he selected what seemed appropriate to him. al-Ṣūfī's work was of great influence not only in the Islamic Orient but also—as we shall see later—in mediaeval and Renaissance Europe.

The same attitude towards the *Almagest* was displayed by al-Bīrūnī who included in his astronomical *magnum opus*, the *Qānūn al-Mas'ūdī*,[11] the full catalogue of Ptolemy's stars, using for his epoch 1030 a longitude value of ≪ Ptolemy+13° ≫. He selected values that appeared suitable to him from the various Arabic versions of the *Almagest*. In the terminology and nomenclature of the stars, he abbreviated much of the lengthy formulae of the *Almagest* and introduced many new short or less complicated designations.

Ulugh Bēg, who for a short time (1447-49) was the ruler of Tīmūr's Mongol empire, had assembled a number of outstanding astronomers at his court who constructed for him the observatory at Samarcand and who composed under his supervision an astronomical work, which also contained the full catalogue of Ptolemy's stars. In the introduction to his star catalogue Ulugh Bēg says that he especially relied upon al-Ṣūfī's work, but when he found discrepancies between al-Ṣūfī's indications and the actual situation in the sky he preferred to repeat himself the observation of all those stars with the exception of a small number of stars invisible to him at Samarcand and which he listed in his catalogue by merely adding a precession constant of 1° for 70 years to Ptolemy's longitudes, for the epoch 1437. The Persian text of Ulugh Bēg's catalogue was edited, together with a Latin translation and an ample commentary, by Thomas Hyde.[12] (In the commentary Hyde quoted a great number of Arabic star names from al-Ṣūfī's work many of which were later introduced into modern astronomical use by Giuseppe Piazzi, 1814.[13]) In 1917, E.B. Knobel published in Washington an English version of the catalogue,[14] including recensions of the coordinates from a large number of manuscripts. For the star nomenclature Knobel followed Schjellerup's French translation of al-Ṣūfī's book of 1874. Knobel's philological comments on Ulugh Bēg's Persian nomenclature are often erroneous and incorrect.

The star nomenclature used by Ulugh Bēg is partly Persian, translated from the Arabic, but partly the original Arabic terms have been retained. Recently I have observed that the textual descriptions of the stars in Ulugh Bēg's catalogue are obviously not the work of Ulugh Bēg. It is known that Naṣīr al-Dīn al-Ṭūsī, whose recension of the *Almagest* of 1247 we have mentioned above, completed perhaps in 1250 a Persian translation of al-Ṣūfī's *Book on the constellations of the fixed stars.* There exists, in Istanbul, a manuscript of al-Ṭūsī's translation (*i.e., Aya Sofya* 2595, 104 folios, stemming from Ulugh Bēg's library) dated at that very date (1250),[15] and it has been assumed by some scholars that it might be al-Ṭūsī's autograph. This manuscript has been edited, in facsimile, in Teheran in 1969.[16] The question whether the Istanbul manuscript is indeed al-Ṭūsī's autograph or not, is still in dispute. I own a copy of the facsimile edition, and I must confess that I have strong doubts about its being an autograph of al-Ṭūsī's. (There exists also a printed edition from that same manuscript published in Teheran, 1972,[17] of which I was unable to obtain a copy.) Whatever be the question of the autograph—anyhow, here we have the text of al-Ṭūsī's Persian translation of al-Ṣūfī's work. A detailed comparison between al-Ṭūsī's translation and Ulugh Bēg's catalogue shows that Ulugh Bēg repeats literally the mixed Persian-Arabic descriptions of the stars given by al-Ṭūsī. Thus, it can be taken for granted that Ulugh Bēg did not commit himself to the translation of al-Ṣūfī's Arabic work, or rather his texts of the star descriptions, but instead he merely used and copied the earlier Persian translation of al-Ṭūsī. Ulugh Bēg's own contribution then lies in the new observation of the stars and the fixing of their coordinates according to his observations of 1437.

So much on the most important star catalogues of the Islamic Orient. Let us now turn to mediaeval Europe.

Here also Ptolemy's *Almagest* formed the basic model for star catalogues which was followed down to Copernicus, and till the invention and astronomical application of the telescope.

Mediaeval Europe, as is well known, had almost totally lost its contact with the Greek sources. Works of Greek or Hellenistic origin were only read in Latin translations. Thus, the first Latin translation of the *Almagest* in Europe was made in Sicily, from the Greek, around 1160 as had been assumed earlier, or before 1154 by Hermannus de Carinthia as is at present assumed by Richard Lemay.[18] This translation remained without an echo in Europe. Presently, there are known only two fragmentary manuscripts of it, and one complete manuscript (Vat. lat. 2056, 13th cent.).

