The Oldest Translation of the Almagest Made for al-Maʾmūn by al-Ḥasan ibn Quraysh: A Text Fragment in Ibn al-Ṣalāḥ's Critique on al-Fārābī's Commentary

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Ptolemy's Science of the Stars in the Middle Ages

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In memory of Paul Kunitzsch (1930-2020)

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The Editors

II. The Arabic Tradition

The Oldest Translation of the *Almagest* Made for al-Maʾmūn by al-Ḥasan ibn Quraysh: A Text Fragment in Ibn al-Ṣalāḥ's Critique on al-Fārābī's Commentary

Johannes Thomann

1. Life and times of Ibn al-Ṣalāḥ (d. 1154 CE)

The first half of the twelfth century was a pivotal time in Western Europe. In that period translation activities from Arabic into Latin became a common enterprise on a large scale in recently conquered territories, of which the centres were Toledo, Palermo and Antioch. This is a well known part of what was called the Renaissance of the Twelfth Century.[1] Less known is the situation in the Islamic World during the same period. Traditionally it was denounced as post-classical, implying some kind of decadence. Politically it was the time when the Seljuqs had surpassed their apogee of power, but still dominated the Islamic East from Syria to Central Asia. The Christian kingdom of Jerusalem in the recently conquered territories was a zone of permanent conflicts, but formed only part of the periphery. The territory of the Fatimids was reduced to Egypt. In the West the Almoravids were about to extend their empire in the Maghreb towards al-Andalus.[2]

Concerning the mathematical disciplines, the first half of the twelfth century has been called the age of Omar Khayyam.[3] His works on geometrical solutions of algebraic problems are famous, and a number of other treatises document a broad field of scientific activities.[4] He was active in Central Asia in the Eastern part of the Seljuk Empire.[5] In this area a great number of lesser-known mathematicians were active, and it must be seen as one of the two main centers of mathematical science at the time.[6] The other center was al-Andalus, where an even greater number of mathematicians were active.[7] Among

[1] Haskins, *The Renaissance*, pp. 278–302.
[2] Kennedy, *An Historical Atlas*, p. 10.
[3] Sarton, *Introduction*, vol. I, pp. 738–83.
[4] *MAOSIC*, pp. 168–70 (No. 420).
[5] Aminrazavi, *The Wine of Wisdom*, pp. 18–31.
[6] *MAOSIC*, pp. 168–86 (Nos 420, 423–26, 435, 437–39, 443, 450, 453, 458–59, 461, 467, 469, 471, 473–76, 484, 489).
[7] *MAOSIC*, pp. 168–86 (Nos 422, 428, 431, 433–34, 436, 440–42, 448–49, 452, 455, 462, 464, 468, 477, 479–80, 483, 486).

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these only Jābir ibn Aflaḥ became famous, since his commentary on the *Almagest* was translated into Latin.[8]

Baghdad had lost its position as the primary place of learning in the Islamic world. However, it attracted still some students of the sciences. Even though it was not the home of eminent scholars, there must have been exceptionally rich and valuable treasures of books available. One of those who took profit of these treasures was Abū l-Futūḥ Aḥmad ibn Muḥammad ibn al-Sarī, called Ibn al-Ṣalāḥ.[9] According to his biographers he was a Persian, born in Hamadān in Western Iran, who came to Baghdad and had gained a reputation as a physician.[10] In this quality he went to the court of Temür Tāsh ibn Īl Ghāzī, the Artuqid ruler at Mārdīn (r. 1122–1154 CE). Towards the end of his life he moved to Damascus, which was ruled by the Börid Atabeg Abaq (r. 1140–1154 CE).[11] There are different statements concerning the date of Ibn al-Ṣalāḥ's death in the sources. According to al-Qifṭī he died at the end of the year 548 (March 1154 CE), and according to Ibn Abī Uṣaybiʿa in the year '540 odd'.[12] A manuscript of the *Conics* of Menelaos at the British Library contains a colophon with the date 'Monday 4 Rabīʿ II 548' (29 June 1153 CE), in which Ibn al-Ṣalāḥ is mentioned.[13] The formula *aṭāla llāhu baqāhu* ('may God make his life long') after his name indicates that he was still alive at that date. This corroborates al-Qifṭī's date March 1154 CE for his death. In the same colophon Ibn al-Ṣalāḥ is called *al-zāhid* ('the ascetic'), which might explain his surname, since *ibn al-ṣalāḥ* ('son of salvation') points to a pious lifestyle.

Ibn al-Ṣalāḥ was a somewhat unusual scholar. Among his preserved works there are only very few which are of his own creation. Almost all of them are critiques directed against the works of others. The targets of his critical attacks were the most famous scholars of the past: Aristotle, Euclid, Ptolemy, Galen, Ibn al-Haytham, Abū Sahl al-Kūhī, Jābir ibn Ibrāhīm al-Ṣābiʾ and al-Fārābī.[14]

The work by Ibn al-Ṣalāḥ which is best known among scholars working on the history of astronomy is his critique of the transmission of coordinates in the star catalogue of the *Almagest*. This is a meticulous analysis of the values of coordinates in a Syriac and four Arabic translations of the *Almagest* and other

[8] *MAOSIC*, p. 176 (No. 448).

[9] *MAOSIC*, pp. 177–78 (No. 458).

[10] Lippert, *Taʾrīḫ al-ḥukamā*, p. 428; Müller, *ʿUyūn al-anbāʾ*, vol. II, pp. 164–67.

[11] For the life of Ibn al-Ṣalāḥ see Lorch, 'Ibn al-Ṣalāḥ's Treatise', p. 401.

[12] Lippert, *Taʾrīḫ al-ḥukamā*, p. 428; Müller, *ʿUyūn al-anbāʾ*, vol. II, p. 164.

[13] MS London, British Library, Or. 13127, fol. 51r, lines 6–14; see the online catalogue at http://searcharchives.bl.uk (search for 'Or 13127'; retrieved 21 April 2016); digital images are available at http://www.qdl.qa/en/archive/81055/vdc_100000038406.0x000001 (retrieved 21 April 2016).

[14] For a list of Ibn al-Ṣalāḥ's works see Thomann, 'Al-Fārābī's Kommentar', pp. 101–02; the marginal glosses by Ibn al-Ṣalāḥ to the text of Menelaos in the MS London, British Library, Or. 13127 are to be added to this list.

works containing a star catalogue. It was edited, translated and commented upon by Paul Kunitzsch in 1975.[15]

2. Ibn al-Ṣalāḥ's critique on al-Fārābī's commentary on the *Almagest*

In the focus of the present paper is another work by Ibn al-Ṣalāḥ on the *Almagest*, namely a critique of al-Fārābī's commentary on the *Almagest*. This work is preserved in a single manuscript in the library of the Holy Shrine in Mashhad (MS 5593).[16] The manuscript was written in 1462 and the work by Ibn al-Ṣalaḥ, contained on pages 81 to 92, is entitled 'Reasoning on Proof of the Error Made by Abū Naṣr al-Fārābī in his Commentary on the Seventeenth Section of the Fifth Book of the Almagest and the Explanation of this Section'.[17]

The passage of the *Almagest* on which Ibn al-Ṣalaḥ writes is not in Chapter V.17 but in Chapter V.19 as we know it from the Greek text and the extant Arabic translations. The topic of the work is a small passage in the section on parallax. At the beginning of Chapter V.19 Ptolemy explains how to find the lunar parallax in altitude.[18] This is the change in the lunar position in vertical direction for an observer at a distance from the centre of the earth. After that Ptolemy explains how to split up this parallax in altitude into two components, the parallax in ecliptical longitude and the parallax in ecliptical latitude.[19] This second part of Chapter V.19 is the topic of Ibn al-Ṣalāḥ's critique.

