Ptolemaeus
Arabus et Latinus

THE *RISĀLA DHĀT AL-KURSĪ* ATTRIBUTED TO PTOLEMY: A TREATISE ON THE CELESTIAL GLOBE WITH STAND

Flora Vafea

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A Treatise on the Celestial Globe with Stand

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Preface

The subject of this book is a 33-chapter Arabic treatise on the description and use of the celestial globe *dhāt al-kursī*. The treatise is preserved in at least twenty-three manuscripts, three of which clearly attribute the treatise to Ptolemy in their titles. In three other manuscripts, the treatise is attributed to Akhawayn in their title or colophon. The celestial globe *dhāt al-kursī* is similar to that described in the work *Introduction to the Phenomena* of Geminus (1st c. BC). The Arabic term *dhāt al-kursī* – meaning 'the ⟨instrument⟩ with stand' – corresponds to the Greek term *καταστηριζομένη (σφαίρα)*, while the term *al-kursī*, meaning chair or stand, corresponds to the Greek term *σφαιροθήκη*.

In the introduction of the work, there is a reference to the treatise of Qusṭ or Qusṭā; this is the 65-chapter treatise on the celestial globe by Qusṭā ibn Lūqā (9th–10th c. AD). There is a close relationship between the two treatises; the treatise *Dhāt al-kursī* is based on the treatise of Qusṭā. Its author mentions that he has omitted the superfluities of Qusṭā's treatise and added some new uses. After a description of the instrument, an explanation of how to position the globe is provided, and then various astronomical problems are discussed. In some problems the globe is used as a model for clarifying certain phenomena, and in other problems measurements and calculations are conducted making use of the globe.

Although the celestial globe and its use were known in Ptolemy's time, this treatise also includes non-Ptolemaic elements such as: the determination of the *qibla*, the domification (determination of the 12 astrological houses), the division of the horizon into 360° that corresponds to the notion of the azimuth, and the use of the coordinates 'mediation' and 'difference of declination' for the stars. The treatise should be considered as a *pseudepigraphon* and not as a genuine work of Ptolemy.

The treatise must have been compiled between the eleventh and the first half of the sixteenth century AD, and the author remains unknown, since there is not enough evidence to establish Akhawayn as the author of this treatise, although his name is mentioned in three manuscripts.

This study was conducted within the project *Ptolemaeus Arabus et Latinus* at the Bavarian Academy of Science and Humanities, in the context of determining whether some of the Arabic treatises attributed to Ptolemy, among them the treatise *Dhāt al-kursī*, are genuine Ptolemaic works or *pseudepigrapha*, and providing critical editions of those treatises. Throughout my research in libraries, the study of the manuscripts and the compilation of the book, I had the support of the director and the research leaders of the project, who

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advised me and facilitated the acquisition of the necessary manuscript scans. I would like to express my gratitude to Benno van Dalen, Dag Nikolaus Hasse, Jan Hogendijk and Alexander Jones, who read multiple versions of my work, in whole or in part, and made suggestions that improved the final outcome; in particular, my deepest gratitude to Benno van Dalen, for his decisive contribution to the typesetting of the Arabic texts. I wish to thank my colleagues José Bellver, María José Parra Pérez and Dirk Grupe who helped me in discovering and locating manuscripts, or by discussing subjects related to my research. I express my thanks to Benjamin Hallum, Johannes Thomann, Ahmed Chaouqui Binebine, Víctor de Castro León, Ali Fikri Yavuz and Leonard Chiarelli who helped me to reach some manuscripts important for my study. I am indebted to Saeed al-Wakeel for helping me in some points of the Arabic text of *Dhāt al-kursī* and for correcting the final versions of both Arabic texts in the book, and to Anna Stevens for the proof reading of the English text. I owe special thanks to the staff of the library Dār al-kutub in Cairo, who are always very helpful. Last but not least, I would like to express my gratitude to the late Paul Kunitzsch for his advice, and a package of his publications corrected by his hand at some points, in our last meeting.

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1. Introduction

Over the centuries that have elapsed since the pinnacle of Hellenistic science, many of the important scientific, philosophical and literary documents of the era have been lost entirely or reduced to fragments, whilst others have been preserved in their original language or in translation. Sometimes, later-compiled works were attributed to famous authors and wise men of the past.

The works of Claudius Ptolemy could not escape this destiny. Among his works some were lost, some were preserved both in the original Greek and in Arabic and/or Latin translations, some survived only through translation, and there is a significant number of treatises attributed but not related to him, the so called *pseudepigrapha*.

The astronomical treatise *Dhāt al-kursī*, which deals with the description and use of a celestial globe with stand, is amongst the works attributed to Claudius Ptolemy. In the section 'Ptolemaios', in volume V of *Geschichte des arabischen Schrifttums* (*GAS*),[1] Fuat Sezgin mentions that the treatise *Dhāt al-kursī* is included in the manuscript Cairo, Dār al-kutub, Ṭalʿat Mīqāt 189, adding that it is not yet clear whether this is a translation of a genuine Ptolemaic work. Sezgin presents the possibilities that the instrument is a version of a planispheric astrolabe or an armillary sphere (*dhāt al-ḥalaq*). David King, in an essay review of Sezgin's *GAS*,[2] mentions that the manuscript Ṭalʿat Mīqāt 189 on the armillary sphere is lost, but 'there are six other copies of an anonymous treatise in 33 chapters in Cairo'.

My research in the library Dār al-kutub in Cairo has shown that there are seven manuscripts of a 33-chapter Arabic treatise on the description and use of the celestial globe *dhāt al-kursī*, two of which clearly attribute the treatise to Ptolemy in their title. In MS Mīqāt Ṭalʿat 189,1, the manuscript mentioned by Sezgin, the title 'Treatise *Dhāt al-kursī* by Ptolemy' is written in the same hand as the rest of the treatise. In MS K 3844,1, the title 'Treatise of Qusṭ on the use of the globe *dhāt al-kursī* by Ptolemy' seems to be a later addition by another hand. In MS Mīqāt Ṭalʿat 202,2, the reading of Ptolemy's name in the title is ambiguous.[3]

During my research, several more manuscripts of this treatise have been found in various libraries. MS Istanbul, Süleymaniye Library 1037,1, which also contains this treatise, has the same title as the first of the above-mentioned manuscripts. MS Istanbul, Süleymaniye Library, Bağdatlı Vehbi 2124,6 attributes

1 Sezgin, *GAS*, vol. V, p. 171.

2 King, 'Notes on the Sources', p. 454.

3 See the discussion in the presentation of the manuscripts below; a photograph of the title is presented in Figure 1 on p. 23.

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the treatise to Akhawayn in the title on f. 105v,[4] while Ptolemy's name is mentioned below its title in the table of contents (f. 1r). According to the library's catalogue, MS Rabat, Bibliothèque Nationale du Royaume du Maroc, D 162,4 attributes this treatise to Ptolemy in its title; however this title does not exist in the manuscript.[5] Ptolemy's name appears in the title of manuscript Damascus, Assad Library, 14621,8, according to the electronic catalogue of the library.[6]

The present study starts with a survey of references to Ptolemaic works in Greek and Arabic sources (Section 1.1). It aims to collect the titles of the various works attributed to Ptolemy, and classify them, taking into consideration whether they are preserved in the original Greek text or a translation, are likely to now be lost, are authentic works or *pseudepigrapha*, or comprise unknown or unidentified works. A discussion of the treatise *Dhāt al-kursī* (Section 1.2) and the corresponding instrument follows (Section 1.3); then the manuscripts used for this study are presented (Section 1.4) and the introduction ends with the results of a historical research on Akhawayn and his works (Section 1.5). Then, I supply a critical edition of the treatise *Dhāt al-kursī*, based on eight of the twenty-three studied manuscripts, accompanied with an English translation (Chapter 2). A commentary on the introduction and each chapter of the treatise follows, with a parallel comparison to the treatise on the celestial globe by Qusṭā ibn Lūqā, which appears to be the source treatise (Chapter 3). A final discussion is presented in Chapter 4. Since Qusṭā's treatise is widely discussed in Chapter 3, three appendices related to this treatise are included. In Appendix 1, the titles of the 65 chapters in English translation are presented. In Appendix 2, there is a correspondence between the chapters of the various Arabic manuscripts of treatise Q, the edition of its Latin translation by Lorch and Martínez Gázquez, and treatise P. A transcription of the Arabic text of the *Treatise on the Use of the Celestial Globe with Stand* by Qusṭā ibn Lūqā is presented in Appendix 3; this text had not been previously published.

1.1 Ptolemy's authentic works and pseudepigrapha: Research on source materials

An essential step in studying the authenticity of works attributed to Ptolemy is the identification of pertinent references in the works of scientists, historians, encyclopaedists and bio-bibliographers. I have conducted this research across both Greek and Arabic source material, and this yielded the following interesting results.

[4] Also mentioned in King, 'Notes on the Sources', p. 454.

[5] See Lévi-Provençal, *Fihris al-makhṭūṭāt*, 2nd ed., no. 449, pp. 141–44. For further discussion see the description of the manuscript in Section 1.4 below.

[6] See additional information on this manuscript below, p. 32

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I. Greek sources[7]

1. Eutocius Ascalonius, 5th–6th century, in his commentary on Archimedes' works, refers to two works by Ptolemy:
   - *Almagest* (*Μεγάλη Σύνταξις*, p. 232, l. 16–17 and *Μαθηματικὴ Σύνταξις*, p. 260, l. 2–3)[8]
   - *On Weights*[9] (*Περὶ ῥοπῶν*, p. 264, l. 7–8)[10]
2. Simplicius, 6th century, in his commentary on Aristotle's *De caelo*,[11] refers to the following works by Ptolemy:
   - *On Weights* (*Περὶ ῥοπῶν*, p. 710, l. 14–15)
   - *On the Elements* (*Περὶ τῶν στοιχείων*, p. 20, l. 10–11)
   - *Optics* (*Ὀπτικά*, p. 20, l. 11)
   - *On Dimension* (*Περὶ διαστάσεως*, p. 9, l. 21–22)
   - *Handy Tables* (*Κανόνες*, p. 33, l. 1)
   - *Planetary Hypotheses* (*Ὑποθέσεις*, p. 456, l. 23)
   - *Almagest* (*Σύνταξις*, p. 474, l. 26–27, p. 539, l. 18)
   - *Geography* (*Γεωγραφία*, p. 549, l. 10)
3. There are also early commentaries on Ptolemy's works:
   - Pappus and Theon (3rd–4th century) wrote commentaries on the *Almagest*.[12]
   - Theon wrote two commentaries on the *Handy Tables* (*Ὑπόμνημα εἰς τοὺς προχείρους Πτολεμαίου κανόνας*).[13]

7 A comprehensive study of Ptolemy's works and detailed discussion of their authenticity appears in Alexander Jones, 'The Ancient Ptolemy'.

8 Eutocius, *Commentarius in dimensionem circuli*, in Heiberg and Stamatis, *Archimedis opera omnia cum commentariis Eutocii*, pp. 228–60.

9 The meaning of the word *ῥοπή* can be 'weight', 'downward momentum', 'turn of the scale' according to Liddell and Scott, *A Greek-English Lexicon*.

10 Eutocius, *Commentarius in libros de planorum aequilibriis*, in Heiberg and Stamatis, *Archimedis opera omnia cum commentariis Eutocii*, pp. 264–318.

11 Simplicius, *Simplicii in Aristotelis De caelo commentaria* (ed. Heiberg).

12 Pappus, *Commentaria in Ptolemaei syntaxin mathematicam v–vi*, and Theon, *Commentaria in Ptolemaei syntaxin mathematicam i–iv*, in Rome, *Commentaires de Pappus et de Théon*; see also Tihon, 'Le Livre V retrouvé'.

13 Tihon, *Le Petit Commentaire*, and Mogenet and Tihon, *Le Grand Commentaire*.

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- Porphyrius (3rd century) wrote a commentary on the *Harmonics* (*Εἰς τὰ ἁρμονικὰ Πτολεμαίου ὑπόμνημα*).[14]
- Paulus Alexandrinus (4th century) in *Elementa Apotelesmatica*[15] and Hephaestion Thebanus (5th century) in *Apotelesmatica*[16] follow Ptolemy's *Tetrabiblos* with many references to their source.

4. According to the *Suda Lexicon*,[17] 10th century, in Greek, Claudius Ptolemy wrote:
    - *Mechanics* (*Μηχανικά*) – 3 books.
    - *On the Appearances and Indications of the Fixed Stars* (*Περὶ φάσεων καὶ ἐπισημασιῶν ἀστέρων ἀπλανῶν*) – 2 books; this corresponds to the *Phaseis*.
    - *Unfolding the Surface of a Sphere* (*Ἅπλωσις ἐπιφανείας σφαίρας*); this corresponds to the *Planisphaerium*.
    - *Handy Tables* (*Πρόχειρος Κανών*).
    - *The Great Astronomy* or *Syntaxis* (*Μέγας ἀστρονόμος ἤτοι Σύνταξις*); this corresponds to the *Almagest*.
    - Other works.

II. Arabic sources[18]

1. Aḥmad ibn Isḥāq al-Yaʿqūbī (d. 897) in his book *Taʾrīkh al-Yaʿqūbī*[19] (or *Taʾrīkh ibn Wāḍiḥ*) mentions the following works by Ptolemy, giving details of their structure:

[14] Porphyrios, *Kommentar zur Harmonielehre des Ptolemaios* (ed. Düring).
[15] Paulus Alexandrinus, *Pauli Alexandrini Elementa apotelesmatica* (ed. Boer).
[16] Hephaestion Thebanus, *Apotelesmatica* (ed. Pingree).
[17] *Suda Lexicon* (ed. Adler), vol. IV, p. 254 (no. 3033).
[18] The current study cannot be considered a complete study of the Arabic sources, since there are probably other unstudied or unpublished works. It is also possible that secondary references to relevant Ptolemaic works exist in works of other medieval Arab scholars. Further research on this subject should be conducted. I have also searched in the following sources, which, however, do not contain separate entries for Ptolemy or Ptolemaic works, but only incidentally mention the *Almagest* and *Tetrabiblos* in entries on other authors:
1. Ibn Khallikān (1211–1282), *Ibn Khallikan's Biographical Dictionary* (ed. de Slane).
2. Al-Maqqarī (1577–1632), *Analectes sur l'histoire et la littérature des Arabes d'Espagne* (eds Dozy et al.).
3. Al-Mubashshir ibn Fātik (11th c. AD), *Mukhtār al-ḥikam wa maḥāsin al-kalim* (ed. Badawī).
4. Abū-l-Fidāʾ (1273–1331), *Abulfedae Annales* (ed. Adler and Reiske).
5. Ibn Abī Uṣaybiʿa (1203–1270), *ʿUyūn al-anbāʾ fī ṭabaqāt al-aṭibbāʾ* (ed. Müller). It is also available in English translation: Ibn Abī Uṣaybiʿa, *History of Physicians* (transl. Kopf).
[19] Al-Yaʿqūbī, *Taʾrīkh*, vol. I, pp. 133–43 and Klamroth, 'Über die Auszüge', pp. 17–27.

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- *Almagest* (كتاب المجسطي): al-Yaʿqūbī presents the titles of the chapters of books I–IV, mentioning that there are nine more books.
- *Book on the Instrument Having Rings* (i.e. the armillary sphere) (كتاب في ذات الحلق): he presents a summary of the description of this armillary sphere which contains 9 rings; then he mentions the titles of the 39 chapters on solving various astronomical problems using this armillary sphere.
- *Book on the Instrument Having Plates, which is the Astrolabe* (كتاب في ذات الصفائح، وهي الأسطرلاب): he presents a summary of the introduction, where the instrument is described, and the titles of 20 chapters on solving various astronomical problems with the astrolabe.
- *Handy Tables* (كتاب القانون في علم النجوم وحسابها):[20] he gives the titles of the chapters.

Klamroth, who translated the text of al-Yaʿqūbī into German, claims that al-Yaʿqūbī had substituted the name of Ptolemy for that of Theon. Among Klamroth's arguments is the fact that the same four treatises are mentioned in the *Fihrist* and by Bar-Hebraeus as works by Theon and that a treatise on the armillary sphere is completely unknown from Greek sources.[21] However, Pappus implies that Ptolemy had described the *meteoroscopeion*, that is an armillary sphere with 9 rings, in a distinct work.[22] The instrument itself is mentioned as *organon meteoroscopikon* (ὄργανον μετεωροσκοπικόν) or *meteoroscopion* (μετεωροσκόπιον) by Ptolemy in Chapter I.3 of his *Geography*.[23] The same instrument is mentioned also by Theon and Pappus[24] in their commentaries on Ptolemy's *Almagest*. Proclus explains that the astrolabe described in *Almagest* V.1 consists of 7 rings, while the *meteoroscopeion* (μετεωροσκοπεῖον) comprises 9 rings.[25]

An Arabic treatise on the armillary sphere, ascribed to Theon, describes an armillary sphere with 9 rings and presents instructions for solving various astronomical and geographical problems with this instrument. My study on this treatise shows that the titles of the

[20] lit. 'Book of Tables on the Science of the Stars and Their Calculation'.

[21] See Klamroth, 'Über die Auszüge', pp. 18–20.