Later, perhaps in 1175, in Toledo, Gerard of Cremona translated the *Almagest* from the Arabic into Latin. This translation became the standard version known and used in Western Europe till Renaissance times when Greek texts started again

to become available.[19] Around 50 manuscripts of this version are still known today, 35 of which complete with regard to the star catalogue. In 1515, this version was printed in Venice. A critical edition of Gerard's version of the star catalogue is at present under preparation.[20]

An Old-Spanish version of Ptolemy's star catalogue was later included in King Alfonso X's astronomical work *Libros del saber de astronomia*, using the Alfonsine longitude value of $\ll$ Ptolemy$+17°8' \gg$. It has not yet been investigated from which sources this translation was made, but certainly Arabic texts were involved. This translation remained without any visible influence on the subsequent European astronomy. The catalogue is included, in the form of *ruedas* (*i.e.*, the stars of each constellation being arranged in the form of a rosette) in vol. i of Manuel Rico y Sinobas' edition of the *Libros del saber*, Madrid, 1863. The edition, unfortunately, is unreliable in matters of spelling and philology. Around 1341, an Old-Italian translation of the *Libros del saber* was made in Florence which has survived in a unique manuscript (Vat. lat. 8174). Book i from it, including the star catalogue, has been edited by P. Knecht in Zaragoza, 1965.[21]

Ptolemy's star catalogue in Gerard of Cremona's Latin translation was so much favoured in Europe that it was also included in or appended to some other astronomical collections.

One of these are the so-called *Alfonsine Tables*. The Spanish original text of these tables has not survived ; only the theoretical introduction is still extant, and it was included by Rico y Sinobas in vol. iv of his edition of the *Libros del saber* (though not forming part of the *Libros* proper). The form generally known in Western Europe as the *Alfonsine Tables* is a collection of planetary and other tables, in Latin, that were composed, under circumstances still insufficiently known, in Paris in the 1320ies.[22] To this Latin corpus of the *Alfonsine Tables*, of which innumerable manuscripts exist and many printed editions were published between 1483 and 1641,[23] was also added a star catalogue. This catalogue is nothing else than Gerard of Cremona's version of the *Almagest* catalogue, with the longitudes of the stars adapted to the Alfonsine value, *i.e.* $\ll$ Ptolemy$+17°8' \gg$.

Secondly, there exists a mediaeval European tradition of al-Ṣūfī. This so-called *Ṣūfī Latinus* is a compilation of disparate astronomical and astrological elements only some of which are really related to al-Ṣūfī. The fundamental section is a star catalogue accompanied by drawings of the 48 constellations, one drawing of each constellation, variously selected from al-Ṣūfī's two drawings of each of them. The star catalogue again proves to be Gerard of Cremona's Latin translation of the *Almagest* catalogue, with the longitudes of the stars adapted to al-Ṣūfī's value, *i.e.* $\ll$ Ptolemy$+12°42' \gg$. Of the *Ṣūfī Latinus* till now eight manuscripts have come to light.[24]

Thus, the leading specimens of star catalogues in Europe, until Copernicus' time, in the *Almagest* itself, in the *Alfonsine Tables*, and in the so-called *Ṣūfī Latinus* tradition, are all formed by one single text, Gerard of Cremona's Latin translation of the *Almagest* star catalogue. Of these, the catalogue appended to the *Alfonsine Tables* was the most popular. It was often copied alone by itself, without the other pertaining tables, and was inflated by later authors with star and constellation names compiled from various astronomical and astrological sources.[25]

Now regarding star tables. These minor star lists are so frequent both in the Islamic Orient and in mediaeval Europe that it is impossible to go here into details.

In the Islamic Orient nearly every astronomer composed one or the other star table. Of the most frequent types of such tables, I shall name the following.

A very common kind of astronomical works in the Orient are the so-called *Zījes*.[26] These usually consist of a theoretical introduction and a collection of astronomical tables, for chronology, for the planets, sun and moon, *etc.* Mostly, a star table is also included. The star tables in the *zīj*-works mostly are merely the result of computation or compilation, and not the result of independent star observation. Most of them use ecliptical coordinates which are derived from the *Almagest* tradition by adding to the longitudes one of the constants for precession, current in the Islamic Orient.