Ptolemy's approach is rather crude. First he makes an approximation by transforming the spherical problem into a plain one and assuming that the two circles of measuring the ecliptical latitude are straight parallel lines. In doing so, the problem is reduced to a trivial geometrical case. Later in the chapter he criticizes this method, invented by Hipparchos, and proposes another solution, allegedly operating 'in a [mathematically] sound way' (κατὰ τὸν ὑγιῆ τρόπον), but this is an approximation too.[20] It seems that he could not find an exact solution by his mathematical means. Otto Neugebauer's verdict was that 'The chapter on parallax is undoubtedly one of the most unsatisfactory sections in the whole Almagest'.[21]

[15] Kunitzsch, *Ibn aṣ-Ṣalāḥ*.

[16] Maʿānī, *Fihrist-i kutub-i ḫaṭṭī*, pp. 344–48; Sezgin, *Geschichte des Arabischen Schrifttums*, p. 195; Thomann, 'Al-Fārābī's Kommentar', pp. 102–04.

[17] *MAOSIC*, p. 178 (No. 458).

[18] Heiberg, *Syntaxis mathematica*, vol. I, pp. 444–45; Toomer, *Ptolemy's Almagest*, pp. 265–66.

[19] Heiberg, *Syntaxis mathematica*, vol. I, pp. 446–50; Toomer, *Ptolemy's Almagest*, pp. 266–67.

[20] Heiberg, *Syntaxis mathematica*, vol. I, pp. 450–55; Toomer, *Ptolemy's Almagest*, pp. 269–71; Pedersen, *A Survey*, pp. 218–19, 471; Neugebauer, *A History*, vol. I, pp. 116–17.

[21] Neugebauer, *A History*, vol. I, p. 116; but see Toomer, *Ptolemy's Almagest*, p. 273, note 87 for a different view.

The first astronomer who was able to provide an exact and valid solution of the same problem was Ḥabash al-Ḥāsib in the mid ninth century.[22] He based his calculations not on Greek trigonometry with chords but on Indian trigonometry with sine and cosine and used for his solution both the cosine rule and the sine rule for spherical triangles. In this case at least Indian style trigonometry was superior to Greek style trigonometry.

Ibn al-Ṣalāḥ writes at the beginning of his treatise:[23]

> I had a look at a book by the outstanding Abū Naṣr al-Fārābī called *Commentary on the Book by Ptolemy Known as the Almagest*. I studied it thoroughly in full clarity and understanding of its concepts up to the information in Chapter 17 of Book V. I found that he wanted to establish the proof based on the relation which was there in connection with a complete commentary on the chapter. But the premises which he used in the composition of his proof were impossible and fallacious.

Thus the critique of Ibn al-Ṣalāḥ is not directed towards Ptolemy himself but towards al-Fārābī's *Commentary on the Almagest*. This work has only recently been discovered, and some information is appropriate here.

3. Al-Fārābī's commentary on the *Almagest*

The great philosopher al-Fārābī (d. 950 CE), who had the honorary title of 'the Second Teacher' (sc. after Aristotle), is most famous for his works on logic, metaphysics and political philosophy. But he wrote also on mathematical disciplines. Since the times of Moritz Steinschneider it has been known that al-Fārābī wrote a commentary on the *Almagest*.[24] It is mentioned in the biographies in al-Qifṭī, Ibn Abī Uṣaybiʿa and al-Ṣafadī, and it appears in a list of commentaries on the *Almagest* by al-Nasawī (eleventh century CE).[25] A supposed copy in the British Library turned out to be the *Talkhīṣ* by Ibn Sīnā,[26] and the work was considered to be lost.[27] In 2011 the discovery of a part of a comprehensive commentary on the *Almagest*, probably al-Fārābī's commentary, was announced.[28] The MS Tehran, Majlis Library, 6531 has a modern title-page with the name of al-Fārābī. The beginning of the original manuscript is missing, and at the end it has no colophon. Thus the text is transmitted

[22] Kennedy, 'Parallax Theory', pp. 42–43.

[23] MS Mashhad, Holy Shrine Library, 5593, p. 81; for the Arabic text see Appendix II.

[24] Steinschneider, *Al-Farabi*, p. 78.

[25] Lippert, *Taʾrīḫ al-ḥukamā*, p. 279; Müller, *ʿUyūn ul-anbāʾ*, vol. II, p. 138; Ritter, *Kitāb al-Wāfī*, vol. I, p. 108; for al-Nasawī see Lorch, *Thābit ibn Qurra*, p. 348.

[26] Goldstein, book review of Sezgin, p. 342.

[27] Janos, 'Al-Fārābī', p. 239; Janos, *Method*, pp. 22–26.

[28] Paper presented at the conference 'Contexts of Learning in Baghdad from 8th–10th centuries', University of Göttingen, September 12–14, 2011, published later as: Thomann, 'From Lyrics', pp. 500–02; first publication: Thomann, 'Ein al-Fārābī zugeschriebener Kommentar', pp. 48–53.

anonymously. It contains a commentary on the *Almagest* based on the Isḥāq translation, and covers parts of Book IX and all of Books X to XIII. In 2012 another manuscript with the same text was found (MS Tehran, Majlis, 6430), but again with no indications of the author.[29] At the beginning several pages are missing, but it covers slightly more text than the first manuscript. Further investigations made an attribution of this commentary to al-Fārābī more and more likely. It is evident that it was written by a philosopher rather than by a professional astronomer.[30] This limits the number of candidates for being the author of the Tehran commentary considerably. Further, there are some characteristics in the vocabulary which coincide with Fārābīan usage.[31]

The identification of the Tehran manuscripts as al-Fārābī's commentary on the *Almagest* finally became beyond doubt when the treatise of Ibn al-Ṣalāḥ on the critique of al-Fārābī's commentary was studied for the first time.[32] The text of Ibn al-Ṣalāḥ consists for a large part of literal quotations from al-Fārābī's commentary. For the first time documented original parts of al-Fārābī's work were at hand. Since the quoted texts belong to Book V of the *Almagest* a direct comparison with the two Tehran manuscripts, which cover Books IX to XIII, was not possible. But the relative quantity of text of al-Fārābī's commentary in comparison to related text of Ptolemy could be estimated and conspicuous terminology could be compared. There is one noteworthy abnormality in the parts quoted by Ibn al-Ṣalāḥ. In the text of al-Fārābī the term for parallax is always *inḥirāf al-manẓar*, while the standard term, also found in the translations of the *Almagest*, is *ikhtilāf al-manẓar*.[33] The reason why al-Fārābī chose this non-standard term may be his propensity to be philologically precise, and indeed, *inḥirāf* 'deviation' is semantically closer to Greek *parallaxis* than *ikhtilāf*, which means simply 'difference'.[34] In any case, the occurrence of this abnormality in the text of the two Tehran manuscripts would provide a perfect terminological test. There is only one passage in Books IX to XIII of the *Almagest* where parallax is mentioned.[35] The corresponding commentary is only preserved in the second Tehran manuscript, where parallax is indeed called *inḥirāf al-manẓar*.[36] Therefore there can hardly be any doubt that the passages quoted by Ibn al-Ṣalāḥ and the text in the two Tehran manuscripts are parts of

[29] Paper presented at the 26th Congress of the Union Européenne des Arabisants et Islamisants (UEAI 26), Basel, September 12–16, 2012; see now Thomann, 'Terminological Fingerprints', pp. 304–05.