[22] See Jones, 'The Ancient Ptolemy', p. 24. Pappus' implication appears in Rome, *Commentaires de Pappus et de Théon*, vol. I, p. 4.

[23] Ptolemy, *Claudii Ptolemaei Geographia* (ed. Müller), vol. I.1, Chapter I.3, Sections 3-4.

[24] Rome, *Commentaires de Pappus et de Théon*; Pappus refers to the *meteoroscopeion* in vol. I, pp. 4, 6, 12, and Theon in vol. II, p. 419.

[25] Proclus, *Procli Diadochi Hypotyposis* (ed. Manitius). Proclus' commentary on the construction and use of the astrolabe (*Περὶ ἀστρολάβου κατασκευῆς καὶ χρήσεως*) is in Chapter 6, pp. 198-211.

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chapters are the same as those described by al-Yaʿqūbī. In particular, two passages from chapters 25 and 26 that al-Yaʿqūbī quotes are almost identical with the corresponding chapters of the treatise ascribed to Theon.[26]

However, six palimpsest leaves from the manuscript Milan, Veneranda Biblioteca Ambrosiana, L 99 Sup., contain a Greek text recently identified as belonging to Ptolemy's *Treatise on the Meteoroscopion*.[27] The treatise is partially preserved. The description of the instrument is similar to that in the Arabic treatise ascribed to Theon, but some of the topics that appear in the recovered Greek text are not included in either al-Yaʿqūbī's list or the Arabic treatise. Thus, it seems that indeed al-Yaʿqūbī had preserved the titles of Theon's treatise, although he considers them to be Ptolemy's. The work of decipherment and interpretation on these palimpsest leaves is ongoing, and promising to reveal a great part of Ptolemy's *Treatise on the Meteoroscopion*, which had been considered as lost.

2. Abū al-Ḥasan ʿAlī ibn al-Ḥusayn al-Masʿūdī (born before 893, died 956 in Egypt).[28] In the last years of his life, he wrote *Kitāb al-Tanbīh wa-l-ishrāf* (*The Book of Notification and Verification*),[29] which was based in part on his earlier historical-geographical works. In this book, he mentions the following works by Ptolemy:

[26] The treatise is preserved in two manuscripts: Istanbul, Topkapı Saray, Ahmet III 3505,6, ff. 117r–133r, and Bombay, Cama Oriental Institute, Mulla Firuz 86, ff. 58r–72r. The titles preserved by al-Yaʿqūbī are closer to those of the latter manuscript; in some cases in the former manuscript, two successive and related chapters are incorporated under the same title.

[27] Gysembergh et al., 'Ptolemy's treatise on the meteoroscope recovered'. The authors provide a preliminary discussion on the ongoing research and argue that Ptolemy is the author of the palimpsested text that has been recovered using multispectral imaging. The exact title of Ptolemy's treatise is unknown.

[28] See Pellat, 'al-Masʿūdī'.

[29] Al-Masʿūdī, *Kitāb al-Tanbīh wal-ishrāf* (ed. de Goeje) and al-Masʿūdī, *Al-Tanbīh wa al-ishrāf* (ed. al-Ṣāūī); a translation into French is presented in Maçoudi, *Le livre de l'avertissement et de la revision* (transl. Carra de Vaux).

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Title	Identification / Translation	Pages (A)	Pages (B)
كتاب المجسطي	*Almagest*	12 / 129	11 / 112+
كتاب المقالات الأربع	*Tetrabiblos*	17 / 129	15–16 / 112
جغرافيا	*Geography*	129	112
القانون	*Handy Tables*	129	112
كتاب الموسيقى	*Book of Music*	129	112
كتاب الأنواء	*Phaseis*	17 / 129	16 / 112
كتاب الهيئة	*Planetary Hypotheses*[30]	12	11
كتاب في المدخل إلى الصناعة الكريّة[31]	*Book on the introduction to the spherical art / manufacture / sphaeropoiia*	69–70	61

Table 1: Ptolemy's works as mentioned by al-Masʿūdī. (A) refers to the edition by de Goeje in 1893, (B) to the edition by al-Ṣāūī in 1938.

The *Book on the Introduction to the Spherical Art / Manufacture* by Ptolemy is also mentioned by al-Bīrūnī (*c.* 973–1048) in *The Chronology of Ancient Nations*.[32] The Arabic term الصناعة الكريّة, translated above

[30] The identification of the treatise كتاب في الهيئة (*Book on the Structure ⟨of the Universe⟩*) is based on the title كتاب بطلميوس في الهيئة المسمّى بالاقتصاص (*Book by Ptolemy on the Structure ⟨of the Universe⟩ called* '*The Exposition*'), as presented in the edition of the Arabic text of the *Planetary Hypotheses* in Morelon, 'La version arabe du Livre des Hypothèses', p. 15. The passage on Mercury and Venus quoted by al-Masʿūdī seems to correspond to the text of the *Planetary Hypotheses* on pp. 64–65 of the edition by Morelon.

[31] The fragment of the *Book on the Introduction to the Spherical Art* given by al-Masʿūdī is as follows: من وراء خطّ الاستواء تحت مدار الجدي سودان مثل السودان التي تحت مدار رأس السرطان من دون خطّ الاستواء مما يلي الشمال، وأن بحر أوقيانس يأتي من ناحية المشرق الشتوي وهو مطلع الجدي ثم ينعطف من المشرق الشتويّ إلى ناحية الشمال إلى أن ينتهي إلى المغرب الصيفيّ، وهو مغرب السرطان (وذكر أنه) إنما وقف على هذا من الكتب التي دونت فيها أخبار المساكن التي عن جنوب بلاد مصر وإنهم وصلوا إلى ذلك بعناية ملوك مصر وإنفاذهم ثقاتهم إلى تلك النواحي ليعرف من هناك من الأمم.
The translation into French by Carra de Vaux, in Maçoudi, *Le livre de l'avertissement et de la révision*, pp. 102–03, is the following:
' … derrière l'Équateur, sous le cercle du Capricorne, habitent des nègres semblables à ceux que l'on voit sous le cercle du Cancer, en deçà de l'Équateur du côté du Nord, et que la mer Océan vient du point où le soleil se lève en hiver, c'est-à-dire où se lève le Capricorne, puis qu'elle s'infléchit vers le Nord pour arriver ensuite au point où le soleil se couche en été, c'est-à-dire où se couche le Cancer. (Il ajoute qu') il a tiré ces renseignements des livres dans lesquels furent consignées les informations sur les peuples au Sud de l'Égypte, livres composés par les soins des rois d'Égypte avec le concours des explorateurs qu'ils envoyèrent dans ces contrées pour connaître les nations qui y habitaient'.

[32] See al-Bīrūnī, *The Chronology of Ancient Nations* (ed. Sachau), p. 322 (Sachau translates the word صناعة as 'art'), and the Arabic text in al-Bīrūnī, *Chronologie orientalischer Völker von Albêrûnî* (ed. Sachau), pp. 325–26. In this passage al-Bīrūnī writes: 'Ptolemy says, in his *Introduction to the Spherical Art*, that the ancient Greeks fixed their beginnings (of the seasons) on the moments when the sun enters the equinoctial and solstitial points, whilst the Chaldeans are said to have commenced the seasons 8 degrees after the equinoxes and solstices'.

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as spherical art / manufacture, could be a translation of the Greek term σφαιροποιία. This term is used by Geminus and can indicate a branch of applied mechanics for constructing models of the heavens, such as celestial globes, armillary spheres and orreries, or describes the spherical arrangement of the cosmos, probably including deferents and epicycles.[33] Proclus also uses this term to describe 'the construction of models representing the celestial motion, worked out also by Archimedes' (ἡ σφαιροποιία κατὰ μίμησιν τῶν οὐρανίων περιφορῶν, οἵαν καὶ Ἀρχιμήδης ἐπραγματεύσατο).[34] The fragment preserved by al-Bīrūnī, although containing geographic elements, does not belong to any of the eight books of Ptolemy's *Geography*. Perhaps it is related to his lost work on Mechanics.

3. Muḥammad bin Isḥāq al-Nadīm (10th century) wrote the *Fihrist* (*The Index*) of the books of all kinds of Arabic literature in 377/987. In this book, the following works are attributed to Ptolemy:[35]

Almagest	كتاب المجسطي
Tetrabiblos	كتاب الأربع
Book of the Nativities	كتاب المواليد
Book of War and Battle	كتاب الحرب والقتال
Book for Extracting the Arrows / Lots	كتاب استخراج السهام
Book of the Revolution of the World Years	كتاب تحويل سنى العالم
Book of the Revolution of the Years of Nativities	كتاب تحويل سنى المواليد
Book of Illness and Drinking Medicine	كتاب المرض وشرب الدواء
Book on the Course of the Seven	كتاب في سير السبعة
Book on the Captives and Prisoners	كتاب في الإسراء والمحبسين
Book on Capturing Good Luck and its Synthesis?	كتاب في اسر السعود واصطناعها
Book of the Opponents, which one will succeed	كتاب الخصمين أيهما يفلح
Book on the Comets (lit. *those with Comae*)	كتاب ذوات الذوائب
Book known as the 'Seventh'	كتاب يعرف بالسابع
Book of the Lots, tabulated	كتاب القرعة، مجدول
Book of Planetary Hypotheses	كتاب اقتصاص أحوال الكواكب
Centiloquium	كتاب الثمرة
Book on Geography of the Oecumene and Description of the Earth	كتاب جغرافيا في المعمور وصفة الأرض

Table 2: Ptolemy's works as mentioned in the *Fihrist*.

33 Evans and Berggren, *Geminos's Introduction to the Phenomena*, pp. 47, 53, 198, 293.

34 Proclus, *Procli Diadochi In primum Euclidis Elementorum* (ed. Friedlein), p. 41.

35 Al-Nadīm, *Kitāb al-Fihrist* (eds Flügel et al.), vol. I, Arabic pp. 267–68. The year of the *Fihrist* is given by Flügel in the preface of vol. I, p. XI.

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4. Ṣāʿid al-Andalusī (1029–1070) in his work *Exposition of the Generations of Nations* (التعريف بطبقات الأمم) [36] written in 1068 mentions the following works by Ptolemy:

    - *Almagest* (كتاب المجسطي)
    - *Geography* (كتاب الجغرافيا)
    - *Optics* (كتاب المناظر)
    - *Tetrabiblos* (كتاب المقالات الأربع في أحكام النجوم)
    - *Book of Music* (كتاب الموسيقى)
    - *Phaseis* (كتاب الأنواء)[37]
    - *Handy Tables* (كتاب القانون)

5. ʿAlī ibn Yūsuf al-Qifṭī (1172–1248) in his work *Taʾrīkh al-ḥukamāʾ* (*The History of Learned Men*),[38] mentions Ptolemy and his works, but he copies earlier authors, such as al-Nadīm, al-Masʿūdī or Ṣāʿid al-Andalusī. In the list of Ptolemy's works, he repeats the list presented in the *Fihrist*, in the same order, omitting four of the works mentioned by al-Nadīm[39] and changing some words in the titles of four other works (see Table 4 and the corresponding notes).

6. Kātip Çelebi or Ḥājjī Khalīfa (1609–1657) was an Ottoman scholar; among his works is the bibliographic encyclopedia *Kashf al-ẓunūn ʿan asāmī al-kutub wa-al-funūn* (*The Removal of Doubt from the Names of Books and the Arts*), in which he lists thousands of books arranged in alphabetical order.[40] He mentions the following works by Ptolemy:

Title	Identification / Translation	Vol. Page (A)	Vol. Column (B)
كتاب تسطيح الكرة	*Planisphaerium*	II.288 / V.61–62	I.403 / II.1404
تعبير الرؤيا	*Interpretation of Dreams*	II.311	I.417
الثمرة في أحكام النجوم	*Fructus / Centiloquium*	II.496	I.524
جغرافيا	Geography	II.602	I.590–91
رسالة ذات الكرسي	*Treatise Dhāt al-kursī*	III.399	I.865

36 Ṣāʿid l'Andalous, *Kitāb Tabaqāt al-Umam* (ed. Cheikho): the list of Ptolemy's works is on p. 29, while the passage on Claudius Ptolemy is on pp. 29–31. A French translation with notes is also available: Blachère, *Ṣâʿid al Andalusî* (the passage on Ptolemy is on pp. 72–73, while Ptolemy's works are listed on p. 72).

37 For the identification see: Morelon, 'Fragment arabe du premier livre du *Phaseis*'.

38 Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert); the section on Ptolemy is on pp. 95–98.

39 The works omitted by al-Qifṭī are: *Centiloquium*, *Book on the Comets*, *Book Known as the 'Seventh'* (كتاب يعرف بالسابع), *Book of the Revolution of the Years of Nativities*.

40 Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel); Kātip Çelebi, *Keşf-el-zunun* (eds Yaltkaya and Bilge).

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Title	Identification / Translation	Vol. Page (A)	Vol. Column (B)
المجسطي	*Almagest*	V.385–89	II.1594–96
كتاب المقالات الأربع	*Tetrabiblos*	VI.49	II.1781

Table 3: Ptolemy's works as mentioned by Ḥājjī Khalīfa. (A) refers to the edition by Flügel in 1835, (B) to the edition by Yaltkaya and Bilge in 1941–1943.

Under the letter *Dhal* (ذ) of the aggregate lemma *risāla* (treatise), Ḥājjī Khalīfa mentions *Risāla Dhāt al-kursī*, giving three authors who wrote on this instrument:[41]

- 'Treatise *Dhāt al-kursī* by Ptolemy. It consists of an introduction and a number of chapters. Later scholars transformed it into Arabic. During its transformation into Arabic it was abbreviated by some of them. It was improved and revised by others (resulting in) an introduction and 38 chapters. Its beginning is: "Praise be to God, who created the high heavens" etc.'
- 'And by Qusṭā ibn Lūqā and it has 65 chapters'
- 'And by ʿAbd al-Raḥmān ibn ʿUmar al-Ṣūfī a great treatise in 3 books containing 157 chapters; its beginning is: "Praise be to God, who raised the heavens by His power" etc.'

The above information is summarized in Table 4.

	Title	English title	Early commentaries	Eutocius	Simplicius	Suda	al-Yaʿqūbī	al-Masʿūdī	Fihrist	Ṣāʿid, al-Andalusī	al-Qifṭī	Ḥājjī Khalīfa
1	Μαθηματικὴ Σύνταξις كتاب المجسطي	*Almagest*	+	+	+	+	+	+	+	+	+	+
2	Γεωγραφικὴ Ὑφήγησις كتاب جغرافيا في المعمور وصفة[42] الأرض	*Book on Geography of the Oecumene and Description of the Earth*			+			+	+	+	+	+

[41] Kātip Çelebi, *Keşf-el-zunun* (eds Yaltkaya and Bilge), vol. I, col. 865 and Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. III, p. 399 (with a phrase repeated in an incorrect position). The original Arabic text of the lemma, as edited by Yaltkaya and Bilge, is as follows:
رسالة ذات الكرسي – لبطلميوس. رتب على مقدمة وعدة أبواب. عربها المتأخرون. ومن معرباتها مختصر لبعضهم. ولغيره هذّبها ونقّحها في مقدمة و 38 بابا. أولها الحمد لله الذي خلق السموات العلي الخ.
ولقسطا ابن لوقا وهي 65 بابا.
ولعبد الرحمن بن عمر الصوفي رسالة كبرى في ثلاث مقالات مشتملة على مائة وسبعة وخمسين بابا أولها الحمد لله الذي سمك السماء بقدرته الخ.

[42] Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert), p. 98: المعمورة من for المعمور وصفة.

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	Title	English title	Early commentaries	Eutocius	Simplicius	Suda	al-Yaʿqūbī	al-Masʿūdī	Fihrist	Ṣāʿid, al-Andalusī	al-Qifṭī	Ḥājjī Khalīfa
3	*Ἀποτελεσματικά – Τετράβιβλος* كتاب المقالات الأربع[43]	*Tetrabiblos*	+					+	+	+	+	+
4	*Ἅπλωσις ἐπιφανείας σφαίρας* كتاب تسطيح الكرة	*Unfolding the Surface of a Sphere (Planisphaerium)*				+						+
5	*Περὶ φάσεων καὶ ἐπισημασιῶν ἀστέρων ἀπλανῶν* كتاب الأنواء	*On the Appearances and Indications of the Fixed Stars (Phaseis)*				+		+		+		
6	*Προχείρων κανόνων διάταξις καὶ ψηφοφορία* القانون	*Handy Tables*	+		+	+	+	+		+		
7	*Ὑποθέσεις τῶν πλανωμένων* كتاب اقتصاص أحوال الكواكب	*Book of Planetary Hypotheses*			+			+	+		+	
8	*Μουσικά* كتاب الموسيقى	*Musica*						+		+		
9	*Ἁρμονικά*	*Harmonics*	+									
10	*Ὀπτικά* كتاب المناظر	*Optics*			+					+		
11	*Περὶ διαστάσεως*	*On Dimension*			+							
12	*Περὶ ῥοπῶν*	*On Weights*		+	+							
13	*Περὶ τῶν στοιχείων*	*On the Elements*			+							
14	*Μηχανικά*	Mechanics				+						
15	كتاب في المدخل إلى الصناعة الكريّة	*Book on the Introduction to the Spherical Art*						+				
16	كتاب الثمرة	*Centiloquium*							+			+
17	رسالة ذات الكرسي	*Treatise Dhāt al-kursī*										+
18	كتاب المواليد	*Book of Nativities*							+		+	
19	كتاب الحرب والقتال	*Book of War and Battle*							+		+	
20	كتاب استخراج السهام	*Book for Extracting the Arrows / Lots*							+		+	

[43] Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert), p. 98: كتاب; al-Nadīm, *Kitāb al-Fihrist* (eds Flügel *et al.*), p. 268: كتاب الأربعة.