Very rare, both in the Orient and in mediaeval Europe, are the cases of independent star observation and resulting star tables.

One example in the Islamic world for independent star observation is the observations carried out by the order of the Abbaside caliph al-Ma'mūn. The results of these observations including a table of 24 stars are laid down in the so-called *Zīj al-Mumtaḥan* (or, in Latin translation, *Tabulae Probatae*) for the epoch 829/30. The table has been printed, in translation, by J. Vernet in 1956.[27] This independent star table, afterwards, had the same fate as Ptolemy's catalogue, *i.e.* it was used as a basis for other star tables that were merely compiled and computed from its values. To the star tables derived from the *Mumtaḥan* star table of 829/30 belong, as I have demonstrated in an article published in 1970,[28] the astrolabe star list of al-Farghānī (25 stars, epoch 856/57) ; a table of 30 stars in the *Zīj* of Ḥabash for the epoch 916/17 (I refer to the Berlin MS, Ahlwardt no. 5750) ; and even two star tables translated into Greek, in Byzantine times, found in cod. Vat. gr. 1056 (14th cent.).

Other independent Islamic observations were made by al-Ṣūfī. As for Ulugh Bēg and his presumed observations, these still need closer investigation to make sure whether his star coordinates are really the result of his own observations,

or merely computed from earlier existing catalogues, especially from al-Ṣūfī's catalogue.

Since I mentioned Byzantine Greek translations of Arabic star tables, I can add that two other Islamic star tables, that of al-Khāzinī in his *Zīj al-Sanjarī* (epoch 1115) and that of al-Ṭūsī in his *Zīj-i Īlkhānī* (epoch 1232), exist in Greek translation in several manuscripts, included in the so-called *Persian Syntaxis* of Georgios Chrysokokkes from the middle of the 14th century. (They have been edited, in their Arabic and Greek versions, in an article in 1964.[29])

Another frequent type of Islamic star tables are lists of astrolabes tars. Their stars are often accorded, apart from the usual eliptical coordinates, equatorial coordinates which were preferred for practical use on the instrument. The equatorial coordinates mostly show values up to the smallest units of minutes which never could be obtained by observation in those times. The explanation is that these equatorial coordinates were derived through calculation from the well established ecliptical coordinates. The same holds good for similar star tables in mediaeval Europe.

Still another type of star tables consists of mere extracts from complete great star catalogues, as for example, a table of 48 stars by Kūshyār ibn Labbān extracted from the *Almagest* (in the Berlin MS Ahlwardt no. 5751, epoch 932), or a table of 81 stars by al-Kharaqī (in the Berlin MS Ahlwardt no. 5669, epoch 1112) derived from al-Ṣūfī's work on the constellations.

In mediaeval Europe such minor star tables were initially introduced through translations of Arabic tables. Thus, the oldest western star table is a list of 27 astrolabe stars derived from an Arabic model, datable to the late 10th century, in Spain. Its coordinates are *mediatio coeli* (*i.e.*, the degree of the ecliptic culminating together with the respective star), which were derived from Arabic models, and a second value of a non-traditional character which could only be read off from an astrolabe.[30] Very old is also a table of 21 astrolabe stars for the epoch 978 by the Spanish-Arabic astronomer Maslama al-Majrīṭī of which a Latin translation (of uncertain origin)[31] and an expanded Latin version of 45 stars[32] have been transmitted. Succeeding to such translated tables, European astronomers compiled and composed their own star tables using the translated shorter tables or the complete Ptolemaic catalogue as models.

The main types of star tables composed and circulated in mediaeval Europe were lists of astrolabe stars or stars to be used on other instruments such as the quadrant or the celestial globe, and star tables extracted from Ptolemy's catalogue, mostly in that recension of it which was included in the *Alfonsine Tables*. Works of the Arabic *zīj*-type are not frequent in Europe. Of this kind, we could mention the *Toledan Tables* (compiled from material translated from the Arabic)[33] in which

several types of star tables were included, all of which translated from the Arabic, *viz.* from various recensions of a star table of the Spanish-Arabic astronomer al-Zarqāllu (or, in Latin, Azarchel; d. 1100).

The most frequent work of the *zīj*-type circulated in Europe were the so-called *Alfonsine Tables*, in the Latin version composed in Paris in the 1320ies. To these was added Ptolemy's star catalogue in the wording of Gerard of Cremona's Latin translation from the Arabic, as mentioned above.