[30] Thomann, 'Ein al-Fārābī zugeschriebener Kommentar', pp. 58–59.

[31] Thomann, 'Terminological Fingerprints', pp. 305–10.

[32] Thomann, 'Al-Fārābī's Kommentar'.

[33] Thomann, 'Al-Fārābī's Kommentar', pp. 110–11; see the text in Appendix II.

[34] Eckhard Neubauer, personal communication (July 26, 2015).

[35] Heiberg, *Syntaxis mathematica*, vol. II, p. 207; Toomer, *Ptolemy's Almagest*, p. 419.

[36] MS Tehran, Majlis Library, 6430, fol. 22r; see the text in Appendix II.

the same work, and that in the twelfth century this work was regarded by the attentive and well-informed Ibn al-Ṣalāḥ as the work of al-Fārābī.

4. An anonymous translation of the *Almagest* and its terminology

At the very beginning of his critique on al-Fārābī's commentary, after the introductory phrase, Ibn al-Ṣalāḥ quotes literally the passage of the *Almagest* upon which al-Fārābī comments.[37] Ibn al-Ṣalāḥ does not say anything about the authorship of the quoted translation, therefore in the following it will be called provisorily 'Anonymous'. In a first step, the text will be compared with the two well-known Arabic translations of the *Almagest* by al-Ḥajjāj and Isḥāq/Thābit.[38] The three Arabic translations, the Greek text and the Latin translation of Gerard of Cremona are given in Appendix I. Words and expressions which differ in the three Arabic translations are listed in the four following tables. The first table contains words and expressions which differ in all three translations:

Greek	*Anonymous*	*Al-Ḥajjāj*	*Isḥāq/Thābit*
ἵνα	فإذا أردنا أن	ولكي	ولكيما / وكيما
διακρίνωμεν	ونفصل ...	نعدل	نقوّم
ἐπισκεψόμεθα	ونأخذ	ونطلب	ننظر
σελιδίῳ	السطر	الجدول	الصفّ
τοσούτων	فإنّا إذا فعلنا ذلك	وذلك	فإن هذا
ἐπειδήπερ	فلمّا	لأنّ	من قبل أن
γραφομένου	الّتي تمرّ	المخطوط على	ترسم مادّة

The second table contains words and expressions which are identical or similar in al-Ḥajjāj and Isḥāq/Thābit but different in the Anonymous:

Greek	*Anonymous*	*Al-Ḥajjāj*	*Isḥāq*
ἀπέχει	بين ... وبين	بعد ... من	بعد ... من
μεσημβρινοῦ	وسط السماء	فلك نصف النهار	دائرة نصف النهار
μεσημβρινοῦ	توسّط القمر السماء	بعد نصف النهار	بعد دائرة نصف النهار
ἀπογραψόμεθα	وكتبناه	أثبتناها	أثبتناها
ἐκκειμένην	اللتين تليان	الّتي على هذه	اللتين في هذا
ἐν κύκλῳ εὐθειῶν κανόνιον	جداول القسي والأ[و]تار	في جدول أوتار القسي	في جدول الأوتار الّتي في الدائرة
εὑρισκομένην	حصلناه	الموجود	يوجد
μερίζοντες	قسمناه	نقسم	ونقسم
συναγόμενα	بما يخرج	ما اجتمع	ما اجتمع
ἕξομεν	علمنا	فهو	فهو

[37] MS Mashhad, Holy Shrine Library, 5593, pp. 81–82.

[38] Other translations of the *Almagest* will be discussed in Section 5.

The third table contains words and expressions which are identical or similar in al-Ḥajjāj and the Anonymous but different in Isḥāq/Thābit:

Greek	*Anonymous*	*Al-Ḥajjāj*	*Isḥāq*
ἰσημερινὰς	المعتدلة	المعتدل	الاستوائيّة
κανόνος	جداول	جداول/ جدول	جدول
εἰς τὸ αὐτὸ μέρος	إلى الموضع الّذي كنّا أدخلناه به فيما تقدّم	ذلك الموضع	في ذلك القسم بعينه
λειπούσας	ما نقص	الّتي تنقص	ما يبقى بعدها
τομὴν	قطعة	القطعة	التقاطع
καὶ ὃν ἂν ἔχῃ	فيكون لنا	فيكون	فأيّ
πολυπλασιάζοντες	فضربناه	فيضرب	فيضاعف
κατὰ κορυφὴν	بسمت الر[ؤ]وس	سمت الرؤوس	سمت الرأس

The fourth table contains words and expressions which are identical or similar in Isḥāq/Thābit and the Anonymous but different in al-Ḥajjāj:

Greek	*Anonymous*	*Al-Ḥajjāj*	*Isḥāq*
παρακειμένας	بحياله	الّتي تقابل	حياله / بحياله
οὖν	ثمّ	ف	ثمّ
ἀδιαφοροῦσιν	كان لا فرق	〈لا〉 تكون ... مختلفة	فليس بينه وبين ... فرقان

The fact that the second table is the largest indicates that the Anonymous differs more from the two other translations than al-Ḥajjāj and Isḥāq/Thābit differ from each other. This leads to the question if the Anonymous version is a genuine translation from the Greek, or a paraphrase of one of the two other Arabic translations.[39] There are three cases in the Anonymous where knowledge of the Greek original is evident. In the Anonymous, Greek διακρίνωμεν ('we distinguish, we set apart') is at first translated by *nufaṣṣilu* ('we divide'). Later in the sentence it is specified by the expression *wa-nafṣila kulla wāḥidin minhumā ʿani l-ākhari* ('and we separate each of them from the other'). This is a precise paraphrase of the litteral meaning of διακρίνω and could not have been derived from one of the two other translations. Al-Ḥajjāj writes *naʿdilu* or *nuʿaddilu* 'we normalize the parallax ...', and Isḥāq *nuqawwimu* 'we arrange the parallax'. This suggests that the anonymous translation is based on the Greek text, and that it is not just a paraphrase of one of the two other translations. A second case is the translation *wa-katabnāhu* ('we have written it') of Greek ἀπογραψόμεθα ('we have written off'). Al-Ḥajjāj and Isḥāq/Thābit translate it with *athbatnāhā* ('we have made it fixed'), which does not preserve

[39] There is no need to consider a translation from the Syriac since according to Ibn al-Ṣalāḥ all Arabic translations were made from the Greek; cf. Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 155, lines 12–19 (Arabic text) and p. 40 (German translation).

the meaning of 'writing'.[40] A third case is the Greek word ἐκκειμένην ('lying outside'), which is translated by the Anonymous as *allatayni taliyāni* ('which are adjacent'). The other translations are less precise: Al-Ḥajjāj translates as *allatī ʿalā* ('which are on') and Isḥāq/Thābit *allatayni fī* ('which are in'). These three examples show clearly that the Anonymous is based on the Greek text independently from the translations of al-Ḥajjāj and Isḥāq/Thābit.

In a next step, some conspicuous expressions used by the Anonymous will be compared to other astronomical texts in order to derive arguments for a chronological classification.