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	Title	English title	Early commentaries	Eutocius	Simplicius	Suda	al-Yaʿqūbī	al-Masʿūdī	Fihrist	Ṣāʿid, al-Andalusī	al-Qifṭī	Ḥājjī Khalīfa
21	كتاب تحويل سنى العالم	*Book of the Revolution of the World Years*							+		+	
22	كتاب تحويل سنى المواليد	*Book of the Revolution of the Years of Nativities*							+			
23	كتاب المرض وشرب الدواء	*Book of Illness and Drinking Medicine*							+		+	
24	كتاب في سَير[44] السبعة	*Book on the Course of the Seven*							+		+	
25	كتاب في الأسرى[45] والمحبسين	*Book on the Captives and Prisoners*							+		+	
26	كتاب في اسر[46] السعود واصطناعها	*Book on Capturing Good Luck and its Synthesis*							+		+	
27	كتاب الخصمين أيهما يفلح	*Book of the Opponents, which one will succeed*							+		+	
28	كتاب ذوات الذوائب	*Book on the Comets*							+			
29	كتاب يعرف بالسابع	*Book known as the 'Seventh'*							+			
30	كتاب القرعة، مجدول	*Book of the Lots, tabulated*							+		+	
31	كتاب في ذات الحلق	*Book on the Armillary Sphere*					+					
32	كتاب في ذات الصفائح	*Book on the Astrolabe*					+					
33	تعبير الرؤيا	*Interpretation of Dreams*										+

Table 4: Consolidated table of works attributed to Ptolemy, as mentioned in various Greek and Arabic sources.

Taking into consideration the above study and the results of Alexander Jones presented in 'The Ancient Ptolemy', we can classify the multitude of the works attributed to Ptolemy into the following five categories:

[44] Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert), p. 98 : سَير for في سَير.

[45] Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert), p. 98: الأسرى and al-Nadīm, *Kitāb al-Fihrist* (eds Flügel et al.), p. 268: في الاسراء for في الأسرى

[46] Al-Qifṭī, *Taʾrīḫ al-ḥukamāʾ* (eds Müller and Lippert), p. 98: اشتراء.

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1. Authentic works of Ptolemy that are preserved entirely or fragmentarily in the original Greek language: 1. *Almagest*,[47] 2. *Geography*,[48] 3. *Tetrabiblos*,[49] 5. *Phaseis*,[50] 6. *Handy Tables*,[51] 7. *Hypotheses*,[52] 9. *Harmonics*[53] and *Meteoroscopion*.[54] In this category we should add *Analemma*,[55] *Inscriptio Canobi*,[56] and *De judicandi facultate et animi principatu*,[57] whose authenticity is confirmed by Jones.

2. Authentic works of Ptolemy that are preserved entirely or fragmentarily in Arabic translation: 1. *Almagest*, 2. *Geography*, 3. *Tetrabiblos*, 4. *Planisphaerium*,[58] 5. *Phaseis* (fragment),[59] 7. *Hypotheses*.[60] The work 10. *Optics* is preserved, although mutilated, in Latin translation.[61]

3. Authentic works of Ptolemy that are apparently lost: 11. *On Dimension*, 12. *On Weights*, 13. *On the Elements*, 14. *Mechanics*, 15. *Book on the Introduction to the Spherical Art*.[62]

[47] Ptolemy, *Syntaxis mathematica* (ed. Heiberg).

[48] Ptolemy, *Claudii Ptolemaei Geographia* (ed. Müller) and Ptolemy, *Claudii Ptolemaei Geographia* (ed. Nobbe); also Ptolemy, *Klaudios Ptolemaios. Handbuch der Geographie* (eds Stückelberger and Grasshoff), with German translation.

[49] Ptolemy, *Apotelesmatica* (eds Boll and Boer); Ptolemy, *Ἀποτελεσματικά* (ed. Hübner).

[50] *Phaseis*, in Ptolemy, *Opera astronomica minora* (ed. Heiberg), pp. 3–67.

[51] *Προχείρων κανόνων διάταξις καὶ ψηφοφορία* in Ptolemy, *Opera astronomica minora* (ed. Heiberg), pp. 159–85; Tihon, *Πτολεμαίου Πρόχειροι κανόνες*; Mercier, *Πτολεμαίου Πρόχειροι κανόνες*. English translation: Stahlman, *The Astronomical Tables*.

[52] Only the first part of Book 1 (Part 1A) survives in Greek: *Hypotheses*, in Ptolemy, *Opera astronomica minora* (ed. Heiberg), pp. 70–106. An English translation of part 1A with commentary on Book 1 appears in Hamm, *Ptolemy's Planetary Theory*.

[53] *Harmonica*: Düring, *Die Harmonielehre des Klaudios Ptolemaios*; an English translation and commentary are presented in Solomon, *Ptolemy Harmonics*.

[54] Gysembergh et al., 'Ptolemy's treatise on the meteoroscope recovered'; preliminary discussion on a recovered palimpsested text. This work is on the same subject as entry 31 of Table 4, the *Book on the Armillary Sphere*, but according to the existing up to now evidence the two works present many differences; see the discussion on pp. 5–6.

[55] *De analemmate* in Ptolemy, *Opera astronomica minora* (ed. Heiberg), pp. 194–216; also Edwards, *Ptolemy's Περὶ ἀναλήμματος*.

[56] *Inscriptio Canobi*, in Ptolemy, *Opera astronomica minora* (ed. Heiberg), pp. 149–55.

[57] *De judicandi facultate et animi principatu* (*Περὶ κριτηρίου καὶ ἡγεμονικοῦ*), in Ptolemy, *Περὶ κριτηρίου* (ed. Lammert).

[58] Anagnostakis, *The Arabic Version*; also Sidoli and Berggren, 'The Arabic Version'.

[59] Morelon, 'Fragment arabe du premier livre du *Phaseis*'.

[60] The whole text of *Hypotheses* (Books 1A–1B and 2) is preserved in Arabic translation. It has been published as facsimile with an English translation of Book 1B in Goldstein, 'The Arabic Version of Ptolemy's Planetary Hypotheses'. The Arabic text of Book 1(A–B) has been edited and translated into French in Morelon, 'La version arabe du Livre des Hypothèses'. A full edition of the Arabic text with English translation by Paul Hullmeine will soon appear in the series *Ptolemaeus Arabus et Latinus – Texts*.

[61] Lejeune, *L'Optique de Claude Ptolémée*; also Smith, *Ptolemy's Theory*.

[62] According to Jones, 'The Ancient Ptolemy', pp. 23–25, 28, the following works should also be considered as authentic but lost works of Ptolemy: i. *On Paradoxical Phases of Venus*, ii. a treatise on

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4. *Pseudepigrapha* preserved in either Greek or Arabic: 8. *Musica*,[63] 16. *Centiloquium* (in both Greek and Arabic);[64] the treatise 17. *Dhāt al-kursī* can be classified in this category, according to the study presented below.

5. Unknown or unidentified works described in Arabic in nos 18-30 and 32-33 of Table 4, which need further investigation in terms of whether they actually existed, if so in what form, and regarding their connection to Ptolemy. For example, no 28, The *Book on the Comets* may have a connection with chapters II.10 and II.14 of Ptolemy's *Tetrabiblos*. This treatise could be related to the Arabic treatise with the same title, which is preserved in MS Cairo, Dār al-kutub, Mīqāt M 204,6 (ff. 75v–76r).

1.2 The treatise *Dhāt al-kursī*

We focus now on the treatise *Dhāt al-kursī*. As we have seen above, among the sources studied, the only reference to this treatise as a work by Ptolemy is that in Ḥājjī Khalīfa's *Kashf al-ẓunūn*, written in the middle of the seventeenth century. Immediately after it, the treatise with the same title by Qusṭā ibn Lūqā is mentioned as well. It seems that Ḥājjī Khalīfa had read at least the preface of the treatise, because he quotes the incipit and some other information from the preface, concerning the abbreviation, improvement and revision of the treatise. He gives a number of 38 chapters, although there are only 33 chapters in all the preserved manuscripts of the treatise.[65]

The preface of the treatise *Dhāt al-kursī*, written in a form of rhymed prose (سَجع), refers to the treatise of Qusṭā, touching upon the superfluities, omissions and defects in the latter. The author declares that he is going to improve the treatise, omit the superfluities and add some new uses. Thus, he admits that the source treatise is that of Qusṭā. The name of Ptolemy is not mentioned at all in the whole text of both treatises.

theory of stellar visibility, and iii. a work related to Euclid's *Elements*.

63 *Πτολεμαίου Μουσικά* in von Jan, *Musici scriptores graeci*, pp. 411–23.

64 Pseudo-Ptolemy, *Καρπός* (ed. Boer). The Arabic text with an Italian translation is included in Martorello and Bezza, *Aḥmad ibn Yusūf ibn al-Dāya: Commento al Centiloquio*, pp. 45–235.

65 The manuscript Istanbul, Süleymaniye Library, Ayasofya 2623 is not complete and includes only 20 chapters. The oldest dated manuscript (Princeton, University Library, IMNS 243,13) was produced almost a century before the compilation of *Kashf al-ẓunūn*. It is possible that either Ḥājjī Khalīfa was acquainted with an extended version of this treatise (the last five chapters could correspond to a lost folio at the end of the treatise), or, most probably, the number 33 (لجـ / ثلاثـة وثلاثيـن) was somehow misunderstood and transmitted as 38 (لح / ثمانيـة وثلاثيـن).

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Because reference to the treatise of Qusṭā is made in this way, I have compared the two treatises in detail in order to establish the relationship between them, and I present the results below, in the commentary and comparison (Chapter 3). Henceforward, I refer to the treatise attributed to Ptolemy as 'treatise P' and that of Qusṭā as 'treatise Q'.

The 33 chapters of the treatise *Dhāt al-kursī* attributed to Ptolemy can be arranged in 6 groups:

1. Positioning the globe, measuring the sun's altitude and finding orientation (Chapters 1, 9, 28);
2. Day- and nighttime arc and time calculation (Chapters 2–7, 32);
3. Astrology: ascendant, four centres and domification (Chapters 8, 10–11);
4. Stars, moon, planets and degrees of the ecliptic: position, rising, culminating and setting (Chapters 12–21, 33);
5. Sun and shadow (Chapters 21–27);
6. 'Longitude' and 'latitude' of the moon, planets and stars not drawn on the globe. Lunar and solar eclipses (Chapters 29–31).[66]

A transcription of the preface, the introduction, the titles of the chapters and the explicit of MS Cairo, Mīqāt Ṭalʿat 189, has been published by Celentano, who examined the treatise *Dhāt al-kursī* in order to check whether it has any relation to the *Book on the Instrument Having Rings* that al-Yaʿqūbī attributed to Ptolemy; al-Yaʿqūbī preserved the chapter titles of this book in his work *Taʾrīkh al-Yaʿqūbī*.[67]

Qusṭā ibn Lūqā (d. *c.* 912 AD) was a prominent translator and scientist of Greek origin. He translated many works on mathematics and astronomy from Greek into Arabic, among them works of Diophantus, Aristarchus, Theodosius, Autolycus and Hypsicles. He also compiled works on medicine, mathematics and astronomy in Arabic. Among his works on astronomy is the *Treatise on the Celestial Globe*, which is the above-mentioned 'treatise Q'. It appears with various titles and is preserved in numerous manuscripts.[68] The

[66] The terms 'longitude' and 'latitude' do not correspond to the ecliptic longitude and latitude; for the meaning of these terms see the commentary on chapters P12 and P29 in Chapter 3.

[67] Celentano, *L'epistola di al-Kindī sulla sfera armillare*; the text is in Appendix I, pp. 54–57, and the comments on the comparison on p. 6. For *Taʾrīkh al-Yaʿqūbī* see pp. 4–6 above.

[68] See Sezgin, *GAS*, vol. VI, pp. 180–82. Sezgin mentions 36 manuscripts, but the manuscripts C, F, L, R, S and T are not included in his list. He presents the following titles for this treatise: 1. *Treatise on the Astronomical Globe* (رسالة في الكرة الفلكية), 2 . *Book on Working with the Astronomical Globe* (كتاب في العمل بالكرة الفلكية), 3. *Treatise on Working with the Globe* (رسالة في العمل بالكرة), 4. *Book on Working with the Star Globe* (كتاب في العمل بالكرة النجومية), and 5. *Treatise on Working with the Globe with Stand* (رسالة في العمل بالكرة ذات الكرسي).

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treatise contains 65 chapters in most manuscripts, but there are problems in their enumeration. An English translation of the chapter titles is included in Appendix 1, the correspondence between the chapters in the manuscripts is presented in Appendix 2, and a transcription of the Arabic text is provided in Appendix 3.

Qusṭā ibn Lūqā used the knowledge included in the astronomical treatises he had translated to compile his treatise on the celestial globe. This will be discussed below, in the commentary and comparison between the two treatises (Chapter 3).

The treatise of Qusṭā on the celestial globe was translated into Latin, Hebrew, Spanish and Italian.[69] There is an English translation of the introduction and first 14 chapters, along with the titles of the rest of the 65 chapters, by W. H. Worrell.[70] A Latin translation (thirteenth century) of this treatise was edited by R. Lorch and J. Martínez Gázquez.[71] Julio Samsó presented a comparison between the treatise of Qusṭā ibn Lūqā and the Alfonsine treatise *Libro de la fayçon dell espera*.[72]

For the present research, eighteen manuscripts of this treatise have been examined:

A: Cairo, Dār al-kutub, Mīqāt Ḥalīm ʿarabī 7, ff. 1r–11r, *c.* 1250 H / AD 1834.[73]

B: Cairo, Dār al-kutub, K ʿarabī 3824,13, ff. 107r–122r, 1170 H / AD 1756–7 .[74]

C: London, British Library, Stowe Orient 10,6, ff. 67r–75v, 16th c.[75]

D: London, British Library, Add. 9598,10, ff. 139r–157v; western Arabic origin.[76]

69 See Sezgin, *GAS*, vol. VI, p. 181.

70 Worrell, 'Qusta ibn Luqa'. The translation of the titles does not always reflect the correct meaning of the chapter.

71 Lorch and Martínez Gázquez, 'Qusta ben Luca. De sphera uolubili'.

72 Samsó, 'Qustā ibn Lūqā'.

73 King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 651.

74 King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 318. The date is according to *GAS*, vol. VI, p. 181.

75 Rieu, *Supplement to the Catalogue*, pp. 511–12, entry 753. I am thankful to Bink Hallum for providing me with access to the three manuscripts (C, D, E) at the British Library.

76 Cureton and Rieu, *Catalogus Codicum Manuscriptorum Orientalium*, pp. 192–94, CCCCVII.

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E: London, British Library, Add. 7490,7, ff. 170v–185v, *c.* 1058 H / AD 1648.[77]

F: Philadelphia, University of Pennsylvania (Lawrence J. Schoenberg Collection), LJS 412,1, ff. 1v–10v, 950 H / AD 1543. This manuscript originates from Cairo.

H: Istanbul, Süleymaniye Library, Esad Efendi 2015,1, ff. 1v–27v, 1181 H / AD 1767–8.

I: Istanbul, Süleymaniye Library, Esad Efendi 2015,3, ff. 33v–58r. The chapters in this manuscript are not numbered.

K: Damascus, National Library, al-Ẓāhirīya 4494, pp. 20–67.

L: Cairo, Central Library of Islamic Manuscripts, 3071,7 (12 unnumbered folios, previously: Library al-Dardīrī 417), 11 Shawwāl 1118 H / 16 January AD 1707.