17 types of European star tables from the tenth to the fourteenth centuries have been edited by myself in a book in 1966,[34] some of which being translations from the Arabic, together with their Arabic originals.

Star tables resulting from independent observation are equally rare in mediaeval Europe as in the Islamic Orient. Most of the tables were formed by merely adding a constant for precession to the Ptolemaic ecliptical coordinates, or by transforming given ecliptical coordinates through calculation into equatorial coordinates. A rare instance of independent observation is found in the table of 40 stars with ecliptical coordinates observed by means of an armillary sphere in Paris in 1246 by John of London. In another paper in "Colloquium 91" a few days ago, I spoke at length about John of London's star table.[35] It has been transmitted in several manuscripts. Many of the new Arabic star names introduced by John of London are still used today in modern international astronomy. Several stars of his table were merged, a few years later, together with a number of stars of the oldest European star table from the end of the 10th century, into a new list of 49 astrolabe stars (with coordinates *mediatio coeli* and declination) which was appended to and transmitted together with the astrolabe treatise commonly ascribed to the Arabic astronomer and astrologer Messahalla.[36] This ascription has been demonstrated to be false; the entire text is a compilation of the middle or second half of the 13th century from various translated Arabic or other compiled Western astrolabe writings.[37] But Pseudo-Messahalla's treatise became the most famous and most widely spread astrolabe treatise in late mediaeval Europe and, therefore, that offspring from John of London's star table also became one of the star tables with the richest transmission in Europe.

At the end it must be underlined that our present knowledge of mediaeval astronomy, both in the Islamic Orient and in Europe, is still utterly restricted. The major part of the material still remains unread, unstudied, and unpublished, in the libraries of all the world. It may seem that the main lines of transmission from classical antiquity to the Islamic Orient and further on to mediaeval Europe are now sufficiently clear. Nevertheless, many details still lack documentary evidence not to speak of the minor works and unknown or lost writings which might come to

light some day. Therefore, it remains a duty for many generations to come to examine carefully the treasures of the libraries in all the world and to publish as many as ever possible of the original sources in all the languages involved.

References and Notes

[1]*Cf.* Nallino (as in note 7, below), vol. i, p. 292f.

[2]A recent English translation is *Ptolemy's Almagest*, Translated and Annotated by G. J. Toomer, London, 1984.

[3]For a study of the various Arabic translations of the *Almagest* see P. Kunitzsch, *Der Almagest. Die Syntaxis Mathematica des Claudius Ptolemäus in arabisch-lateinischer Überlieferung*, Wiesbaden, 1974.

[4]*See* Kunitzsch, *op. cit.*, pp. 117–125.

[5]*See* Kunitzsch, *op. cit.*, pp. 115–117.

[6]Claudius Ptolemäus, *Der Sternkatalog des Almagest. Die arabisch-mittelalterliche Tradition.* vol. i: *Die arabischen Übersetzungen.* Herausgegeben und bearbeitet von P. Kunitzsch, Wiesbaden, 1986.

[7]*Al-Battānī sive Albatenii opus astronomicum*, Ed. and Transl. by C. A. Nallino, i–iii, Milan, 1899–1907; repr. Hildesheim/New York, 1977.

[8]Ibn aṣ-Ṣalāḥ, *Zur Kritik der Koordinatenüberlieferung im Sternkatalog des Almagest*, Ed. and Transl. by P. Kunitzsch, Göttingen, 1975.

[9]*Cf.* P. Kunitzsch, New Light on al-Battānī's *Zīj*, *Centaurus*, **18**, 270–274, 1974; *idem*, in the work cited in note 8, Appendix II, pp. 97–108.

[10]*Ṣuwaru'l-Kawākib or Uranometry*, Published by the Dairatu'l-Ma'arifi'l-'Osmania, Hyderabad/Dn., 1373/1954; repr. Beirut, 1981; French transl. by H. C. F. C. Schjellerup, *Description des étoiles fixes...par...Abd-al-Rahman al-Ŝûfi*, St. Pétersbourg, 1874.

[11]*Al-Qānūn al-Mas'ūdī*, Published by the Dairatu'l-Ma'arifi'l-'Osmania, i–iii, Hyderabad/Dn., 1373–75/1954–56.

[12]*Tabulae longitudinis ac latitudinis stellarum fixarum, ex observatione Ulugh Beighi*, Ed. and Transl. by Thomas Hyde, Oxford, 1665.