The Greek adjective μεσημβρινός means literally 'belonging to noon', composed of the adjective μέσος ('middle'), the substantive ἡμέρα ('day') and the suffix -ινος (for building adjectives). In an astronomical context ὁ μεσημβρινός κύκλος ('the circle belonging to noon') is the technical term for 'meridian', and μεσημβρινός can be used alone as a noun to denote 'meridian', as is the case in the text here. Al-Ḥajjāj uses *falak niṣf al-nahār* ('sphere of half day') and Isḥāq/Thābit *dāʾirat niṣf al-nahār* ('circle of midday'). In the translation of the *Anaphorikos* by Hypsikles, made either by Qusṭā ibn Lūqā or Isḥāq ibn Ḥunayn, μεσημβρινός is translated also as *niṣf al-nahār*. The expressions *falak niṣf al-nahār*, *dāʾirat niṣf al-nahār* and *khaṭṭ niṣf al-nahār* ('line of midday') became standard and were used interchangeably in astronomical texts of different epochs. Ḥabash al-Ḥāsib (d. *c.* 864 CE) uses *falak niṣf al-nahār* and *khaṭṭ niṣf al-nahār* as technical terms for 'meridian'.[41] Al-Bīrūnī (973–1048) uses *falak niṣf al-nahār* for 'meridian' in his introductory work on astronomy and astrology.[42] The term *dāʾirat niṣf al-nahār* is found in the terminological dictionary by al-Tahānawī (eighteenth century).[43] Different from these common translations, the Anonymous translates μεσημβρινός as *wasaṭ al-samāʾ* ('middle of the heaven'). It is conspicuous that in one of the oldest extant Arabic astronomical texts, *On the Use of the Astrolabe* by al-Khwārizmī, *khaṭṭ wasaṭ al-samāʾ* ('line of the middle of heaven') is used as the technical term for 'meridian'.[44] Besides that the expression *wasaṭ al-samāʾ* is used for a different notion. In contrast to *khaṭṭ wasaṭ al-samāʾ*, which denotes a line, *wasaṭ*

[40] No example for *athbata* in Lane's Lexicon refers to 'writing', see Lane, *An Arabic-English Lexicon*, p. 329.

[41] MS Istanbul, Süleymaniye Library, Yeni Cami 784, fols 130v, 149r, 150r, 156r–v, 161v, 162v, 164v, 190r–v (*falak niṣf al-nahār*), fols 130v, 151v, 167v, 168v–170v, 172r–v, 176r, 190r, 191r, 194v, 195v, 196v, 197v, 198v, 208r, 219v, 220r (*khaṭṭ niṣf al-nahār*).

[42] Wright, *The Book of Instruction*, p. 49 (§ 129).

[43] Daḥrūj, *Kashshāf*, p. 241.

[44] Charette and Schmidl, 'Al-Khwārizmī', p. 115 (§ 2c), p. 116 (§ 2d), p. 116 (§ 3) et passim.

al-samāʾ denotes a point defined by the intersection of the meridian with the ecliptic. This becomes evident when al-Khwārizmī writes:[45]

> [Then look at which degree] is cut by the line of midheaven (*khaṭṭ wasaṭ al-samāʾ*), and this will be the degree of midheaven (*darajat wasaṭ al-samāʾ*).

The expression *darajat wasaṭ al-samāʾ* in the sense of '(ecliptical) degree of the meridian' is used by Ḥabash too.[46] Later the meaning of *wasaṭ al-samāʾ* became restricted to 'the point of intersection of the ecliptic with the meridian'. But obviously the Anonymous imitates the Greek expression ὁ μεσημβρινός as an abbreviated form of ὁ μεσημβρινός κύκλος by writing *wasaṭ al-samāʾ* as an abbreviated form of *khaṭṭ wasaṭ al-samāʾ*.

Another abnormality concerns the translation of the Greek conjunction ἵνα ('that, in order that'). Al-Ḥajjāj translates it as *wa-lākin* ('however, yet, but'), and Isḥāq/Thābit more literally as *wa-likaymā* ('that, in order that'). The Anonymous departs considerably from the Greek text and starts the sentence by *wa-idhā aradnā an naʿrifa* ('when we want to know'). A similar expression is found only once in the Greek *Almagest*: Chapter III.8 begins with the expression Ὁσάκις οὖν ἂν ἐθέλωμεν ... ἐπιγιγνώσκειν ('So whenever we want to know').[47] There must thus have been another source of inspiration for the Anonymous to use this expression. Indeed, in al-Khwārizmī's treatise 'On the Use of the Astrolabe' 42 paragraphs out of 53 (79%) start either with *idhā aradta an taʿrifa* ('when you want to know'), *idhā aradta an taʿlama* (ditto), *in aradta an taʿrifa* (ditto), or *idhā aradta* ('when you wish') followed by a noun in the accusative. The second person singular was based on the style of Sanskrit astronomical works, while the first person plural was the style of Greek works.[48] The Anonymous keeps the first person plural from the Greek text, but uses the conditional phrase that was the standard start of a paragraph in astronomical treatises of his time. The phrase *idhā aradta an taʿrifa* ('when you want to know') and its synonyms are found in later astronomical texts too, but never again as rigorously as in the astronomical writings of al-Khwārizmī. In the *Zīj* of Ḥabash al-Ḥāsib it occurs only twelve times.[49] In the *Zīj* of al-Battānī still 40 chapters and subchapters out of 65 (62%) start with such a phrase,[50] and in

[45] Charette and Schmidl, 'Al-Khwārizmī', p. 116 (§ 3).

[46] MS Istanbul, Süleymaniye Library, Yeni Cami 784, fols 160r, 161r, 169r–185v, 205r–222v.

[47] Heiberg, *Syntaxis mathematica*, vol. I, p. 259, lines 12–14; Toomer, *Ptolemy's Almagest*, p. 169.

[48] Thomann, 'From Lyrics', pp. 510–14.

[49] MS Istanbul, Süleymaniye Library, Yeni Cami 784, fols 74v, 78r, 101v (2x), 102v, 124r, 224v, 225r (3x), 228v.

[50] Nallino, *Al-Battānī*, vol. III, p. 20 line 6, p. 29 line 7, p. 30 line 11, p. 31 line 23, p. 31 line 23, p. 33 line 33 et passim.

contrast, Thābit ibn Qurra uses the phrase rarely.[51] Al-Bīrūnī uses the phrase only occasionally. For example, in Book V of his *Qānūn* the phrase occurs at the beginning of three chapters out of 21 (14%).[52]

A third noteworthy case is the terminology for 'table', 'row' and 'column'. In the *Almagest* the Greek expressions are κανῶν (literally 'straight rod, bar'), στίχος ('row of soldiers', also 'line of poetry'), and σελίδιον, diminutive of σελίς ('cross-beam', also 'column in a papyrus or a mathematical table'). Al-Ḥajjāj translates these terms as *jadāwil*,[53] plural of *jadwal* (litteraly 'creek, brook'), *saṭr* ('line')[54] and *jadwal*. In Isḥāq/Thābit they are translated as *jadwal*, *saṭr*[55] and *ṣaff* ('row, line'). In the terms for 'table' a shift from the plural *jadāwil* to the singular *jadwal* is seen. If the plural is used for 'table', it is logical to use the singular for 'column'. However, the Anonymous calls the table *jadāwil*, but uses *saṭr* for 'column' instead, the same term which Isḥaq/Thābit use in the sense of 'row'. The same use of *saṭr* in the sense of 'column' is found in al-Khwārizmī's *On the Construction of the Astrolabe*.[56] It is also found in Yaḥyā ibn Abī Manṣūr's *al-Zīj al-Mumtaḥan*.[57] Al-Battānī uses *saṭr* still in the same sense.[58] But otherwise *saṭr* was used predominantly for 'row'. This holds for Thābit ibn Qurra,[59] for the *Mafātīḥ al-ʿulūm* (tenth c. CE),[60] and also for Ibn al-Ṣalāḥ.[61]

These examples suggest that the translation of the Anonymous was made at an early time, probably at the beginning of the ninth century CE. At least, nothing in the terminology speaks against such an early date.