M: Princeton, University Library, Garrett 3168Y,1, ff. 2v–12v, 12th c. H.[78]

N: Istanbul, Topkapi Saray, Ahmet III 3505,5, ff. 95r–116r, 661 H / AD 1263.[79]

O: Istanbul, Topkapi Saray, Ahmet III, 3475,1, (ff. 1v–78v), undated.[80]

R: Paris, Bibliothèque nationale de France, arabe 7244,1, ff. 1v–18v, 2 Jumādā al-Thānī 1188 H / 10 August AD 1774, in western Arabic handwriting.[81]

77 Cureton and Rieu, *Catalogus Codicum Manuscriptorum Orientalium*, pp. 197–98, CCCCXV.
78 Mach, *Catalogue of Arabic Manuscripts*, no. 4901, p. 423. The manuscript is online available at: https://dpul.princeton.edu/islamicmss/catalog/st74cv08m (accessed on 30.1.2021).
79 The manuscript bears the almond-shaped seal of Sultan Bāyazīt II on ff. 1r and 218v, and the round seal of Sultan Ahmet III on f. 1r. It was included in the library inventory of Bāyazīt II (1502/3–1503/4) preserved in MS Budapest, Library of the Hungarian Academy of Sciences, Oriental Collection, Török F. 59; see Necipoğlu et al., *Treasures of Knowledge*, vol. II, pp. 209, 405. The table of contents on f. 1r of MS N, except for Qusṭā's name, is listed on p. 319 (lines 18–19) and p. 320 (lines 1–3) of the manuscript containing the inventory, which is presented in this volume both as facsimile and as transliteration. It is remarkable that neither the table of contents on f. 1r nor the inventory mentions the sixth treatise in the manuscript, *Book of Interpretation of the Armillary Sphere that Theon of Alexandria mentions*, which is on ff. 117r–133r.
80 The manuscript bears the almond-shaped seal of Sultan Bāyazīt II (r. 1481–1512) on ff. 1r and 97v, and the round seal of Sultan Ahmet III (r. 1703–1730) on f. 1r, so the manuscript cannot be dated to the 10th c. H (AD 1591–1688) as mentioned in GAS, vol. VI, p. 181. For the seals of the above-mentioned sultans see Necipoğlu, Appendix III in *Treasures of Knowledge*, vol. I, in particular pp. 1025–50.
81 In MS R, f. 17, which contains the text of chapter 22 (without its title) followed by chapters 23–26 and the beginning of chapter 27, is misplaced; its correct position is between f. 8 and f. 9. There are two successive pairs of folios numbered as 6 and 7; then f. 8 follows and the numbering continues normally. The manuscript is online available through gallica.bnf.fr/ Bibliothèque nationale de France: https://gallica.bnf.fr/ark:/12148/btv1b10031259s (accessed on 06.11.2021).

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S: Paris, Bibliothèque nationale de France, arabe 2544,11, ff. 79v–83v.[82]

T: Tirana, National Library of Albania, Dr 6/23E,11, ff. 151r–176v, 1082(?) H / AD 1671.[83]

U: Hydarabad, Salar Jung, kalām 136,2, ff. 94v–117v.[84]

Z: Meshhed, Holy Shrine, 5595,1, ff. 1v–8r.

1.3 The instrument *dhāt al-kursī*

The treatise *Dhāt al-kursī* describes an astronomical instrument and gives instructions on how to use it for solving some astronomical and astrological problems. The meaning of the title *Dhāt al-kursī* is the following: *kursī* كرسي in Arabic means 'chair, throne, stand' and *dhāt* ذات is the feminine form of *dhū* ذو and means 'endowed with, having', so the term *dhāt al-kursī* means 'having a stand'. Here *dhāt al-kursī* refers to *al-kura* (الكرة), the globe; so, *al-kura dhāt al-kursī* means 'the globe with stand'. The constellation of Cassiopeia is also called in Arabic *Dhāt al-kursī*, because Cassiopeia is sitting on a throne.

A detailed description of the instrument is presented in the introduction of treatise P and the first chapter of treatise Q, while a discussion of its design is included in my commentary on the introduction.

This type of celestial globe is described in the work *Introduction to the Phenomena* of Geminus (1st c. BC),[85] approximately two centuries before Ptolemy. The Arabic term *dhāt al-kursī* corresponds to the Greek term *καταστηριζομένη (σφαίρα)*, while the term *al-kursī* corresponds to the Greek term *σφαιροθήκη*.

82 MS S contains only 25 chapters of Qusṭā ibn Lūqā's treatise; their correspondence to the chapters of the complete version is presented in Appendix 2. The manuscript is online available through gallica.bnf.fr/ Bibliothèque nationale de France: https://gallica.bnf.fr/ark:/12148/btv1b100375232 (accessed on 20.9.2021).

83 Mentioned as manuscript An VIII/21E in al-Ḥalwajī and ʿAẓīmī, *Catalogue of Islamic Manuscripts*, no. 354, pp. 272–73. The authors of the catalogue consider the third (ff. 25v–30r, *On the Quadrant*) and the fourth (ff. 30v–42v, *On the Astrolabe*) treatises of the manuscript as one. The folio numbering is not systematic; after f. 39, few folios bear numbers, usually at the beginning or the end of the treatises. Two folios are not included in the numbering, one between f. 36 and f. 37, and one between f. 125 and f. 149. The treatise is on ff. 151r–176v, according to the folio numbers existing in the manuscript. No date is mentioned at the end of Qusṭā's treatise. The date of the second treatise is 1082 H on f. 24v, while the sixth and tenth treatises, written in Turkish, mention 182 as year of copying (1082 or 1182 H?) on ff. 112v and 148v respectively. Since the handwriting in these three treatises is similar, I think that the year 1082 H is more probable.

84 I am thankful to Leonard Chiarelli, University of Utah, for providing me with this manuscript.

85 Aujac, *Géminos. Introduction aux Phénomènes*, also Evans and Berggren, *Geminos's Introduction to the Phenomena* and Manitius, *Gemini Elementa astronomiae*; the description of the celestial globe is in Chapter 5: 'The Circles on the Sphere'.

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Ptolemy describes the construction of a celestial globe with stand in Chapter VIII.3 of his *Almagest*.[86] This globe can be used eternally because the precession of the equinoxes has been taken into consideration at its conception. Thus, only two circles are drawn on this globe: the ecliptic (divided into 360°) and a great circle through the poles of the ecliptic; the location of the Milky Way is also marked on the globe. There are two rotatable rings around the globe: one of them represents the solstitial colure and is mounted through the poles of the ecliptic; the other ring represents the meridian and is mounted to the ring of the solstitial colure at the positions of the two poles of the equator. Sirius is positioned on the great circle through the poles of the ecliptic, according to its latitude; the point of intersection of the ecliptic with the semicircle through the poles of the ecliptic and Sirius is considered as the beginning of the graduation on the ecliptic. The system that comprises the globe with the two attached rings is placed on a stand (βάσις), the upper horizontal ring of which represents the horizon. The globe can be adjusted to the desired latitude by elevating the north celestial pole above the horizon according to the latitude.

The precession globe described by Ptolemy differs significantly from the globe *dhāt al-kursī* described in treatises P and Q. Thus, the mention of Ptolemy in the title 'The treatise *Dhāt al-kursī* by Ptolemy' must be understood as referring to the treatise, rather than the instrument. This is also confirmed by Ḥājjī Khalīfa, who clearly refers to three authors who wrote on the instrument *dhāt al-kursī*: Ptolemy, Qusṭā ibn Lūqā and al-Ṣūfī.

Leontius (7th c.), in his partially preserved treatise *On the Construction of the Aratean Sphere* (Περὶ κατασκευῆς Ἀρατείας σφαίρας),[87] describes the construction of a globe with stand similar to that described by Geminus. Both Geminus and Leontius put the arctic and antarctic circles on the globe.[88] The presence of these circles on the globe shows that the celestial poles were not adjustable to the latitude of the locality; Geminus' globe corresponds to the latitude of Rhodes (φ=36°), whilst Leontius' corresponds to that of Constantinople (φ=41°). This is the most significant difference between these globes

86 Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part II, pp. 179–85, and Toomer, *Ptolemy's Almagest*, pp. 404–07.

87 Leontius, 'De sphaerae Arateae constructione', in Maass, *Commentariorum in Aratum reliquiae*, pp. 559–67.

88 According to Geminus, 'the arctic circle is the largest of the always-visible circles touching the horizon at one point and situated wholly above the Earth. The stars lying within it neither rise nor set, but are seen through the whole night turning around the pole', while 'the antarctic circle is equal [in size], and parallel to, the arctic circle, being tangent to the horizon at one point and situated wholly beneath the Earth. The stars lying within it are always invisible to us' (see Evans and Berggren, *Geminos's Introduction to the Phenomena*, pp. 149, 151). These definitions denote that for a given terrestrial latitude φ, the arctic circle is the circle of north latitude 90°−φ, and the antarctic circle is the circle of south latitude 90°−φ.

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and the globe described in treatises P and Q, where the celestial poles are adjustable to the local latitude.

The above descriptions of a celestial globe with stand are preserved in the original Greek texts.[89] There are also descriptions coming from Arabic sources,[90] such as that in the *Book on the Sphere and its Use*, written by Ḥabash al-Ḥāsib in the ninth century, with a description of the celestial globe and 14 chapters on its use,[91] and in the treatise *On the Use of the Celestial Globe* by al-Ṣūfī,[92] written between AD 983 and 986. The latter contains 157 chapters arranged in three books; the description of the globe with stand is included in Chapters 1–2 of the first book. The celestial globe described by al-Ṣūfī is similar to that of treatises P and Q.

1.4 Presentation of the manuscripts

For the edition of the treatise *Dhāt al-kursī* attributed to Ptolemy, seven manuscripts coming from the Egyptian National Library (Dār al-kutub) in Cairo and one from the Süleymaniye Library in Istanbul have been used. The manuscripts are the following:

1. Cairo, Dār al-kutub, Mīqāt Ṭalʿat ʿarabī 189,1 (MS A / ا).

   Mentioned in Sezgin, *GAS*, vol. V.[93] The manuscript consists of 7 folios and is paginated. The title of the treatise رسالة ذات الكرسي لبطلميوس (*Treatise on the ⟨Globe⟩ with Stand by Ptolemy*) appears on p. 1, and the text of the treatise is on pp. 2–11 (27 lines per page). In the margins of pp. 2, 3 and 5 there are some glosses in Arabic and Ottoman Turkish. On pp. 12–14 there is the first part of a treatise on the astrolabe in Turkish. There is no date written in the manuscript.

2. Cairo, Dār al-kutub, K ʿarabī 3844.

   Mentioned in King's catalogue.[94] This manuscript consists of 96 folios and is foliated. It contains two copies of the treatise: on ff. 1r–14r

[89] For a more detailed discussion on the globes described in Greek sources see Vafea, 'From the Celestial Globe'.

[90] An excellent presentation of celestial globes of Arabic origin, with or without stand, can be found in Savage-Smith, *Islamicate Celestial Globes*.

[91] Lorch and Kunitzsch, 'Ḥabash al-Ḥāsib's Book on the Sphere'. The stand is not mentioned in this treatise.

[92] MS Istanbul, Topkapi Saray, Ahmet III 3505,1 ff. 1–62, also Kennedy, 'Al-Ṣūfī on the Celestial Globe'. In the appendix of this article, Kennedy presents the titles of the 157 chapters in English translation and a short summary of the content of most of the chapters.

[93] Sezgin, *GAS*, vol. V, p. 171.

[94] King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, pp. 320–21.

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(MS B / ب) and on ff. 59v–69v (MS J / ج), both of them copied from the same exemplar.[95]

1. MS B / ب: f. 1r contains only the title of the treatise: رسالة القسط في العمل بالكرة ذات الكرسي لبطليموس (*Treatise of Qusṭ on the Use of the Globe with Stand by Ptolemy*). The MS is dated 1149 H (AD 1736–7) on f. 14r. There are no glosses at all. The numbers of the chapters and the *abjad* numbers within the text are written in red colour; red is also used to separate the paragraphs in the introduction. There are 17 lines per page (16 on f. 12v). On f. 15r there is a table presenting the geographical longitudes and latitudes of 43 cities.

2. MS J / ج: On f. 59v, above the text of the treatise, the title رسالة القسط (*Treatise of Qusṭ*) appears. The MS is dated 1144 H (AD 1731–2) on f. 69v. There are numerous interlinear and marginal glosses, some of them in Ottoman Turkish. Only a few important glosses are mentioned in the apparatus of the critical edition below. The numbers of the chapters and the *abjad* numbers within the text are written in red colour; red is also used to separate the paragraphs in the introduction. There are 19 lines per page.

The titles of both treatises are written in the same hand, different from that of the treatises, and seem to be later additions. The title *Treatise of Qusṭ* is probably taken from the introduction of the treatise, where the reference to the treatise of Qusṭā ibn Lūqā appears.

3. Cairo, Dār al-kutub, Mīqāt M ʿarabī 101 (MS D / د).

Mentioned in the Khedive catalogue of the Dār al-kutub,[96] and in King's catalogue.[97] The manuscript consists of 12 numbered folios. There is no prominent title in the treatise, while the phrase رسائل ارتفاع ('Treatises altitude') written on f. 1r is misleading; the name of the author is not mentioned. The treatise is written on ff. 1v–12r, with 19 lines per page. The manuscript is dated 1159 H (AD 1746)[98] on f. 12r. There are several marginal glosses, most of them making comparisons with the treatise of Qusṭā ibn Lūqā. Red is used as in the manuscripts B and J. On f. 12v

95 Manuscripts B, J and H were copied within a period of seven years (1142–1149 H) and have several variants in common; there are also some differences, which exclude the possibility that one of them was copied from one of the other two.

96 Vollers et al., *Fihrist al-kutub*, vol. V, p. 249.

97 King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 385.

98 The month Dhū al-Qaʿdah 1159, mentioned in the colophon, corresponds to 15 November–14 December AD 1746 (Gregorian).

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there is a table presenting the geographical longitudes and latitudes of 36 cities, but for two of them the coordinates were omitted.

4. Cairo, Dār al-kutub, Riyāḍiyāt Taymūr ʿarabī 106,11 (MS H / هـ).

   Mentioned in King's catalogue.[99] The whole manuscript consists of 132 folios and is paginated (pp. 1–264). The treatise appears on pp. 232–52, with 19 lines per page. There is neither title nor author name. The manuscript is dated 1142 H (AD 1729–30) on p. 252.[100] There are only two marginal notes. On p. 253 there is a table presenting the geographical longitudes and latitudes of 118 cities.[101] This manuscript was copied from the same exemplar as manuscripts B and J.

5. Cairo, Dār al-kutub, Mīqāt Ṭalʿat ʿarabī 202,2 (MS U / و).

   Mentioned in King's catalogue.[102] This manuscript consists of 81 folios, 80 of which are numbered; one additional unnumbered folio follows f. 65 and contains the title of the second treatise on its recto. After the title there are two empty opposite pages and the treatise on the celestial globe appears on ff. 66v–74v (21 lines per page). The title is written in four lines (Figure 1). In the first two lines we read رسالة مقبولة لكرة[103] المسماة ('An acceptable treatise on the globe called…'), while the next two lines seem to have no connection to the previous: بارك الله لمن له أطلّ لعلمه ('God bless the one who has approached to His knowledge'). Probably the copyist misunderstood the handwriting in the exemplar; it could be ذات الكرسي لبطليموس as in the title of MS B, or بذات الكرسي لبطليموس; both of them mean 'having a stand by Ptolemy'. The phrase الكرة المسماة بذات الكرسي appears in the first lines of the treatise, and in the title of manuscript O / ع (see below). The manuscript is dated 1160 H (AD 1747) on f. 74v. There are some glosses on ff. 66v–69v.

[99] The manuscript is described in King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, pp. 581–83; the treatise *Dhāt al-kursī* appears on p. 582.

[100] The date is erroneously given as 1150 H in King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 582.

[101] The geographical tables that appear in manuscripts B, D and H include different groups of cities; only a few of these, such as Mecca, Medina and Baghdad, appear in all three manuscripts. Taking into consideration that such tables are included after the treatise in only 3 out of the 23 manuscripts and that the problems discussed in this treatise do not require the knowledge of the coordinates of distant cities, it can be concluded that these tables do not belong to the treatise *Dhāt al-kursī* itself.

[102] King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 490.

[103] لكرة should be written as للكرة.

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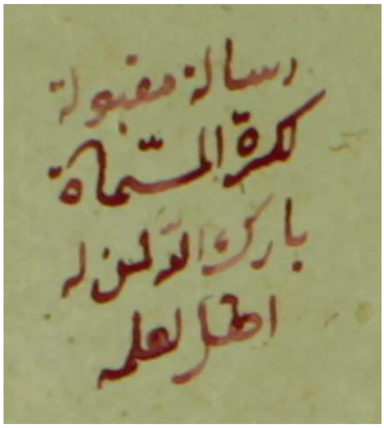

Figure 1: The title of the treatise in MS U.

6. Cairo, Dār al-kutub, Mīqāt M ʿarabī 106,2 (MS Z / ز).

   Mentioned in the Khedive catalogue of the Dār al-kutub, in King's catalogue, in *Osmanlı Astronomi*, and in *MAOSIC*.[104] The whole manuscript consists of 12 numbered folios. On ff. 1v–7r there is a treatise of Muhammad ibn ʿAlī al-Ḥamīdī (or al-Ḥumaīdī) on the celestial globe.[105] The treatise of interest here is the second one, on ff. 7v–12r (21 lines per page). The title الكرة (*The Globe*) is written in red in the upper margin of f. 7v, above the text of the treatise. The manuscript is dated on f. 12r, but only 3 digits of the year are written: ١١٨ (118), which could be read as 1118 H (AD 1706–7).[106] Folio 8 was cut vertically after it had been writ-

[104] Vollers et al., *Fihrist al-kutub*, vol. V, pp. 297–98; King, *A Catalogue of the Cairo Scientific Manuscripts*, Part I, p. 386; İhsanoğlu, *Osmanlı Astronomi*, no 31, p. 65; and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.