[13]G. Piazzi, *Praecipuarum stellarum inerrantium positiones...*, Palermo, 1814.

[14]E. B. Knobel, *Ulugh Beg's Catalogue of Stars*, Washington, 1917.

[15]*Cf.* M. Krause, *Stambuler Handschriften islamischer Mathematiker*, Berlin, 1936 (Quellen und Studien zur Geschichte der Mathematik Astronomie und Physik, Abt. B: Studien, Bd. 3, Heft 4), p. 498 (work no. 20).

[16]*Tarjama-i ṣuwar-i kawākib*, be qalam-i Khwāja Naṣīr al-Dīn-i Ṭūsī, Tehran, 1348 Sh. (= 1969).

[17]Ed. by Sayyed Mo'ezz al-Din Mahdavi, Tehran, 1351 Sh. (= 1972).

[18]A paper by R. Lemay, "Hermann de Carinthe, auteur de la traduction "sicilienne" de l'*Almageste* à partir du grec", is presently in preparation.

[19]For a study of Gerard's Latin translation see the work cited in note 3, above.

[20]It will appear later as vol. ii of the work cited in note 6, above.

[21]P. Knecht, *I libri astronomici di Alfonso X in una versione fiorentina del trecento*, Zaragoza, 1965.

[22]*Cf.* the introduction to the recent edition by E. Poulle, *Les Tables Alfonsines avec les canons de Jean de Saxe*, Paris, 1984. (This edition does not include the star catalogue.)

[23]For my studies of the star catalogue, I have used the following editions : Venice 1483; Venice 1492; Venice 1518 (but at the end of the book : 1521); Venice 1524; Paris 1545; Paris 1553; and Madrid 1641.

[24]*Cf.* P. Kunitzsch, Ṣūfī Latinus, *Zeitschrift der Deutschen Morgenländischen Gesellschaft*, **115**, 65–74, 1965. Here, six manuscripts are mentioned. In the meantime, two more manuscripts have been found : Berlin, Hamilton, cod. 556 (78 D 12); and Gotha, cod. M II 141. From the latter, the drawings of the 48 constellations have been edited, in facsimile, by G. Strohmaier, *Die Sterne des Abd ar-Rahman as-Sufi*, Leipzig/Weimar, 1984.

[25]A good example of that inflated type is in Vienna, cod. Lat. 5415 (dated 1444), fol. 217r–251r.

[26]*Cf.* E. S. Kennedy, *A Survey of Islamic Astronomical Tables*, Philadelphia, 1956 (Transactions of the American Philosophical Society, N.S., vol. 46, part 2).

[27]J. Vernet, Las 'Tabulae Probatae', in *Homenaje a J. M. Millás Vallicrosa*, ii, Barcelona, 1956, pp. 501ff., esp. p. 519.

[28]P. Kunitzsch, Die arabische Herkunft von zwei Sternverzeichnissen in cod. Vat. gr. 1056, *Zeitschrift der Deutschen Morgenländischen Gesellschaft*, **120**, 281–287, 1970.

[29]P. Kunitzsch, Das Fixsternverzeichnis in der 'Persischen Syntaxis' des Georgios Chrysokokkes, *Byzantinische Zeitschrift*, **57**, 383–406, 1964.

[30]Edited and discussed as "Type III" in the work cited in note 34, below.

[31]It is "Type I" in the work cited in note 34, below.

[32]"Type II" in the work cited in note 34, below.

[33]*Cf.* G. J. Toomer, A survey of the Toledan Tables, *Osiris*, **15**, 1968.

[34]P. Kunitzsch, *Typen von Sternverzeichnissen in astronomischen Handschriften des zehnten bis vierzehnten Jahrhunderts*, Wiesbaden, 1966.

[35]It will be published in the "Proceedings" of that Colloqium. See also P. Kunitzsch, John of London and his unknown Arabic source, *Journal for the History of Astronomy*, **17**, 51–57, 1986.

[36]It is "Type VIII" in the work cited in note 34, above.

[37]*Cf.* P. Kunitzsch, On the authenticity of the treatise on the composition and use of the astrolabe ascribed to Messahalla, *Archives Internationales d'Histoire des Sciences*, **31**, no. 106, 42–62, 1981; M. Viladrich, On the sources of the Alphonsine Treatise Dealing with the Construction of the Plane Astrolabe, *Journal for the History of Arabic Science*, **6**, 167–171, 1982.