5. Translations of the *Almagest* known to Ibn al-Ṣalāḥ

Ibn al-Ṣalāḥ mentions in his work on the star catalogue of the *Almagest* explicitly which translations he had at hand:[62]

[51] Lorch, *Thābit ibn Qurra*, pp. 42–111: no occurrences; Morelon, *Thābit ibn Qurra*, pp. 65, 135, 137; shorter expressions as *wa-in aradta* and the like: pp. 96, 101, 105, 135, 138, 139, 141, 145, 146, 148, 149, 150, 160.

[52] al-Bīrūnī, *al-Qānunu'l-Masʿūdī*, vol. II, pp. 516 line 3, 522 line 7, 526 line 3.

[53] This is the reading in MS Leiden, Universiteitsbibliotheek, Or. 680, fol. 85v. In MS London, British Library, Add. 7474, fol. 150r the singular *jadwal* is found.

[54] *Almagest* I.10, final paragraph; see MS London, British Library, Add. 7474, fol. 14r, line 3.

[55] *Almagest* I.10, final paragraph; see MS Tunis, National Library, 7116, fol. 9v, line 4.

[56] Charette and Schmidl, 'Al-Khwārizmī', p. 110, line 6.

[57] Sezgin, *Al-Zīj al-Maʾmūnī*, p. 125, line 4.

[58] See the glossary in Nallino, *Al-Battānī*, vol. III, p. 337.

[59] Morelon, *Thābit ibn Qurra*, p. 55, line 7 and p. 106, line 18.

[60] van Vloten, *Liber Mafâtîh al-olûm*, p. 55, line 8.

[61] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 131, line 21.

[62] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 155, lines 12–20 (Arabic text) and p. 40 (German translation).

> Five copies (*nusakh*) of the Book al-Majisṭī, different in language and translation had come about (*kāna qad ḥasala*), a Syriac copy, translated from the Greek, a second copy in the translation of al-Ḥasan ibn Quraysh for al-Maʾmūn, from Greek into Arabic, a third copy in the translation of al-Ḥajjāj ibn Yūsuf ibn Maṭar and Hilīyā ibn Sarjūn, also for al-Maʾmūn from Greek into Arabic, a fourth copy in the translation of Isḥāq ibn Ḥunayn for Abū al-Ṣaqr ibn Bulbul, from Greek into Arabic, and this [copy] is the original archetype (*dustūr*) of Isḥāq and in his handwriting, and a fifth copy with the correction of Thābit ibn Qurra of this translation of Isḥāq ibn Ḥunayn for Abū al-Ṣaqr ibn Bulbul. It agrees (*muwāfiq*) with Isḥāq's translation except for the pieces of information which were in the margin of the version of Isḥāq, such as doubts (*tashakkuk*) [concerning variant readings]. These pieces of information were not in the copy of Thābit. All these copies were differing and faulty.

According to this statement, Ibn al-Ṣalāḥ had four Arabic translations at his disposal, which he lists in chronological order: A translation by al-Ḥasan ibn Quraysh, the translation by al-Ḥajjāj, the original translation of Isḥāq in an autograph with marginal notes, and the Isḥāq/Thābit translation. The last three translations are well known, and the translations of al-Ḥajjāj and of Isḥāq/Thābit exist in a number of manuscripts.[63] Later on in the text, Ibn al-Ṣalāḥ calls the translation by al-Ḥasan ibn al-Quraysh 'the Maʾmūnic translation by al-Ḥasan' (*al-maʾmūnī bi-naql al-Ḥasan*),[64] or simply 'al-Ḥasan's translation' (*naql al-Ḥasan*),[65] or occasionally also 'the Maʾmūnic [translation]' (*al-maʾmūnī*).[66] There is a passage in Ibn al-Nadīm's *Fihrist* on a translation of the *Almagest* made before al-Ḥajjāj, but al-Ḥasan ibn Quraysh is not mentioned there,[67] nor is he mentioned in Ibn al-Nadīm's list of translators from Greek into Arabic.[68] The only biographical source which makes a reference to him is Ibn Abī ʿUṣaybīʿa in his biography of the physician Sahl al-Kawsaj, where al-Ḥasan ibn Quraysh is listed among the colleagues of Sahl.[69]

Sahl al-Kawsaj died shortly before the Caliph al-Maʾmūn (d. 833 CE). Despite the lack of further evidence of a translation of al-Ḥasan ibn Quraysh, the account of Ibn al-Ṣalāḥ has to be taken seriously. He must have had a manuscript of this translation at hand, from which he quoted as often as from the other translations. Most of the quotations concerned numerical values of star coordinates. Ibn al-Ṣalāḥ did not explicitly evaluate the different translations in general. There are approximately equally many cases in which he judges the numerical values in the Maʾmūnic translation to be correct against some of

[63] Kunitzsch, *Claudius Ptolemäus*, vol. I, pp. 3–4; Kunitzsch, 'A Hitherto Unknown', pp. 31–32.
[64] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 149, line 12 (Arabic text) and p. 49 (German translation).
[65] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 139, lines 9–10 (Arabic text) and p. 63 (German translation).
[66] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 149, line 15 (Arabic text) and p. 49 (German translation).
[67] Dodge, *The Fihrist*, vol. II, p. 639.
[68] Dodge, *The Fihrist*, vol. II, pp. 586–88.
[69] Müller, *ʿUyūn ul-anbāʾ*, vol. I, p. 160, line 23; cf. Kunitzsch, *Der Almagest*, p. 23, note 33.

the other translations, as cases in which he judges them to be wrong. Often the Maʾmūnic translation agrees with the Syriac translation against those of al-Ḥajjāj and Isḥāq (or Isḥāq/Thābit).

Besides the critique of numerical values, there are also a few remarks on different translations of star names. In one case Ibn al-Ṣalāḥ criticized al-Ḥasan, since he translated Greek βέλος ('arrow') with *nawl* ('loom').[70] In another case concerning the translation of Greek ὁ θύρσος ('the wand of Thyrsos') he wrote:[71]

> This star (= b Cen), and the eighth, ninth and tenth [star] (= ψac[1] Cen) stand according to the translation of Isḥāq on the 'branches of vine' (*ʿalā quḍbān al-karm*), but according to the Syriac on the 'shield' (*ʿalā l-turs*), which is called in Syriac *sakrā*, and according to the version of al-Ḥasan ibn Quraysh on the 'lance' (*ʿalā l-ḥarba*). Similarily I saw them in the form of a lance (*ṣūrat ḥarba*) on a celestial globe made by the Ḥarranians. The lance appears to me as the most likely [translation], since Centaur is holding a wild beast of prey at its forefoot, and it is mentioned in the commentary to Aratos that Centaur wanted to sacrifice the animal to the God, and to fumigate it with the nearby incense burner.

In the manuscript of Isḥāq's translation the star is called 'branch of vine' in the singular (*qaḍīb al-karm*), and never in the plural.[72] The Syriac translater read ὁ θυρεός ('oblong shield') instead of ὁ θύρσος.[73] The translation of al-Ḥajjāj is not quoted, but it agrees with the Syriac translation by rendering the star name as *al-turs* ('the shield'). Thus we see that in this case Ibn al-Ṣalāḥ prefers the Maʾmūnic translation against all others. Considering this judgment, it would seem perfectly reasonable if he would quote the *Almagest* in the Maʾmūnic translation at other occasions as well.