[105] A comparison of al-Ḥamīdī's treatise with that attributed to Ptolemy shows that they have different structure and wording, and thus al-Ḥamīdī cannot be the author of the latter. The fact that al-Ḥamīdī's name is mentioned in a note near the colophon of treatise P in manuscript U (see the Arabic text and corresponding translation) could raise suspicion that he is the author of this treatise.

[106] Both treatises in the manuscript are written in the same hand. There are at least four more manuscripts containing the treatise of al-Ḥamīdī in the Dār al-kutub in Cairo, two of which are dated: Mīqāt Ṭalʿat ʿarabī 164, in 1250 H (AD 1790–1), and Mujāmīʿa Ṭalʿat ʿarabī 925, in 1172 H (AD 1758–9). The manuscript 306 TE 28 of the Bašagić collection of Islamic manuscripts in the University Library in Bratislava, contains the same treatise of Muḥammad ibn ʿAlī al-Ḥamīdī on the celestial globe and is dated 1118 H / AD 1706, see Bašagić, *Popis orijentalnih rukopisa*, p. 332 and http://retrobib.ulib.sk/Basagic/EN/306.htm. This shows that this work existed in manuscript form in 1118 H, and supports the reading of 118 as 1118 H. The reading of this date as 1018 H (AD 1609–10) in Vollers et al., *Fihrist al-kutub*, vol. V, p. 297 cannot be correct, since al-Ḥamīdī died on 26 Jumādā I 1179 H (10 November 1765), as mentioned on pp. 279 and 299 in the same volume, thus he was not yet born in 1018 H. The date of the manuscript is given as 1118 H in King, *A Catalogue of the Cairo Scientific Manuscripts*, p. 386.

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ten, and then reconnected; thus one or two letters were lost in every line on both sides of the cut. The scribe of this manuscript was not careful; there are many spelling errors and omissions of single words.

7. Istanbul, Süleymaniye Library, Laleli 2135,4 (MS K / ک).[107]

   The whole manuscript consists of 166 numbered folios. The treatise is on ff. 133v–138r and is dated 4 Shawwāl 1158 H (30 October AD 1745 Gregorian) in the colophon on f. 138r. There are several notes in the margins or between the lines, in particular on ff. 133v–134v, that correct, complete or explain the main text, many of them written in the hand of the copyist. The treatise, either in its main text or the notes, includes some elements that are not included in the manuscripts from the Dār al-kutub in Cairo. The handwriting in these marginal notes seems to be that of the copyist and not of a later reader. It is possible that he had either copied the notes from the exemplar, or attempted to correct or update the text using information from other sources.[108] The manuscript bears the round *waqf* seal of Sultan Mustafa III (r. 1757–1774) on f. 1r.[109] Manuscripts D from the Dār al-kutub and K have a common antecedent manuscript.[110]

Fifteen more manuscripts were examined but not included in the critical edition. The details of these manuscripts are as follows:

1. Riyadh, University Library, MS 1007, Falak 520 RB (MS Ḥ / ح).[111]

   The title, later added on the first page of the manuscript, is رسالة في علم الفلك (*Treatise on Astronomy*), while on the information sheet of the manuscript the following information is given: 'Treatise of Qusṭ on using the globe having a stand, authorship Ptolemy?' (رسالة القسط بالعمل بالكرة ذات الكرسي، تأليف بطليموس؟), estimated date: thirteenth century H,[112] 'edition of the Egyptian Dār al-kutub 1: 428' (نشرة دار الكتب المصرية، ١:٤٢٨).

107 Mentioned in İhsanoğlu, *Osmanlı Astronomi*, no 31, p. 65, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303, as a work of Akhawayn, although the manuscript is anonymous.

108 For example, the addition of the number 47 (سبعة وأربعين) in Chapter 31 could have been made after comparison with the corresponding Chapter 61 from the treatise of Qusṭā ibn Lūqā, while the addition of the number 66;25 (سو كه) in Chapters 24 and 25 may have been to 'update' the crude approximation of (the complementary of) the obliquity of the ecliptic.

109 For the identification of the seal of Sultan Mustafa III, see Necipoğlu, Appendix III in *Treasures of Knowledge*, vol. I, p. 1056.

110 At the beginning of Chapter 30 in both manuscripts D and K, there is a redundant addition of the same passage of 3–4 lines coming from the beginning of Chapter 33. This fact attests that manuscripts D and K stem from the same manuscript that contained this additional text. Manuscript D was copied approximately 13 months after manuscript K.

111 The manuscript is online available at https://al-mostafa.info/data/arabic/depot/gap.php?file=m010551.pdf (accessed on 31.1.2021).

112 The thirteenth century H corresponds to AD 1785–1882.

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It consists of 9 folios (19 lines per page). The text of the manuscript is very similar to that of manuscript U from the Dār al-kutub.

2. Tirana, National Library of Albania, MS 523.11 Dr 6/23D (MS Ṭ / ط).[113]

The manuscript consists of 9 folios. The title of the treatise رسالة كرة (*Treatise ⟨on the⟩ Globe*) appears on p. 1 in a statement of ownership by Sharīfī Muṣṭafā Pasha, governor of Shkodra in 'the year 240' (probably 1240 H, i.e. AD 1824–5), and the text of the treatise is on pp. 2–18 (19 lines per page). The manuscript is stamped with a mark of Muṣṭafā Pasha that bears the date 1251 H (1835–1836). Probably, the owner was Mustafa Pasha Bushatlliu (1797–1860), the last ruler of the Bushatlliu dynasty, who reigned over the Pashalik of Scutari (Shkodra) from 1815 to 1831.[114] The text of the manuscript follows the pattern of manuscript U from the Dār al-kutub.

3. Istanbul, Süleymaniye Library, Haci Mahmud Efendi 5688,6 (MS I / ي).

Mentioned in *Osmanlı Astronomi* and *MAOSIC* as a work of Akhawayn, although it is anonymous.[115] The whole manuscript consists of 124 numbered folios. The treatise appears on ff. 74r–82r. The title رسالة ذات الكرسي (*Treatise on the ⟨Globe⟩ with Stand*) is written on the upper left corner of f. 74r by another hand, and it is not included in the table of contents listed on the inside front cover. There is no date written at the end of the treatise, but on f. 91v there is a date (March 1682) expressed in five calendars, while on the opposite f. 92r the corresponding date 1093 H is mentioned.[116] This evidence suggests an approximate date 1093 H / AD 1682 for the manuscript.[117]

4. Istanbul, Süleymaniye Library, Pertevniyal 971–980,1 (MS L / ل).

This is a collection of separate treatises 'هدا مجموعة رسائل من الجزئيات' according to the title on f. 1r; each treatise has its own number, thus the

[113] Mentioned as manuscript An VIII/31F in al-Ḥalwajī and ʿAẓīmī, *Catalogue of Islamic Manuscripts*, no. 347, p. 267.

[114] Some details about his life can be found in Elsie, *A Biographical Dictionary of Albanian History*, pp. 63–64.

[115] İhsanoğlu, *Osmanlı Astronomi*, no 31, p. 65, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.

[116] The treatise في الإختيارات (*On the Selections*) starts on f. 91v. The dates in various calendars mentioned on this folio are the following: Yazdegerd Shahrīvar 1051, Roman March 1993, Coptic Paremhat 1398, Jalali Farvardīn 604, Christian March 1682. All of them correspond to the period between 10 and 25 March 1682 (Julian). On f. 100v of the same treatise, there is a note where 'Tūt, the beginning of the Coptic year 1399' (1 Tūt 1399 corresponds to 8 September AD 1682 Gregorian) is written above 'Farvardīn mah of the *qadīm* (i.e. the old Persian calendar) 1052'; the beginning of this month corresponds to 7 October AD 1682 Gregorian).

[117] This manuscript has some variants in common with manuscripts B, J, H, U and Z used in the critical edition; there are also some omissions and copying errors that appear only here.

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manuscript is denoted by the numbers of these ten treatises, Pertevniyal 971–980. The whole manuscript consists of 163 numbered folios plus a blank folio after the first treatise, and two folios at the beginning and end of the manuscript. The treatise *Dhāt al-kursī* is on ff. 1v–11v, corresponding to Pertevniyal 971, and is untitled. The last six lines of the treatise are scribbled slanting in the lower margin without a date. The manuscript may be dated between approximately AD 1735 and 1739, according to the date 1151 H (AD 1738–9) written on ff. 40v and 64r, at the end of the treatises in Pertevniyal 973 and 975 respectively, and the date 1148 H (AD 1735–6) written on f. 128v, at the end of the treatise in Pertevniyal 978.[118] The stamp of Pertevniyal on ff. 1r and 164r bears the date 1279 H (AD 1862–3). The text of the treatise follows the pattern of manuscripts B, J and H, and the manuscript is contemporary with these. There are many glosses written in the margins and even between the lines on ff. 1v–7r, 10v and 11v.

5. Istanbul, Süleymaniye Library, Süleymaniye 1037,1 (MS M / م).

The whole manuscript consists of 318 numbered folios plus two folios at the beginning and end, and an unnumbered blank folio within the volume. The treatise is on ff. 1v–12r and the title رسالة ذات الكرسي لبطلميوس (*Treatise on the ⟨Globe⟩ with Stand by Ptolemy*) appears twice, on f. 1r and on the first unnumbered folio, which contains the table of contents. Although there is no date at the end of the treatise, the dates 1182 H (AD 1768–9) and 1178 H (AD 1764–5) that appear on ff. 75r and 93r, at the end of the fourth and fifth treatises respectively, give an approximate date for the manuscript. The text of the treatise closely follows the pattern of manuscript A; even the colophon and several of the glosses that appear in the margins of ff. 2v, 3r, 5r, 9v and 11r are the same. The second treatise of the manuscript is the same as the unfinished treatise on the astrolabe in manuscript A, but here it is complete. The differences between the two manuscripts show that they were copied from the same exemplar, not one from the other.

6. Istanbul, Süleymaniye Library, Ayasofya 2623,1 (MS N / ن).

This manuscript consists of 92 numbered folios plus an unnumbered one at the beginning of the volume; the recto of this folio contains the table of contents. The manuscript contains five treatises, written by various hands on different qualities of paper. The almond-shaped seal

118 The handwriting is similar in manuscripts Pertevniyal 971, 978, 979 and 980.

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of Sultan Bāyazīt II (r. 1481–1512) appears at the beginning of the 2nd, 3rd and 4th treatises (ff. 14r, 34r and 85r respectively) and at the end of the 2nd, 3rd and 5th treatises (ff. 33v, 84v and 92v respectively); the round seal of Sultan Mahmud I (r. 1730–1754) appears only on f. 1r.[119] The 2nd treatise is dated Dhū al-Qaʿdah 834 H (between 11 July and 9 August AD 1431 Julian) on f. 33v, and the 3rd treatise 863 H (AD 1458–9) on f. 84v. The rest of the treatises are undated. The treatise of our interest appears on ff. 1v–13v, while its title رسالة الكرة (*Treatise on the Globe*) is written only in the table of contents. The treatise contains only 20 chapters; Chapters 11, 13–20, 29–31 and 33 of treatise P have been omitted, while Chapter 9 has been placed as Chapter 2. Most of the preface has been omitted and the introduction has been completely modified. There are also minor modifications in the chapters included in the treatise. There are some glosses on ff. 3v–6v, 8v, 10v, 11r and 13v. On f. 1r, there is a statement mentioning that the treatise had been abbreviated and corrected according to the *sharʿiya* for Sultan Mahmud by Aḥmad Sheikh Zade.[120] The handwriting of this statement is similar to that of the treatise in question and the oval seal on f. 1r that contains the name Aḥmad; thus the part of the manuscript containing this treatise was most probably written for Sultan Mahmud I, as his seal attests, and can be dated within his reign.

7. Princeton, University Library, Garrett 3168Y,2 (MS O / ع).

The manuscript consists of 17 numbered folios, and contains the treatise of Qusṭā ibn Lūqā on the celestial globe (ff. 2v–12v), the anonymous treatise رسالة في الكرة المسماة بذات الكرسي *Treatise on the Globe which is called 'with Stand'* (ff. 12v–16v) and another short passage on f. 17r. The titles of both treatises written on f. 2r seem to be a later addition by a different hand. There is no date on the manuscript; according to the library's online catalogue, the manuscript is 'between 17–? and 18–?',[121] while in the printed catalogue it is approximately dated 11th–

[119] For the seals of the above-mentioned sultans see Necipoğlu, Appendix III in *Treasures of Knowledge*, vol. I; for Sultan Bāyazīt II see pp. 1025–75; for Sultan Mahmud I see pp. 1060, 1062 and 1074. On ff. 84v and 85r, the seals of Sultan Bāyazīt II are on a folded corner of the manuscript. This fact shows that the original size of the folios of some treatises was probably larger; later the margins of these folios were cut – leaving only the seals with the original margin –, so that the five treatises could be bound in one volume.

[120] The chapters dealing with stars have been removed, as well the chapter on the domification.

[121] https://dpul.princeton.edu/islamicmss/catalog/st74cv08m, accessed on 30.1.2021. The manuscript is online available at the Princeton Digital Library of Islamic Manuscripts through the above link.

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12th c. H (AD 1592–1786).[122] The text has many variants in common with manuscripts B, J and H used in the critical edition.

8. Princeton, University Library, Garrett 1066Y,3 (MS F / ف).[123]

   The manuscript consists of 111 numbered folios. The title of the treatise is رسالة كرة ذات الكرسي (*Treatise* ⟨*on the*⟩ *Globe with Stand*) and appears on f. 20r, and the text of the treatise is on ff. 20v–28v. Although there is neither colophon, nor date at the end of this treatise, the manuscript can be dated 1131 H (AD 1718–9) according to the date mentioned in three other treatises on ff. 13r, 57v and 69v. There is an error in chapter enumeration after Chapter 8: There is no Chapter 9, and Chapters P9–P33 are numbered from 10 to 34. At the beginning of Chapter 31, which corresponds to P30, the same redundant addition from Chapter P33 appears as in manuscripts D and K. However, MS F has more variants in common with MS K. These three manuscripts belong to the same family.

9. Berlin, Staatsbibliothek Preußischer Kulturbesitz, Landberg 131,2 (MS Ṣ / ص).[124]

   The manuscript consists of 167 numbered folios, and the treatise appears on ff. 16v–25v. A title رسالة الكرة (Treatise on the Globe) is only found in the table of contents on f. 2r, written by a different hand. The colophon is undated. However, three other treatises in the same manuscript are dated 1136 H (f. 39v), 1141 H (f. 76r) and 1140 H (f. 79v); also according to the library's data, the manuscript is dated 1136 H / AD 1723–4.[125] It has several variants in common with manuscripts B, J and H used in the critical edition, and does not present any significant differences. There are some glosses on ff. 18r, 18v and 20r.

10. Istanbul, Süleymaniye Library, Bağdatlı Vehbi 2063,3 (MS Sh / ش).[126]

[122] See Mach, *Catalogue of Arabic Manuscripts*, no. 4967, p. 428. For the first treatise of the manuscript, only the 12th c. H (AD 1689–1786) is mentioned (no. 4901, p. 423); however, both treatises are written in the same hand. The reference to a manuscript from al-Azhar Library in Cairo allegedly containing the same treatise, mentioned in entry no. 4967, corresponds to the manuscript Ḥalīm, Falak wa mīqāt 328, which only contains the anonymous *Treatise on the Globe with Stand* with 13 chapters. The two treatises only have the first five words of the incipit in common.

[123] Mach, *Catalogue of Arabic Manuscripts*, no. 4967, p. 428. The manuscript is in the Princeton Digital Library of Islamic Manuscripts, and online available at https://dpul.princeton.edu/islamicmss/catalog/rv042x35s (accessed on 30.1.2021).

[124] Ahlwardt, *Verzeichnis der arabischen Handschriften*, vol. V, no. 5869, p. 269.

[125] http://resolver.staatsbibliothek-berlin.de/SBB000306D800000000, accessed 10.3.2024, gives the date as 1136 H / AD 1723–24.

[126] Mentioned as a work of Akhawayn, although the treatise is anonymous, in İhsanoğlu, *Osmanlı Astronomi*, no. 31, p. 65, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303; however, in both

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The manuscript consists of 39 numbered folios. The treatise on the celestial globe *dhāt al-kursī* appears on ff. 30v–39r without a title. In a short colophon on f. 39r, the manuscript is dated 1158 H (AD 1745–6). There are various interlinear or marginal glosses on almost every folio. It has several variants in common with manuscripts B, J and H used in the critical edition.

11. Istanbul, Süleymaniye Library, Yazma Bağişlar 1353,4 (MS Th / ث).

Mentioned in *Osmanlı Astronomi* and *MAOSIC* as a work of Akhawayn, although the treatise is anonymous.[127] The manuscript consists of 85 numbered folios. The treatise on the celestial globe appears on ff. 40r–48r; on f. 40r there are only the title *Treatise ⟨on⟩ the Globe* رسالة كرة and a stamp with the manuscript's data. The title on f. 40v is *Treatise on the Knowledge of the Globe* رسالة في علم الكرة. In the colophon (f. 48r), it is mentioned that the treatise was completed on 29 Ramaḍān 1155 H (27.11.1742) at Constantinople / Istanbul قسطنطنية by the copyist ʿAbd-Allāh ibn Muḥammad. The treatise consists of 32 chapters, instead of 33; chapter 22 has been omitted. There are variants in common with all of the manuscripts used in the critical edition, mostly with B, J, H, Z. The 8 glosses in the introduction, in the margins of ff. 36v–37v, are not in common with those in the other manuscripts.

12. Rabat, Bibliothèque Nationale du Royaume du Maroc,[128] D 162,4 (MS Kh / خ).

The manuscript consists of 248 folios, both foliated and paginated, and was copied at the beginning of Jumādā al-Thānīa 1273 H (this month began on 27 January AD 1857); the style of the script is western Arabic (Maghrebi). It is mentioned in the second edition of the catalogue by Lévi-Provençal, where the treatise in question appears with the title *Treatise on the Globe which is called 'with Stand' by the Wise Astronomer Ptolemy the Roman / Greek* رسالة في الكرة المسماة بذات الكرسي لبطلميوس الرومي الحكيم الفلكي,[129] although there is no such title in the

sources the manuscript number is erroneously written as 2023 instead of 2063.

127 İhsanoğlu, *Osmanlı Astronomi*, no. 31, p. 65, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.

128 This library was previously called *al-Khizāna al-ʿĀmma*.

129 See Lévi-Provençal, *Fihris al-makhṭūṭāt*, 2nd ed., no. 449, pp. 141–44; the fourth treatise is described on p. 142. In Lévi-Provençal, *Les manuscrits arabes de Rabat*, 1st ed., no. 449, pp. 172–75, the treatise is not mentioned. It seems that the title was added by Ṣālaḥ al-Tādlī and Saīd al-Mrābṭī, who made the revision of the 1st edition. I am grateful to Ahmed Chaouqui Binebine and Víctor de Castro León for providing me with the manuscript scans, and to José Bellver who also helped in acquiring the scans and noted the omission of the treatise in the first edition of the catalogue.

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manuscript. There are two treatises on the celestial globe in the manuscript; on pp. 1–21 the *Treatise of al-Ḥamīdī on the Globe*, and on pp. 147–70 the *Treatise on the Globe*; these titles are quoted only in the table of contents (f. 1r). The treatise stems from the same exemplar as MS D from the Dār al-kutub used in the critical edition, and belongs to the family of manuscripts D, F, K.[130] However, manuscript Kh includes several additional variants.

There are also three manuscripts that attribute the treatise to Muḥyī al-Dīn Muḥammad ibn Qāsim, known as Akhawayn (15th c. AD).[131] These manuscripts are the following:

1. Princeton, University Library, Islamic Manuscripts New Series 243,13 (MS R / ر).[132]

   The manuscript consists of 136 numbered folios, and includes astronomical treatises in Arabic, Ottoman Turkish and Persian copied in different times between the sixteenth and seventeenth century AD. The treatise in question appears on ff. 132r–136r. There is no title at the beginning of the treatise, but in the table of contents on f. 1r, two رسالة كرة (*Treatise* ⟨*on the*⟩ *Globe*) are mentioned. The first one is a distorted version of Qusṭā ibn Lūqā's treatise on the globe, and appears on ff. 100v–131v; the second one corresponds to treatise P. The text of the treatise has several variants in common with manuscripts B, J and H used in the critical edition. In Chapters 11–28, empty spaces had been left for the enumeration of the chapters and the *abjad* numbers within the chapters, probably to be filled later with red colour. The colophon,

130 The part of the redundant addition at the beginning of Chapter 30 that appears in manuscripts K and F, and was crossed out in MS D, has been omitted in MS Kh, leaving only the word البلد that was not crossed out in D. However, MS Kh does not stem from D, because MS Kh contains some variants that had been omitted or altered in MS D, e.g. ذلك الكوكب في in Kh omitted in D (P5), وفي معرفة البعد بين مشارق الكوكبين in Kh omitted in D (P13), سو in Kh instead of هو in D (P24), and others. For similar reasons, none of the manuscripts K, D, Kh stems from F, which is the oldest of the family; e.g. manuscripts K, D, Kh contain the correct variants كد (24) and معكوسًا instead of the erroneous يب (12) and منكوسًا in F (P24 and P25 respectively), they also contain the term طلوع in the title of P20 omitted in F, and others. Also, manuscripts D, Kh do not stem from K, because some variants omitted in K, such as من أجزاء الأفق in P13, وجهة عرضه in P20, and الثابتة in P23, appear in D and Kh.

131 I am grateful to my colleague José Bellver (at the time: Ptolemaeus Arabus et Latinus), who noticed the attribution to Akhawayn in these manuscripts.

132 Mentioned as a work of Akhawayn in Mach and Ormsby, *Handlist of Arabic Manuscripts (New Series)*, no. 1227, p. 287; in İhsanoğlu, *Osmanlı Astronomi*, no. 31, p. 65; and in Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303. The manuscript is in the Princeton Digital Library of Islamic Manuscripts, and online available at https://dpul.princeton.edu/islamicmss/catalog/j9602390r (accessed on 30.1.2021).

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in red colour, includes elements of the colophons of manuscripts A, K and M, and an attribution of the last three treatises to Muḥammad, known as Akhawayn.[133] The date is mentioned as 'the beginnings of the month Rajab of the year 965 H' and corresponds to April 1558. Thus, this is the oldest copy of the treatise found so far. Since the preceding treatise in the manuscript was copied in 1018 H (AD 1609–10), we may conclude that the initial volume containing the three treatises had been dismantled, and this volume had been bound later. Only the anonymous and undated third treatise of the manuscript (ff. 32v–40r), which deals with the sine quadrant, seems to have the same handwriting as the treatise attributed to Akhawayn. This treatise consists of 10 numbered chapters and the beginning is missing, although f. 32r is empty.

2. Istanbul, Beyazit State Library, Veliyüddin Efendi 3194,9 (MS S / س).[134]

The title of the treatise رسالة مولانا اخوين لذات الكرسي (*Treatise of our master Akhawayn for the ⟨Globe⟩ with Stand*), on f. 88r, attributes the treatise to Akhawayn. The text of the treatise is on ff. 88v–94v and has no significant differences from that of the rest of the manuscripts examined; there are several variants in common with manuscripts B, J, H, U and Z used in the critical edition. In the margins, the enumeration of the chapters with the beginning of each title is repeated. There are also some glosses on ff. 88–90. In the lower margin of f. 90v, there are three astrological diagrams. At the end of the treatise is mentioned تمّت الرسالة، حسن بن محمد، سنة ١١٥٤ ('The treatise has been completed, Ḥasan ibn Muḥammad, year 1154'); thus the treatise was copied in 1154 H (AD 1741–2).

3. Istanbul, Süleymaniye Library, Bağdatlı Vehbi 2124,6 (MS T / ت).[135]

The manuscript consists of 134 partially numbered folios plus an unnumbered folio with the table of contents at the beginning. The treatise appears on ff. 105v–114v; however, only f. 110 is numbered. There are 19 lines per page on ff. 105v–113v, while f. 114 is more densely written, presumably in the same hand, containing 30–31 lines per page. The title in the table of contents is رسالة الكرة ذات الكرسي (*Treatise on the Globe with Stand*) and below it the name of Ptolemy (بطلموس) is

[133] For the Arabic text of the colophon and an English translation, see the critical edition below, pp. 94–95.
[134] Mentioned as a work of Akhawayn in İhsanoğlu, *Osmanlı Astronomi*, no. 31, p. 65; and in Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.
[135] Mentioned as a work of Akhawayn in İhsanoğlu, *Osmanlı Astronomi*, no. 31, p. 65, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303; however, in both sources the manuscript number is erroneously written as 2123 instead of 2124.

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written in another hand, while on the top of f. 105v it is stated in red colour that 'this is the *Treatise of our master Akhawayn for the ⟨Globe⟩ with Stand*' هذه رسالة مولانا اخوين لذات الكرسي. The manuscript is dated 1191 H (AD 1777–8) on f. 114v. Various glosses appear on f. 106r between the lines, and on ff. 107r–108r, 109r and 113r in the margins. In the right margin of f. 109r, three astrological diagrams are drawn, almost identical to those on ff. 63v and 90v of manuscripts J and S, respectively. There are many variants in common with manuscript S, and additional ones that appear only in this manuscript.

Lastly, Ptolemy's name appears in the title of a manuscript that probably contains treatise P, but has not been examined. According to the electronic catalogue of the Assad Library in Damascus, the manuscript 14621,8 of the library contains the *Explanation of the Treatise on the ⟨Globe⟩ with Stand by Ptolemy* (شرح رسالة ذات الكرسي لبطليموس) on ff. 80–90. The treatise comprises 33 chapters and the extended incipit and explicit provided are in accordance with the corresponding passages of treatise P. The date of the manuscript is not mentioned. The manuscript previously belonged to the Library of the Madrasa al-Aḥmadīya in Aleppo.[136]

As for the various glosses that appear in the manuscripts, there are groups of manuscripts that include the same or slightly modified glosses:

1. Manuscripts J, L, Ṣ, Sh, S and T, e.g. in Chapters P1, P2, P3, P4, P9. Some of these glosses appear in the modified manuscript N, in the chapters corresponding to P2, P3 and P9. The same three astrological diagrams appear in manuscripts J, S and T in Chapters P10 and P11.[137]
2. Manuscripts U and Ṭ, e.g. in Chapters P3, P4, P6 and P9. The glosses in P4 and P9 are the same as in the first group.
3. Manuscripts A and M: there are four glosses in common in the introduction and Chapters P1 and P9.

The manuscripts from Istanbul can be approximately dated between 1682 and 1778, while the dates of the six dated manuscripts from the Dār al-kutub in Cairo are between 1706 and 1747. At that time Egypt was part of the Ottoman Empire; this fact explains the glosses in Ottoman Turkish on manuscripts A, J, D and U. Two of the manuscripts from Cairo, J and H, were copied during the government of Egypt by Köprülü Abdullah Pasha, of Albanian ori-

[136] In 1988 the *waqf* Libraries of Aleppo merged with the Assad Library in Damascus; see as-Sawwas, 'Syria', in Roger, *World Survey of Islamic Manuscripts*, p. 192.

[137] One of the diagrams is slightly modified in T. Manuscript D also contains an astrological diagram in these chapters, but it is a different one.

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gin (provincial governor of Egypt from July 1729 to July 1731).[138] Köprülü was appointed by Sultan Ahmet III (r. 1703–1730), who had established a library in Istanbul in 1719. The manuscripts Z, F and Ṣ were also copied during the reign of Sultan Ahmet III. Four other manuscripts (D, U, Sh and K) were copied while Koca Rāgib Pasha was provincial governor of Egypt (1744–1748);[139] he was a scholar, poet and manuscript collector, and had established the Rāgib Pasha Library in Istanbul when he was Grand Vizier (1757–1763). There is a possibility that he had brought the carefully written manuscript Laleli 2135 (MS K) from Cairo to Istanbul. On f. 1r of MS K appears the seal of Sultan Mustafa III (r. 1757–1774), whose sister Sāliha Sultan married Koca Rāgib Pasha after he became Grand Vizier.[140]

These Ottoman authorities may have had a special interest in copying certain Arabic manuscripts, perhaps reflecting broader societal engagement at this time with scientific writings. We must take in consideration that the eighteenth century follows the era of Galileo and Kepler, which brought new developments to astronomy, and thus an increased interest in this field. In that century, many celestial globes were constructed, as the exhibits in various museums attest. A manual for their use was necessary, and the treatise *Dhāt al-kursī* could have played this role. Reflecting the global trend towards engagement with science, new libraries were established in Istanbul and this caused an increased demand for scientific manuscripts.[141] Some manuscripts may have been ordered and brought from various parts of the Ottoman Empire, among them Cairo.

Table 5 summarises the principal information on the manuscripts of the treatise *Dhāt al-kursī* presented above.

siglum	manuscript	pag./fol.	date H	date AD	title
A	Cairo, Mīqāt Ṭalʿat 189,1	pp. 1–11	–	–	رسالة ذات الكرسي لبطليموس *Treatise on the ⟨Globe⟩ with Stand by Ptolemy*

[138] Öztuna, *Büyük Osmanlı Tarihi*, pp. 412–16; Mehmed Süreyya, *Sicill-i Osmanî* (eds Akbayar and Kahraman), vol. I, p. 81; and al-Jabartī, *Merveilles biographiques et historiques* (ed. Mansour et al.), vol. II, pp. 5–9.

[139] Öztuna, *Büyük Osmanlı Tarihi*, pp. 412–16; Mehmed Süreyya, *Sicill-i Osmanî* (eds Akbayar and Kahraman), vol. IV, pp. 1340–41; also al-Jabartī, *ʿAbd al-Raḥmān al-Jabartī's History of Egypt* (eds Philipp and Perlmann), pp. 248–51 and al-Jabartī, *Merveilles biographiques et historiques* (ed. Mansour et al.), vol. II, pp. 26–29.

[140] Mehmed Süreyya, *Sicill-i Osmanî* (eds Akbayar and Kahraman), vol. IV, p. 1340.

[141] An epigraph on the main gate of the Enderûn building, constructed by Sultan Ahmet III for his library, explains that 'this dwelling, destined to collect books, was built at his own expense as a good deed to serve the lofty ideal of encouraging the learning of science'.

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siglum	manuscript	pag./fol.	date H	date AD	title
B	Cairo, K 3844,1	ff. 1r–14r	1149	1736–7	رسالة القسط في العمل بالكرة ذات الكرسي لبطليموس *Treatise of Qusṭ on the Use of the Globe with Stand by Ptolemy*
J	Cairo, K 3844,8	ff. 59v–69v	1144	1731–2	رسالة القسط *Treatise of Qusṭ*
D	Cairo, Mīqāt M 101	ff. 1r–12r	1159	1746	رسائل ارتفاع Treatises Altitude
H	Cairo, Riyāḍiyāt Taymūr 106,11	pp. 232–52	1142	1729–30	–
U	Cairo, Mīqāt Ṭalʿat 202,2	ff. 66v–74v	1160	1747	رسالة مقبولة لكرة المسماة ⟨بذات الكرسي لبطليموس⟩ An Acceptable Treatise on the Globe called ⟨*Dhāt al-kursī* by Ptolemy⟩
Z	Cairo, Mīqāt M 106,2	ff. 7v–12r	1118	1706–7	الكرة *The Globe*
Ḥ	University of Riyadh 1007, Falak 520 RB	ff. 1–9	13th c.	1785–1882	رسالة في علم الفلك *Treatise on Astronomy*
Ṭ	National Library of Albania, 523.11 Dr 6/23D	ff. 1–9	1240	1824–5	رسالة كرة *Treatise ⟨on the⟩ Globe*
I	Istanbul, Haci Mahmud Efendi 5688,6	ff. 74r–82r	*c.* 1093	*c.* 1682	رسالة ذات الكرسي *Treatise on the ⟨Globe⟩ with Stand*
K	Istanbul, Laleli 2135,4	ff. 133v–138r	1158	1745	–
L	Istanbul, Pertevniyal 971	ff. 1v–11v	*c.* 1148–1151	*c.* 1735–1739	–
M	Istanbul, Süleymaniye 1037,1	ff. 1v–12r	*c.* 1178–1182	*c.* 1764–1769	رسالة ذات الكرسي لبطلميوس *Treatise on the ⟨Globe⟩ with Stand by Ptolemy*

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siglum	manuscript	pag./fol.	date H	date AD	title
N	Istanbul, Ayasofya 2623,1	ff. 1v–13v	1143–1168	1730–1754	رسالة الكرة *Treatise on the Globe*
S	Istanbul, Veliyüddin 3194,9	ff. 88r–94v	1154	1741–2	رسالة مولانا اخوين لذات الكرسي *Treatise of our master Akhawayn for the ⟨Globe⟩ with Stand*
Sh	Istanbul, Bağdatlı Vehbi 2063,3	ff. 30v–39r	1158	1745–6	–
T	Istanbul, Bağdatlı Vehbi 2124,6	ff. 105v–114v	1191	1777–8	رسالة مولانا اخوين لذات الكرسي *Treatise of our master Akhawayn for the ⟨Globe⟩ with Stand*
Th	Istanbul, Yazma Bağişlar 1353,4	ff. 40r–48r	29 Ramaḍān 1155	27.11.1742	رسالة في علم الكرة *Treatise on the Knowledge of the Globe*
O	Princeton, Garrett 3168Y,2	ff. 12v–16v	–	–	رسالة في الكرة المسماة بذات الكرسي *Treatise on the Globe which is called 'with Stand'*
F	Princeton, Garrett 1066Y,3	ff. 20r–28v	1131	1718–9	رسالة كرة ذات الكرسي *Treatise ⟨on the⟩ Globe with Stand*
R	Princeton, IMNS 243,13	ff. 132r–136r	Rajab 965	end of April 1558	–
Ṣ	Berlin, Landberg 131,2	ff. 16v–25v	(1136)	(1723-4)	رسالة الكرة *Treatise on the Globe*
Kh	Rabat, BNRM, D 162,4	pp. 147–70	Jumādā II 1273	end of January 1857	رسالة في الكرة *Treatise on the Globe*

Table 5: List of manuscripts of the treatise *Dhāt al-kursī* attributed to Ptolemy.