6. Authorship of the translation quoted by Ibn al-Ṣalāḥ in his critique on al-Fārābī

It seems reasonable to assume that the anonymous translation of the *Almagest* quoted by Ibn al-Ṣalāḥ in his critique on al-Fārābī's commentary was one of the four Arabic translations which he used in his work on the star catalogue. It has been shown that the Anonymous differs considerably from al-Ḥajjāj and Isḥāq/Thābit. In view of the fact that the Anonymous has even less in common with Isḥāq/Thābit than with al-Ḥajjāj, the Anonymous could hardly be identical with the original translation of Isḥāq. There are only few cases where

[70] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 145, lines 1–2 (Arabic text) and p. 54 (German translation); cf. Kunitzsch, *Der Almagest*, pp. 184–85.

[71] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, p. 134, line 20 – p. 133, line 1 (Arabic text) and pp. 70–71 (German translation).

[72] Kunitzsch, *Der Almagest*, p. 339.

[73] Kunitzsch, *Der Almagest*, p. 339, note 191.

Ibn al-Ṣalāḥ reported differences between Isḥāq/Thābit and the original Isḥāq translation in numerical values, and none in verbal expressions. Therefore, the Maʾmūnic translation remains as the only candidate among the translations used by Ibn al-Ṣalāḥ in his work on the star coordinates.

Two more possibilities have to be taken into consideration. Ibn al-Ṣalāḥ had some knowledge of Greek, and he might have translated the passage of V.19 himself. But it has already been demonstrated that the terminology used by Ibn al-Ṣalāḥ in his own works does not correspond to the Anonymous.[74]

Besides the translations mentioned by Ibn al-Ṣalāḥ, there was another translation made by Thābit ibn Qurra after having finished his corrections for the Isḥāq translation.[75] Even though unlikely, it cannot be excluded that Thābit's own translation became available to Ibn al-Ṣalāḥ only after he had finished his work on the star coordinates, and then he used it in his critique on al-Fārābī. However, there are examples which show that the terminology in the Anonymous does not correspond to Thābit's terminology in his own works.[76]

At this point, the only option remains to identify the Anonymous with the old Maʾmūnic translation. This is compatible with the observations concerning its terminology, which point rather to an early epoch, when technical terms in astronomy were not yet as standardized as they became later. Moreover, there is nothing in the text which precludes from assuming an early date in the first third of the ninth century CE.

In the former section on the terminology of the Anonymous it was observed that some of its peculiarities are found also in the *Zīj* of al-Battānī. This can be explained now, since Paul Kunitzsch found that al-Battānī's star catalogue was mainly based on the Maʾmūnic translation.[77] Therefore it is likely that al-Battānī adopted some of the terminology of the Maʾmūnic translation too.

A final problem remains to be discussed. The statement of the authorship of the Maʾmūnic translation does not correspond to the passage on the early translation of the *Almagest* in Ibn al-Nadīm's *Fihrist*:[78]

> The first person to become interested in translating it and issuing it in Arabic was Yaḥyā ibn Khālid ibn Barmak. A group of people explained it for him but, as they did not understand it perfectly, he was not satisfied with it, so he called upon Abū Ḥassān and Salm, the director of the Bayt al-Ḥikmah, for its explanation. They made sure [of its meaning] and persevered in making it accurate, after having sum-

[74] See Section 4.

[75] See Lorch, *Thābit ibn Qurra*, pp. 355–57; Grupe, 'The Thābit-Version', and Grupe's article in this volume.

[76] See Section 4.

[77] Kunitzsch, *Ibn aṣ-Ṣalāḥ*, pp. 97–108.

[78] Dodge, *The Fihrist*, vol. II, p. 639.

> moned the best translators, testing their translation, and making sure of its good literary style and accuracy.

The name of al-Ḥasan ibn Quraysh, to whom Ibn al-Ṣalāḥ attributed the Maʾmūnic translation, is not mentioned here. However, this is no contradiction, since the text, taken at face value, does not mention the names of the translators, but only those of the supervisors, who did not translate themselves. The date of the translation indicated by Ibn al-Nadīm differs from the one indicated by Ibn al-Ṣalāḥ, who wrote that the translation was made for al-Maʾmūn (d. 833 CE). According to Ibn al-Nadīm the initiator was Hārūn al-Rashīd's famous Vizier Yaḥyā ibn Khālid ibn Barmak (733 or 737–805 CE). He was responsible for translations of literary and scientific texts into Arabic, but his main focus was on works in Sanskrit.[79] This orientation towards Indian works was a consequence of his Buddhist family background from Balkh. Greek works were translated too, but not from Greek, but from Middle Persian or Syriac, and this would also hold for a translation of the *Almagest*.[80]

There is a sharp contrast between the reports of Ibn al-Nadīm and of Ibn al-Ṣalāḥ on the earliest Arabic translation of the *Almagest*. Paul Kunitzsch characterized this in the following way:[81]

> This witness [of Ibn al-Ṣalāḥ] is of the utmost importance because of its authenticity, and it merits to be placed on the same level as the direct transmission. With its brief objectivity and unambiguity it distinguishes itself impressively from the vague or verbose bibliographical notes of the other authors, which in general do nothing else then to quote second-hand information without verifying it, and to carry it on from book to book.

Even if this may be somewhat exaggerated, Ibn al-Ṣalāḥ has been proven to be a meticulous and scrutinizing scholar who based his judgment on first-hand investigation. Therefore it is the preferable option to accept his attribution of the Maʾmūnic translation to al-Ḥasan ibn Quraysh, and to consider Ibn al-Nadīm's narrative with great caution. The attribution of authorship to al-Ḥasan ibn Quraysh can claim to be based on the most trustworthy source, and to be at present without alternatives.

[79] van Bladel, 'Barmakids', p. 35.

[80] van Bladel, 'The Bactrian Background', p. 85.

[81] Kunitzsch, *Der Almagest*, p. 23: 'Dieses Zeugnis ist wegen seiner Authentizität von allergrößter Bedeutung und verdient es, mit der direkten Überlieferung auf eine Stufe gestellt zu werden. Es hebt sich in seiner knappen Sachlichkeit und Eindeutigkeit eindrucksvoll von den vagen oder weitschweifigen bibliographischen Notizen der übrigen Autoren ab, die im allgemeinen nichts anderes tun, als Angaben zweiter Hand ohne eigene Nachprüfung zu zitieren und von Buch zu Buch weiterzuschleppen'.

7. Conclusions

The translation of the *Almagest* quoted by Ibn al-Ṣalāḥ in his critique of al-Fārābī's commentary contains knowledge of the Greek text which could not have been derived from the translations of al-Ḥajjāj and Isḥāq/Thābit. It shows more differences from both the translation of al-Ḥajjāj and the translation of Isḥāq/Thābit than the latter two among themselves. Besides that, it has more in common with al-Ḥajjāj than with Isḥāq/Thābit. Its terminology agrees best with some of the earliest preserved Arabic astronomical texts by al-Khwārizmī, and therefore an early chronological classification, possibly at the beginning of the ninth century CE, is probable. From the four Arabic translations of the *Almagest* which Ibn al-Ṣalāḥ used in his work on the star coordinates only the Maʾmūnic translation by al-Ḥasan ibn Quraysh could be the one which he quoted in his critique of al-Fārābī's commentary, an attribution which is supported by our terminological analysis. Only scattered splinters of this translation have hitherto been available. Now a small, but intact window into its text has been opened.