1.5 Who was Akhawayn?

Muḥammad, known as Akhawayn, is mentioned as the author in the colophon of the oldest preserved manuscript of the treatise *Dhāt al-kursī* (MS R); Mūlānā Akhawayn is stated as the author in the titles of manuscripts S and T.

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Who was Akhawayn? Is there any early bio-bibliographical reference to Akhawayn as author of *Dhāt al-kursī*?

Taşköprüzade (901–968 H / AD 1495–1561), in his biographic encyclopedia *al-Shaqāʾīq al-nuʿmāniyya fī ʿUlamāʾ al-Dawla al-ʿUthmāniyya* (Anemones, on the Scholars of the Ottoman Era), mentions that Akhawayn studied with some scholars of Rūm (i.e. the area of the Byzantine Empire) and he learned many things from science. He became professor in some madrasas and later on he was transferred to one of the Eight Colleges (probably one of the *Ṣaḥn-i Thamān* madrasas founded by Sultan Meḥmet II at the great Fātiḥ mosque).[142] He died at the end of the ninth century H. Taşköprüzade preserves the titles of three works by Akhawayn:

i. Notes on the note *of the 'Sharḥ al-tajrīd'* حواش على حاشية شرح تجريد

ii. *Epistle on the Judgment of the Heretic* رسالة في أحكام الزنديق

iii. *Treatise explaining the Sine Quadrant* رسالة في شرح الربع المجيب.[143]

Muḥyī al-Dīn Muḥammad ibn Qāsim, known as Akhawayn, is mentioned repeatedly by **Ḥājjī Khalīfa** in his book *Kashf al-ẓunūn*, where Akhawayn's death is placed in 904 H (AD 1498–9) or at the end of 900 H (AD 1495).[144] Furthermore, Akhawayn is mentioned as the author of

i. A comment on the interpretation of the Quran by al-Bīḍāwī under the title تعليقة على أنوار التنزيل وأسرار التأويل[145]

ii. A note on Islamic Theology حاشية على تجريد الكلام[146]

iii. An *Epistle on the Judgment of the Heretic* رسالة في أحكام الزنديق, which is also presented under the short title *The Famous Sword* السيف المشهور

[142] In Uzunçarşılı, *Osmanlı Devletinin İlmiye Teşkilatı*, p. 14, we read the following information: 'The director of the sixth madrasa (the sixth of the *Ṣaḥn* Madrasas) was Sinân Kirmâstî, and for the first time, while his daily wages were fifty silver coins, Mevlâ Ahaveyn (i.e. Akhawayn) became a müderris / professor with eighty silver coins in 894/1489'.

[143] Taşköprüzade, *al-Shaqāʾīq al-nuʿmāniyya*, p. 116.

[144] Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel); 904 H is stated in vol. II, p. 197 and vol. III, p. 645, while the end of 900 H is mentioned in vol. III p. 363.

[145] Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. I, p. 478. It is a note –concerning the suras II and III (الزهراوين) of the Quran– on the work of al-Bīḍāwī, *The Lights of Quran and the Secrets of the Meaning*, mentioned as no. 1402 in vol. I, p. 469.

[146] Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. II, pp. 196–97. According to Ḥājjī Khalīfa, al-Sayyid al-Sharīf ʿAlī ibn Muḥammad al-Jurjānī (d. 816) wrote a commentary on the work of Naṣīr al-Dīn Abū Jaʿfar al-Tūṣī (d. 672 H) *Tajrīd al-kalām*, mentioned as no. 2448 in vol. II, pp. 193–95. Then, among other authors, Akhawayn wrote a note on that commentary.

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and the extended one *The Famous Sword on the Heretic and Curser of the Prophet* السيف المشهور على الزنديق وشاتم الرسول [147]

iv. A *Treatise on the Sine Quadrant*, which is a commentary on the treatise of ʿAṭāʾ Allāh al-ʿAjamī (15th c. AD).[148]

Also, **Ḥājjī Khalīfa**, in his work *The Ladder of Elevation to the Lives of the Great and Famous by Generation* سلم الوصول إلى طبقات الفحول, written in 1651–2, a biographical dictionary of 8561 scholars, includes Akhawayn in the entry no. 4486, presenting the following information: Akhawayn died in Constantinople / Istanbul (قسطنطينية) in the month Rabīʿ al-ʾAwwal of the year 904 H (17 October–15 November 1498 Julian). He studied the scientists of his era, then he became a professor in several madrasas and later on at the *Ṣaḥn* madrasa. His works are notes on the *Sharḥ al-tajrīd* and the principles (أوائل) of interpretation (tafsīr / تفسير) of al-Bīḍāwī, an *Epistle on the Judgment of the Heretic* that he wrote for the heresy of Mūllā Luṭfī, and a *Treatise on the Sine Quadrant*. The author of *al-Shaqāʾīq* mentions him.[149]

Ibn al-ʿImād (1032–1089 H / AD 1622/3–1678/9), in his work *Nuggets of Gold in the Chronicles of Those Who Have Passed Away* شذرات الذهب في أخبار مَن ذهب, [150] classifies Akhawayn among the prominent scholars, and repeats that he was teaching in one of the Thamān madrasas, adding that he was a *ḥanafī* (i.e. follower of the Islamic Ḥanafī juridical school), gives 899 H (AD 1493–4) as the year of his death, and cites three works by Muḥyī al-Dīn, known as Akhawayn: *Note on the 'Sharḥ al-tajrīd' of al-Sharīf al-Jurjānī*, *Epistle on the Judgment of the Heretic* and *Treatise explaining the Sine Quadrant*.

The information preserved by the historians of the sixteenth and seventeenth centuries is recurring in the works of several authors of the nineteenth and twentieth centuries, sometimes with certain modifications.[151] None of the

[147] Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. III, pp. 363, 408 and 644–45. Akhawayn wrote this treatise to show why Mūllā Luṭfī was deserving of death.

[148] Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. III, p. 402.

[149] Kātip Çelebi, *Sullam al-wūṣūl īlā ṭabaqāt* (ed. İhsanoğlu et al.), vol. III, no. 4486, p. 223.

[150] Ibn al-ʿImād, *Shadharāt al-dhahab fī akhbār man dhahaba* (ed. al-Arnāūʾūṭ and al-Arnāūʾūṭ) vol. IX, p. 549.

[151] **Mehmed Süreyya** (1845–1909), in *Sicill-i Osmanî* (ed. Akbayar and Kahraman), vol. IV, p. 1105, presents the information that Akhawayn was professor at the *Ṣaḥn* madrasas and died in Bursa (Ḥājjī Khalīfa in *Sullam al-wūṣūl* states that he died in Istanbul) in 900 H / AD 1494–5; he is buried in the Zeyniye cemetery. He only presents two titles of his work, the notes on the *Sharḥ al-tajrīd* and the *Epistle on the Judgment of the Heretic*. **Al-Baghdādī** (d. 1920), in *Hadiyya al-ʿārifīn*, mentions the three works of Akhawayn from vols II and III of *Kashf al-ẓunūn* and states that he died in 904 H (pp. 831–32). **Kaḥḥāla** (1905–1987) in his 15-volume work *Muʿjam al-muʾallifīn* presents the information given by Taşköprüzade (*al-Shaqāʾīq al-nuʿmāniyya*) in vol. IX, p. 31, by Ḥājjī Khalīfa (*Kashf al-ẓunūn*) in vol. XI, p. 136, by Ibn al-ʿImād (*Shadharāt*) in vol. XII, p. 206, and by the more recent al-Baghdādī in vol. VIII, p. 118. **Al-Ziriklī** (1893–1976), in *al-Aʿlām . Qāmūs tarā-*

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aforementioned authors cites the treatises *Dhāt al-kursī* and *Problems in the Science of Astronomy*. However, Suter (1848–1922) refers to two works of Akhawayn: *Treatise on the Sine Quadrant* according to Taşköprüzade, and *Problems in the Science of Astronomy* written for Sinān Pasha and preserved in the Vienna manuscript 1422.[152] The latter is attributed to 'Muḥammad famous as Akhawayn' on f. 3v of the manuscript of the Österreichische Nationalbibliothek in Vienna (now Cod. A. F. 418),[153] within the text of the treatise. This work is discussed by Saliba in *Islamic Science* and in *Arabic Planetary Theories*.[154] The same treatise is mentioned by Brockelmann (1868–1956) together with the notes on the interpretation of the Quran by Akhawayn and *The Famous Sword*.[155]

Only in contemporary studies the *Treatise Dhāt al-kursī* is presented as a work of Akhawayn, probably due to the attribution in three manuscripts. İhsanoğlu, studying the history of astronomy literature during the Ottoman period, presents the following works of Akhawayn:[156]

i. A note on the *Sharḥ al-tajrīd* of al-Sayyid al-Sharīf;
ii. *Epistle on the Judgment of the Heretic*;
iii. *Problems (Ishkalāt) in the Science of Astronomy*;
iv. A treatise on the quadrant. The title first appears as رسالة الجيب الجامع, which could be translated as *Treatise of the Universal Sine*; then it is written as *Treatise explaining the Sine Quadrant*;
v. *Treatise on the Globe called Dhāt al-kursī*;
vi. Notes on the Commentary on the *Mulakhkhaṣ* by Qāḍī Zāde.

The last four works are also mentioned by Rosenfeld and İhsanoğlu in *MAOSIC*,[157] where the treatise on the quadrant is described as 'Commentary on Treatise of ʿAtaallah al-ʿAjāmi on the Sine Quadrant' (*sic*), with a reference to *Kashf al-ẓunūn* and al-ʿAjamī, but without providing any further information. However, in *Osmanlı Astronomi*, which is an earlier work of İhsanoğlu, the

jim, vol. VII, p. 5, claims that Akhawayn was a Damascene noble, and only lists the comment on the interpretation of the Quran as a work of Akhawayn (from vol. I of *Kashf al-ẓunūn*).

152 Suter, *Die Mathematiker und Astronomen*, p. 185; section 448 deals with Akhawayn. Sinān Pasha (d. 891 H / AD 1486), mentioned on f. 4v (line 7) in the Vienna manuscript, was a scholar and vezir of Sultan Meḥmet II; Suter presents him in section 443, p. 180.

153 Flügel, *Die arabischen, persischen und turkischen Handschriften*, no. 1422, pp. 488–89. The same treatise exists in two other manuscripts: Manisa, Provincial Public Library 1698/5, ff. 78–92 (79v–93a in the library's database), and Kütahya, Vahit Pasha Library 793, according to İhsanoğlu, *Osmanlı Astronomi*, p. 64, and Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.

154 Saliba, *Islamic Science*, pp. 111–12, 274, 289; and Saliba, 'Arabic Planetary Theories', pp. 59–61.

155 Brockelmann, *Geschichte der Arabischen Litteratur*, p. 230; and Brockelmann, *Geschichte der Arabischen Litteratur. Zweiter Supplement Band*, p. 322.

156 İhsanoğlu, *Osmanlı Astronomi*, no. 31, pp. 64–66. In Turkish bibliography the name Akhawayn appears as Ahaveyn, Ahavayn, or al-Akhwīn.

157 Rosenfeld and İhsanoğlu, *MAOSIC*, no. 893, p. 303.

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treatise is described as consisting of an introduction and 16 chapters, the incipit is quoted and a list of seven manuscripts containing the treatise is given. The incipit is very similar to that of the treatise of Mīrim Chelebī (1475–1525), having the same title and the same number of chapters, and quoted on p. 93 of the same book. The treatise of Mīrim Chelebī was written in 1494 and dedicated to Sultan Bāyazīt II (r. 1481–1512).[158] At the first look, it is unclear whether these are two different treatises, and who the real author is in case they are identical, Akhawayn or Mīrim Chelebī. For example, the colophon of *Risālat al-jayb al-jāmiʿ* in manuscript Princeton, University Library, Garrett 317Y,4, ff. 48v–55v, attributes the treatise to Akhawayn, while, as Mach states, the same text in manuscripts Berlin, SBPK, Or. oct. 34 (Ahlwardt 5855) and Garrett 2006,20 is ascribed to Mīrim Chelebī; however, this name is not mentioned in the Berlin manuscript.[159] Probably, the information stated in *Osmanlı Astronomi* was not included in *MAOSIC* because of the above contradiction.

Table 6 summarises the information on the works attributed to Akhawayn, as presented above.

	Title	Subject	Taşköprüzade	Ḥājjī Khalīfa	Ibn al-ʿImād	Süreyya	al-Baghdādī	Kaḥḥāla	al-Ziriklī	Suter	Brockelman	İhsanoğlu
1	أنوار التنزيل وأسرار التأويل	Comment on the interpretation of the Quran		+				+	+		+	
2	حاشية على شرح تجريد الكلام	Note on Islamic theology	+	+	+	+	+	+				+
3	السيف المشهور على الزنديق وشاتم الرسول	*Epistle on the Judgment of the Heretic*	+	+	+	+	+	+			+	+
4	رسالة في شرح الربع المجيب	*Treatise on the Sine Quadrant*	+	+	+		+	+		+		+
5	الإشكلات في علم الهيئة	*Problems in the Science of Astronomy*								+	+	+

[158] Rosenfeld and İhsanoğlu, *MAOSIC*, no. 940, A4, p. 317; İhsanoğlu, *Osmanlı Astronomi*, no. 47 (2), p. 93; Ahlwardt, *Verzeichnis der arabischen Handschriften*, vol. V, no. 5855, p. 262.

[159] Mach, *Catalogue of Arabic Manuscripts*, no. 4939, p. 426; Hitti et al., *Descriptive Catalog of the Garrett Collection*, no. 2006,20, pp. 599–600; Ahlwardt, *Verzeichnis der arabischen Handschriften*, vol. V, no. 5855, p. 262.

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6	ذات الكرسي	*Dhāt al-kursī*										+
7	حواش على شرح قاضي زاده على الملخص	*Notes on the commentary on Mulakh-khaṣ by Qāḍī Zāde*										+

Table 6: List of the works attributed to Akhawayn.

We will examine the astronomical works no. 4, 5 and 7 of the above table, which appear in Ihsanoglu's works, trying to shed light on the complicated problem of their authorship. It is necessary to take into consideration some information about Mīrim Chelebī. **Taşköprüzade** attests that Mīrim Chelebī was a prominent scholar with wide knowledge on science, history and both Arabic and Persian poetry. Sultan Bāyazīt II had appointed him as his instructor and studied with him mathematical sciences.[160] **Ḥājjī Khalīfa**, in his book *Kashf al-ẓunūn*, mentions several works of Mīrim Chelebī, among them the following works on the quadrant; all of the quadrant treatises were ordered by Sultan Bāyazīt II:[161]

i. A *Treatise on the Universal Quadrant* (*Risālat al-rubʿ al-jāmiʿa*) consisting of an introduction and 21 chapters;
ii. A *Treatise on the (Universal) Quadrant al-Shakkāziya* finished by 913 H / AD 1507–8 and consisting of an introduction and 21 chapters;
iii. A *Treatise on the Work with the (Universal) Quadrant al-Shakkāziya* consisting of an introduction and 29 chapters;
iv. A *Treatise on the Almucantar Quadrant* written in Persian and containing 20 chapters;
v. A *Treatise on the Sine Quadrant* written in Persian.

The first of the above treatises is the closest to the *Risālat al-jayb al-jāmiʿ(a)* that appears in the above-mentioned manuscripts. It is written in Arabic, but it consists of 21 instead of 16 chapters in the existing manuscripts and the title slightly diverges.

Considering the above information we may conclude that Mīrim Chelebī should have mentioned Sultan Bāyazīt II in his treatise, while Akhawayn should have written that this work is a commentary on the treatise of ʿAṭāʾ Allāh al-ʿAjamī. I compared the incipit, the explicit and the titles of the 16 chapters of the anonymous manuscript Berlin, Or. oct. 34 as they are presented by Ahlwardt,[162] who attributes this work to Mīrim Chelebī, with three other manuscripts:

160 Taşköprüzade, *al-Shaqāʾiq al-nuʿmāniyya*, p. 198.
161 Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. III, nos 6142–43, p. 401, and no. 6147, p. 402.
162 Ahlwardt, *Verzeichnis der arabischen Handschriften*, vol. V, no. 5855, p. 262.

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i. Manisa, Provincial Public Library 6591,6, ff. 87v–96r, anonymous, attributed to Mīrim Chelebī by Rosenfeld and İhsanoğlu;
ii. Istanbul, Süleymaniye Library, Aşir Efendi 470,9, ff. 109v–120v/80v–91v (there is a double foliation), (*c.* 989 H), attributed to Akhawayn in its title;[163]
iii. Istanbul, Millet Library, Feyzullah Efendi 2178,2, ff. 7v–23v, attributed to Akhawayn in its title.

The three manuscripts examined contain the same text that is in agreement with the description of the manuscript Berlin, Or. oct. 34 in the catalogue. Thus, it is confirmed that this is a unique treatise that appears in some manuscripts attributed to Akhawayn (e.g. Aşir Efendi 470,9; Feyzullah Efendi 2178,2; Garrett 317Y,4) and in some others it is anonymous (e.g. Manisa 6591,6; Berlin, Or. oct. 34).[164] It is not clear whether there are manuscripts where the name of Mīrim Chelebī is stated.