Appendix I: Text and Translations of *Almagest* V.19.2

Greek text:[82]

ἵνα οὖν καὶ τὴν πρὸς τὸν διὰ μέσων τῶν ζῳδίων τότε γινομένην παράλλαξιν διακρίνωμεν κατά τε μῆκος καὶ κατὰ πλάτος, τὰς αὐτὰς πάλιν ἰσημερινὰς ὥρας, ἃς ἀπέχει τοῦ μεσημβρινοῦ ἡ σελήνη, εἰσενεγκόντες εἰς τὸ αὐτὸ μέρος τοῦ τῶν γωνιῶν κανόνος ἐπισκεψόμεθα τὰς παρακειμένας τῷ ἀριθμῷ τῶν ὡρῶν μοίρας, ἐὰν μὲν πρὸ τοῦ μεσημβρινοῦ ᾖ ἡ σελήνη, τὰς ἐν τῷ γ′ σελιδίῳ, ἐὰν δὲ μετὰ τὸν μεσημβρινόν, τὰς ἐν τῷ δ′, κἂν μὲν ἐντὸς τῶν ϛ μοιρῶν ὦσιν, αὐτὰς ἀπογραψόμεθα, ἐὰν δ' ὑπὲρ τὰς ϛ, τὰς λειπούσας εἰς τὰς ρπ· τοσούτων γὰρ ἔσται ἡ ἐλάσσων τῶν περὶ τὴν ἐκκειμένην τομὴν γωνιῶν, οἵων ἡ μία ὀρθὴ ϛ. τὰς ἀπογεγραμμένας οὖν μοίρας διπλώσαντες εἰσοίσομεν εἰς τὸ τῶν ἐν κύκλῳ εὐθειῶν κανόνιον αὐτάς τε καὶ τὰς λειπούσας εἰς τὰς ρπ, καὶ ὃν ἂν ἔχῃ λόγον ἡ τὴν τῶν δεδιπλωμένων μοιρῶν περιφέρειαν ὑποτείνουσα εὐθεῖα πρὸς τὴν ὑποτείνουσαν τὴν λείπουσαν εἰς τὸ ἡμικύκλιον, τοῦτον ἕξει τὸν λόγον ἡ κατὰ πλάτος παράλλαξις πρὸς τὴν κατὰ μῆκος, ἐπειδήπερ αἱ τηλικαῦται τῶν κύκλων περιφέρειαι ἀδιαφοροῦσιν εὐθειῶν. πολυπλασιάζοντες οὖν τὸν ἀριθμὸν τῶν παρακειμένων εὐθειῶν ἐπὶ τὴν εὑρισκομένην ὡς ἐπὶ τοῦ διὰ τοῦ κατὰ κορυφὴν σημείου γραφομένου κύκλου παράλλαξιν καὶ τὰ γινόμενα μερίζοντες εἰς τὸν ρκ χωρὶς τὰ ἐκ τοῦ μερισμοῦ συναγόμενα μόρια ἕξομεν τῆς οἰκείας παραλλάξεως.

[82] Heiberg, *Syntaxis mathematica*, vol. I, pp. 446–47.

English translation:[83]

Now, in order to determine the parallax with respect to the ecliptic, in both longitude and latitude, at the given time, we again enter, with the same distance of the moon from the meridian in equinoctial hours [as before], into the same part of the Table of Angles [II.13], and take the number of degrees corresponding to that hour, in the third column if the moon is to the east of the meridian, or in the fourth column if it is to the west of the meridian. We examine the result, and if it is less than 90° we write down the number itself; but if it is greater than 90°, we write down its supplement, since that will be the size in degrees of the lesser of the two angles at the intersection [of ecliptic and altitude circle] in question. We double the number written down, and enter with this [doubled] number, and also with its supplement, into the Table of Chords [I.11]. The ratio of the chord of the doubled number to the chord of the supplement will give the ratio of the latitudinal parallax to the longitudinal parallax (for circular arcs of such small size are not noticeably different from straight lines). So we multiply the amounts of the chords in question by the parallax determined with respect to the altitude circle, and divide the products, each separately, by 120. The results of the division give us the separate components of the parallax.

Old Maʾmūnic translation:[84]

فإذا أردنا أن نعرف اختلاف المنظر ‹الّذي ينحرف به يعني القمر عن النقطة الّتي هو فيها من فلك البروج› في الطول والعرض ونفصل كلّ واحد منهما عن الآخر فإنّا نأخذ أيضا الساعات المعتدلة الّتي بين القمر وبين وسط السماء فندخلها إلى جداول الزوايا إلى الموضع الّذي كنّا أدخلناه به فيما تقدّم ونأخذ ما بحياله في السطر الثالث إن كانت الساعات في قبل توسّط القمر السماء وإن كانت الساعات بعد توسط القمر السماء مما في السطر الرابع فما وجدنا أي السطرين أخذناه وكتبناه إن كان ما فيه أقلّ من تسعين جزءا وإن لم يكن أقلّ من تسعين جزءا كتبنا ما نقص عن مائة وثمنين جزءا فإنّا إذا فعلنا ذلك كنّا قد أخذنا الزاوية الصغرى من الزاويتين اللتين تليان قطعة القوس الّتي بين سمت الر[ؤ]وس وموضع القمر بالمقدار الّذي تكون به الزاوية القائمة تسعين جزءا ثمّ نضـ[ـع]ـف الأجزاء التي كتبنا و نأخذ وتر ما يجتمع من جداول القسي والأ[و]تار ووتر ما نقصت هذه الأجزاء عن مائة وثمانين جزءا فيكون لنا نسبة وتر الأجزاء الّتي أضعفت إلى وتر ما نقصته تلك الأجزاء المضعفة على مائة وثمانين جزءا كنسبة اختلاف المنظر الّذي في العرض إلى اختلاف المنظر الّذي في الطول فلمّا كان لا فرق بين استعمال القسي وبين استعمال أوتارها عند هذه الحال لأنّ القسي ههنا صغار جدّا كنّا متّى أخذنا كلّ واحد من هذين الوترين فضربناه في اختلاف منظر القمر الّذي قد حصلناه من الدائرة الّتي تمرّ بسمت الر[ؤ]وس فما اجتمع من كلّ واحد منهما قسمناه على مائة وعشرين جزءا علمنا بما يخرج من القسمة كم اختلاف المنظر في الطول والعرض

[83] Toomer, *Ptolemy's Almagest*, p. 266.
[84] MS Mashhad, Holy Shrine Library, 4493, pp. 81–82.

English translation:

If we want to know the parallax⟨, with which it deviates, that is to say the moon from the point on which it is on the ecliptic,⟩ in longitude and latitude, and to split apart each of the two from the other, we take again [as before] the equinoctial hours which are between the moon and midheaven. We enter with them the tables of angles at the [same] place at which we had entered with them in what was already mentioned before. If the hours are before [the time when] the moon is in midheaven, we take in the third column [the value] that is opposite. If the hours are after [the time when] the moon is in midheaven, we take in the fourth column [the value] that is opposite. We take what we find in either of the two columns and write it down, if it is less then ninety degrees. If it is not less than ninety degrees, we write down [the amount by] which it is less than hundred eighty degrees. When we have done this, we have taken the smaller of the two angles which are adjacent to the division by the arc between the zenith and the position of the moon, using a measure in which a right angle has ninety degrees. Next we double the degrees which we have written down, and we take the chord which is collected in the tables of arcs and chords, and [we take] the chord of [the amount by] which it is less than hundred eighty degrees. Thus we will have the ratio of the chord of the degrees which were doubled to the chord of the complement of these doubled numbers from hundred and eighty degrees. [This ratio] is like the ratio of the parallax in latitude to the parallax in longitude, since there is no difference in the use of angles and the use of their chords in this situation, because the arcs here are very small. When we take each of these two chords, multiply them with the parallax of the moon, which we have already obtained on the circle through the zenith, and divide each of the two results by hundred and twenty parts, then we know from the results of the division how much the parallax is in longitude and in latitude.

Translation of al-Ḥajjāj:[85]

ولكي نعدل اختلاف المنظر الّذي يكون في ذلك الوقت في الطول والعرض نأخذ تلك الساعات المعتدل أيضا[86] الّتي هي بعد القمر من فلك نصف النهار فندخلها في ذلك الموضع من جداول[87] الزوايا ونطلب الأجزاء الّتي تقابل عدد الساعات[88] فإن[89] كان موضع القمر قبل نصف النهار أخذنا الأجزاء الّتي في الجدول الثالث وإن كان موضعه بعد نصف النهار أخذنا الأجزاء التي

[85] Text of MS Leiden, Universiteitsbibliotheek, Or. 680, fol. 85v; variant readings of MS London, British Library, Add. 7474, fol. 150r–v in the footnotes.

[86] فنأخذ أيضا الساعات.

[87] جدول.

[88] الساعات الّتي هي بعد القمر من فلك نصف النهار.

[89] خوضع القمر قبل.

في الجدول الرابع فإن كانت الأجزاء أقلّ من التسعين[90] أثبتناها وإن كانت أكثر من التسعين[91] أثبتنا الأجزاء التي تنقص عن تمام مائة وثمانين[92] جزءا وذلك هو قدر الزاوية الصغرى من الزوايا[93] التي على هذه القطعة بالمقدار الذي به تكون الزاوية القائمة تسعين[94] جزءا فنأخذ الأجزاء التي أثبتنا فنضعّفها وندخل ما اجتمع في جدول أوتار القسي ندخل تلك الأجزاء بعينها وما[95] نقص من[96] تمام مائة وثمانين جزءا[97] فيكون نسبة وتر القوس التي هي ضعف هذه الأجزاء إلى الوتر الذي توتّر[98] القوس الناقصة عن تمام نصف الدائرة كنسبة اختلاف منظر القمر في العرض إلى اختلافه في الطول لأنّ أقدار مثل هذه القسي من الأفلاك <لا> تكون أوتارها مختلفة فيضرب[99] عدد هذه الأوتار في عدد هذه الأوتار في عدد أوتار قسي اختلاف المنظر الموجود كمثل اختلاف المنظر الذي يكون في الفلك المخطوط على نقطة سمت الرؤوس ثمّ نقسم ما اجتمع على مائة وعشرين فما خرج من القسمة من الأجزاء فهو اختلاف ذلك المنظر

Translation of Isḥāq/Thābit:[100]

وكيما[101] نقوّم[102] أيضا اختلاف[103] النظر الّذي يكون[104] عند ذلك بالقياس إلى فلك البروج في الطول وفي العرض فإنّا ندخل أيضا تلك الساعات الاستوائيّة بأعيانها التي هي بعد القمر من دائرة نصف النهار في ذلك القسم بعينه من جدول الزوايا ثمّ ننظر ما حيال[105] ذلك العدد من الساعات من أجزاء[106] أمّا إن كان القمر قبل دائرة نصف النهار فما كان من الاجزاء حياله[107] في الصفّ الثالث وأمّا إن كان بعد دائرة نصف النهار فما كان من الأجزاء حياله[108] في الصفّ الرابع فإن كانت الأجزاء تسعين وما[109] دون ذلك أثبتناها[110] وإن كانت مجاوزة للتسعين أثبتنا ما يبقى بعدها إلى مائة وثمانين فإن هذا مبلغ أصغر الزاويتين اللتين في هذا التقاطع بالأجزاء التي بها زاوية واحدة قائمة تسعون جزءا ثمّ نضعّف ما أثبتناه من الأجزاء بعينه وما أثبتناه مما[111] هو ما يبقى بعد التسعين إلى مائة وثمانين وندخله في جدول الأوتار التي في الدائرة فأيّ نسبة كانت للخط المستقيم الذي يوتّر قوس الأجزاء المضعّفة إلى الخطّ الذي يوتّر القوس الباقية إلى نصف الدائرة فبقي نسبة اختلاف المنظر في العرض إلى اختلاف المنظر في الطول من قبل أن ما كان هذا مقداره من قسي الدولية[112] فليس بينه وبين الخطوط المستقيمة فرقان[113] فيضاعف عدد الخطوط المستقيمة التي بإزائها باختلاف المنظر الذي يوجد في الدائرة العظمى التي ترسم مادّة بالنقطة التي على سمت الرأس[114] ويقسم ما اجتمع على مائة وعشرين كلّ واحد من العددين على حياله فما حصل من[115] الأجزاء عند القسمة فهو اختلاف المنظر على حسب العدد المقسوم

Appendix II: Arabic texts translated in the main text

Ibn al-Ṣalāḥ's critique:[116]

كنت نظرت كتابا للفاضل أبي نصر الفارابي موسوما بشرح كتاب بطلميوس المعروف بالمجسطي فتصفّحته مستوفيا حقّ الإصفاء والتفهّم بمعانيه بحيث انتهيت إلى انباء الفصل السابع عشر في المقالة الخامسة وجدته يروم إقامة البرهان على النسب التي هناك مع شرح للفصل مستوفى الّا أنّ تلك المقدّمات التي يستعملها في تركيب برهانه ممتنعة مغالطيّة

90 تسعين 91 تسعين 92 المائة والثمانين 93 الزاوية 94 ص 95 وندخل ما 96 عن
97 ø 98 فتكون 99 فنضرب

100 Text of MS Tunis, National Library, 7116, fol. 88r; variant readings of MS Philadelphia, Penn Libraries, LJS 268, fol. 65r in the footnotes.

101 ولكيما 102 يُقَومُ 103 اختلافات 104 الّتي تكون 105 بحيال 106 الأجزاء
107 بحياله 108 بحيّاله 109 بما 110 أثبتناها بعين 111 فما 112 Read الدورية?
113 .فرق 114 وبمركز القمر 115 فما حصل من

116 MS Mashhad, Holy Shrine Library, 5593, p. 81.

Al-Fārābī's commentary on *Almagest* V.19:[117]

وقد بقي الآن أن نستخرج في هذا الانحراف المعلوم انحراف المنظر في العرض وانحراف المنظر في الطول والسبيل إلى ذلك أن أخذ تلك الساعات المعتدلة بعينها او الساعات وما اتّفق فيها وهي بعد القمر من دائرة نصف النهار في ذلك الجدول بعينهُ الّذي كنا أدخلنا تلك الساعات فيه

English translation:

Now it remains to extract for that known parallax (*inḥirāf al-manẓar*) the latitudinal parallax (*inḥirāf al-manẓar fī l-ʿarḍ*) and the longitudinal parallax (*inḥirāf al-manẓar fī l-ṭūl*). The means for that are that we take those equinoctial hours themselves, or the [seasonal] hours and what [difference] occurs in them. These are the distance of the moon from the circle of the meridian in that same table in which we had entered those hours [already before].

Al-Fārābī's commentary on *Almagest* V.19:[118]

وقد صحّحنا موضع القمر كلّ جهاته في تلك الساعة وبانحراف منظره

English translation:
We confirmed the position of the moon in all directions in that hour and with its parallax (*wa-bi-nḥirāfi manẓarihi*).

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[117] MS Mashhad, Holy Shrine Library, 5593, p. 82.
[118] MS Tehran, Majlis Library, 6430, fol. 46v.

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