In the text of the treatise, almost half of the preface is dedicated to Sultan Bāyazīt, son of Sultan Muḥammad (i.e. Meḥmet II the Conqueror), where the author clarifies that this work was written for him. There is no reference to ʿAṭāʾ Allāh al-ʿAjamī and his treatise on the sine quadrant. Hence, the attribution of the treatise to Mīrim Chelebī by Ahlwardt stands to reason, inasmuch as he was teaching Bāyazīt, and Ḥājjī Khalīfa mentions a similar treatise by him in Arabic. However, we cannot absolutely exclude the possibility that Akhawayn dedicated a treatise on the sine quadrant to the Sultan, and this treatise was different from his commentary on the work of al-ʿAjamī mentioned by Ḥājjī Khalīfa.

The doubts on the authenticity of the titles and colophons that attribute the *Risālat al-rubʿ al-jāmiʿ(a)* to Akhawayn can also be extended to those of the Treatise *Dhāt al-kursī*.

The *Notes on the Commentary on the Mulakhkhaṣ by Qāḍī Zāde*, according to *Osmanlı Astronomi* and *MAOSIC*, appear in the manuscript Manisa, Provincial Public Library 1697. The examination of the manuscript shows that the attribution is according to a dedication, or a statement of ownership, on f. 2r: 'these are the notes of our master Akhawayn on the commentary of Qāḍī Zāde on the astronomy of al-Jaghminī'. At the end of the note we read that

[163] In the same manuscript another work by Mīrim Chelebī is included: the *Treatise on the (Universal) Quadrant al-Shakkāziya* in 21 chapters (ff. 93v–107r / 64v–78r), written in Persian and dedicated to the Sultan Bāyazīt.
[164] Manuscript Zürich, Zentralbibliothek, Or. 4,5 (ff. 122v–142v) contains the same anonymous treatise, which is attributed to Mīrim Chelebī after comparison with MS Berlin, Or. oct. 34 (Ahlwardt 5855); see Nünlist et al., *Katalog der Handschriften der Zentralbibliothek Zürich*, pp. 19–20.

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the authors are 'Yūsuf and Muḥammad both famous as Akhawayn / the two brothers'.[165] This work is dedicated to the vizier Maḥmūd Pasha.[166]

As for the preserved manuscripts of the treatise *Problems (Ishkalāt) in the Science of Astronomy*, a comparison of its first part between the manuscripts Vienna, Cod. A. F. 418 (shortly MS V), which is ascribed to Akhawayn, and the anonymous manuscript Kütahya, Vahidpaşa Library 793 (shortly MS K) gives interesting results. The text of the first part in MS K (f. 1v) is only a fragment of that in MS V (ff. 3v–5v); f. 1v of MS K contains half of the text of f. 3v, some fragments from f. 5r and few words from the colophon on f. 5v of MS V. Among the omissions are the name of Akhawayn with the phrases before and after it, and the name of Sinān Pasha. The whole text on f. 4 of MS V has been omitted. These omissions seem to be deliberate. On the other hand, the beginning of the second part on f. 6v of MS V appears to be almost complete on f. 2 of MS K.

A question difficult to answer is raised: Who and for what reason added (or removed) the name of Akhawayn to (or from) these treatises? It is known that Akhawayn was one of the judges in the trial of Mūllā Luṭfī (or Molla Lütfi), prominent scholar, mathematician and theologian, who was accused of being heretic, sentenced to death and beheaded. Akhawayn wrote an epistle about this (*The Famous Sword on the Heretic and Curser of the Prophet*). Mūllā Luṭfī's execution was being discussed for many years afterwards and the historians express doubts whether the accusation was well grounded.[167] Perhaps the defenders of Mūllā Luṭfī and opponents of Akhawayn tried to remove his name from some of his works in that polarised period. It is also possible that Akhawayn's students at the *Ṣaḥn* madrasa added his name on the manuscripts they were using during their study with him, even if he was not the real author.

165 Ḥājjī Khalīfa in *Kashf al-ẓunūn* (ed. Flügel, vol. VI, pp. 113–14) cites four persons who wrote notes on the *Commentary on the Mulakhkhaṣ by Qāḍī Zāde* in the total of 14 commentaries on the *Mulakhkhaṣ*. However, none of them was called Akhawayn. According to the library's data base the author of those notes is Yūsuf ibn Muḥammad Akhawayn.

166 Perhaps this person was Maḥmūd Pasha (1420–1474), a vizier during the reign of Meḥmet II the Conqueror, who had established a mosque and a madrasa in Istanbul. He was a patron of scholars and poets and had a rich personal library; see Stavrides, *The Sultan of Vezirs*. Akhawayn and Maḥmūd Pasha could have met in Istanbul during their lifespan.

167 *Molla Luṭfi*, in Jones, *Censorship*, vol. III, p. 1471; Ocak, *Osmanlı Toplumunda Zındıklar*, pp. 205–27; Maraş, 'Tokatlı Molla Lütfi', in *DÎVÂN İlmî Araştırmalar*.

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2. The Arabic text and translation of the treatise *Dhāt al-kursī* attributed to Ptolemy

List of abbreviations in the critical edition

Meaning	**Symbol**
addition	+
addition of the word هذا above the line	+↑هذا
addition of the word هذا below the line	+↓ هذا
the word في is written above the word هذا	هذا ↑في
the word في is written below the word هذا	هذا ↓في
omitted	–
written twice	×٢
the word هذا is struck through	~~هذا~~
one word or phrase, now unidentifiable, has been struck through or deleted	~~...~~
change of page / folio in MS د	/د/
f. 9r	٩ا
f. 9v	٩ب

In the edition of the Arabic text and the translation I use various types of brackets:

⟨...⟩ to complete an omission in the Arabic text and the corresponding translation;

(...) to complete the text of the translation with a word or phrase not existing in the Arabic text, but necessary for correct rendering;

[...] to denote the translation of an Arabic word or phrase that is superfluous in the English text and could be omitted.

In the figures included in the commentary, the following notation is used:

φ	terrestrial latitude
δ	declination
h	altitude
Z	zenith
P and P′	north and south celestial poles
Π and Π′	north and south poles of the ecliptic
σ and σ′	points of summer and winter solstices
γ and γ′	points of vernal and autumnal equinoxes
circle γσγ′σ′	ecliptic (in red colour in the colour figures)
circle γEγ′W	equator (in green colour in the colour figures)
circle ENWS	horizon (in blue colour in the colour figures)

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/١ا/

رسالة ذات الكرسي لبطلميوس

/٢ا/ بسم الله الرحمن الرحيم.

/ب ١ب/ /ج ٥٩ب/ /د ١ب/ /هـ ٢٣٢/ /و ٦٦ب/ /ز ٧ب/ /ک ١٣٣ب/

الحمد لله الذي خلق السموات العُلى، وزيّنها بمصابيح الدجى، والصلاة على رسوله الذي هو قطب دائرة أهل التُقى، وعلى آله وأصحابه الذين هم نُجوم الهُدى، وبعد:

فإنّ الكرة المسماة بذات الكرسي كرة عجيبة وآلة غريبة، وأعمالها كثيرة وحصولها يسيرة. وإنّ سائر الآلات العمليّة تستعين من العلوم الرياضيّة، وإنّ ذات الكرسي، وإنّ كانت شريكة في الاستعانة، لكنّها منفردة عن غيرها في الإعانة. ولمّا كانت رسالة القُسْطا خارجة عن القِسطِ، محتاجة إلى طيّ الزوائد، خالية عن بعض الفوائد، مشوبة بالمساهلة، بل مملوّة بالمسامحة، أردت أن أطرح الزوائد وألحق بعض الفوائد، وأترك ما وقع فيها من مسامحة المتقدمين، وأذكر ما تقرر عليه رأي المتأخرين. والمرجوّ ممن نظر فيه أن يلاحظ أوقاتي فيعفو هفواتي والله المستعان وعليه التكلان.

/ب ٢ا/ والرسالة /ب/ مرتبة على مقدمة وعدّة أبواب.

2 الرحيم] ک: +وبه ثقتي **3** الدجى] ب ز: الدحى والصلاة] ا ب ج د و: والصلوة، هـ: والصلوة والسلام **4** التُقى] هـ: النقى الذين] و: اللذين وبعد] ز: — **5** المسماة] ب: السماة وحصولها] ب ج هـ: وهو لها، و: وحولها +↓ حصولها، ک: في الهامش الأيمن: +واحوالها **6** يسيرة] ب: مسيرة العمليّة] ب: العلمية تستعين] ا: نستعين، ب ز: تسعين الرياضيّة] ب: الرياضة، ز: الرضية وإنّ ذات] ز: وإن اذات **7** منفردة] ز: منفرد **8** رسالة] و: رسائل +↓ رسالة القُسْطا] ج د و: القُسطِ، ب هـ ز: القسط، و: في الهامش الأيسر: +وهو اسم يوناني أصله القسطا رحم ببقاء فيه، ک: القُسْط؛ +↓ اسم حكيم من الحكماء طيّ] هـ: لحى الزوائد] ز: الد وائر خالية] ز: حالية **9** الزوائد] ز: الن روائد **10** الفوائد] ب ج هـ: الفرائد مسامحة] و: مسامحات رأي] و: آرآء +↓ رأي **11** والمرجوّ] ب ز: والمرحو نظر] ز: ننظر أوقاتي] ب ج ل: اوتأنّي، ا د: اويأتي، هـ: اوتاني، و: أوقاتي +↓ اوتاتي، ز: اوتأتي، ک: اوتاتي، وفي الهامش الأيمن: أوقاتي، خ: عَوائقي فيعفو] ب: فيعمو، هـ ز: فيعفوا هفواتي] ج هـ: صفواتي

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Treatise on 'the ⟨globe⟩ with stand' by Ptolemy [1]

In the name of God the Merciful the Compassionate.

Praise be to God, who created the high heavens and embellished them with lanterns shining in the darkness, and prayers upon His Messenger, who is the pole of the circle of the pious people, and upon his family and his companions, who are the stars of the right guidance; [and then:]

The globe called *dhāt al-kursī* (with stand) is an astonishing globe and an unusual instrument having many functions and easy outcomes. All practical instruments rely on the mathematical sciences, but 'the ⟨globe⟩ with stand', although similar in use, is distinct from the others in the assistance (that it offers). Since the treatise of Qusṭā is imbalanced,[2] requires reduction[3] of superfluities, omits certain uses (of the globe), is flawed by carelessness, and in fact is full of laxity, I wished to remove the superfluities, include further uses, leave aside the laxity introduced by previous (scholars) and mention the conclusions of the later (scholars).[4] I hope that whoever studies it will perceive my time[5] and excuse my blunders, and God is the Helper and all reliance is upon Him.

The treatise consists of an introduction and a number of chapters.

1 The variants of the title, both in Arabic and English, are presented in Table 5 in the Introduction.

2 The author puns on Qusṭā's name here.

3 lit. 'folding'.

4 lit. 'what the views of later (scholars) settled on'.

5 The meaning is somewhat unclear here. It is possible that the corresponding Arabic term has not been correctly transmitted, since there are several variants in the manuscripts that do not give sense to the sentence. I have chosen the term أوقاتي, i.e. 'my times', as the best solution among the offered possibilities. This term appears in manuscripts U, Ḥ, Ṭ and K. The variant عَوائقي, i.e. 'my difficulties', that appears only in manuscript Kh could also be acceptable. Another solution is to read the term as ويتأني, i.e. 'to be patient', which has several common characters with some variants; in this case the translation would be 'pay attention and be patient' instead of 'perceive my time'.

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/ج ٦٠أ/ **فالمقدمة: في بيان الرسوم التي /ج/ على الكرة وبيان أسمائها:**

الكرة ويقال لها ذات الكرسي أيضًا، آلة مؤلفة من نفس الكرة والحلقة الثابتة /هـ ٢٣٣/ /هـ/ عليها، وهي حلقة نصف النهار، والكرسي الحامل لها.

وأمّا الرسوم:

/د ٢أ/ /د/ فمنها فلك البروج، وهي الدائرة المرسومة على نفس الكرة المقسومة شس قسما متساوية؛ المكتوب عليها أسماء البروج يب ومُوقّع على كلّ برج منها عدد درجاته.

ومنها الدوائر المارة بأوائل البروج: وهي الدوائر الستة المتقاطعة في قطبي فلك البروج، وإحداها مارة بقطبي المعدّل أيضًا، مسماة بالمارة بالأقطاب الأربعة. وتُكتَب /و ٦٧أ/ /و/ هذه الدوائر وفلك البروج في بعض الآلة بالحمرة.

ومنها معدّل النهار: وهو دائرة مقاطعة لدائرة فلك البروج في أوّل الحمل وأوّل الميزان؛ وهي أيضًا مقسومة شس جزءا متساوية، مكتوب عليها أعداد تبدأ من ١ إلى شس.

15 الكرة[1]] ب ج: ×٢ والحلقة] د ز: والخلقة الثابتة] هـ: + ~~عليها~~ **16** حلقة] ب ج هـ: – د ز: خلقة والكرسي] ز: + وهو **18** الدائرة] ز: الدوائر الدائرة المرسومة] ك: دائرة مرسومة شس] ا: +↓ ٣٦٠، د و ز ك: بشس **19** متساوية] د: متساويًا، ز: متساويتا عليها] ز: عيها يب] ز: بيب ومُوقّع] ا: والموقع برج] ب ز: بروج **20** درجاته] ز: درجة **21** الدوائر[2]] ز: الداوائر الستة] ك: السّت المتقاطعة] ب: التقاطعة، ز: المقاطعة قطبي] ز: قطب **22** وإحداها] ا ب ج د هـ و ز ك: وأحديها أيضًا] و: + هي مسماة] هـ: مسمات بالأقطاب] ز: بالأقطار وتُكتَب] ا ب ج د ز: ويكتب **23** وفلك] و: –، ز: فلك في...الآلة] ز: – بعض] هـ: –، ج: ↓ الآلة بالحمرة] ز: + في الغالب **24** وهو] ز: وهي مقاطعة] ز: متقاطعة لدائرة] ب ز: الدائرة أوّل...وأوّل] ز: أقل **25** وهي] ا د: وهو شس] د و ز ك: بشس شس...١] ك: في الهامش الأيمن جزءا] ا د: جزء، ب ج هـ و: أجزاء، ز: غير واضح مكتوب] ز: مكتون أعداد] ا د ز ك: أعدادها تبدأ] ا و: يبتدأ، ب ج د هـ ك: يبتدئ ١] ز: –

18 شس] ٣٦٠ **19** يب] ١٢ **25** شس] ٣٦٠

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Introduction

On the presentation of the drawings which are on the globe and presentation of their names:

The globe, also called 'the ⟨globe⟩ with stand', is an instrument consisting of the globe itself, the fixed ring on it, which is the meridian ring, and the stand that supports it.

As for the drawings:

[Among them is] the *ecliptic*: This is the circle which is drawn on the globe itself, divided into 360 equal parts. Written on it are the names of the 12 zodiacal signs; on each of the signs, the number corresponding to its degrees is inscribed.

[Among them are] the *circles passing through the first points of the signs*: These are the six circles that intersect (each other) at the two poles of the ecliptic. One of them also passes through the two poles of the equator, and so is called the one which passes through the four poles. These circles and the ecliptic are drawn in red on the instrument.

[Among them is] *the equator*: This is the circle that intersects the circle of the ecliptic at the first point of Aries and the first point of Libra. It is also divided into 360 equal parts; the numbers are written on it starting from 1 up to 360.

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/ب ٢ب/ ومنها دائرة نصف النهار: فهي الحلقة الثابتة على الكرة، والكرة /ب/ تتحرك في داخلها، وهي أيضًا تتحرك على الكرة. وهي أيضًا مقسومة شس جزءا متساوية.

ومنها دائرة الأفق: وهي حلقة الكرسي التي تنصب عليها الكرة، وهي أيضًا مقسومة شس جزءا متساوية، وقّع عليها أعداد مشارق الصيف، ومشارق الشتاء، ومغارب الشتاء، ومغارب الصيف.

/ج ٦٠ب/ /ا ٣١/ /د ٢ب/ /ج/ ومنها خطّ المشرق والمغرب: وهو الخطّ الذي كُتِب في طرفيه /ا/ لفظا المشرق والمغرب، /د/ المقطوع بدائرة الأفق.

ومنها خطّ نصف النهار: وهو الخطّ الذي كُتِب في طرفيه لفظا الشمال والجنوب، المقطوع بالأفق.

/هـ ٢٣٤/ ومنها قطبا فلك معدّل النهار: وهما الثقبان اللذان فيهما /هـ/ المسماران اللذان بهما تُثَبَّت الحلقة على الكرة، وبهما تدور الحلقة على الكرة والكرة في الحلقة. وهما ثابتان، وبعدهما عن أجزاء فلك معدّل النهار كلّها متساو.

/ز ٨ا/ ومنها قطبا فلك البروج: وهما النقطتان اللتان /ز/ تتقاطع عليهما الدوائر الست المذكورة؛ وبعدهما عن أجزاء دائرة فلك البروج كلّها متساو.

27 الحلقة] د: الخلقة تتحرك...28 داخلها] ز: يتحرك في داحلها **28** تتحرك] ب ج ز يتحرك وهي[2]] ا: فهي شس] د و ز ک: بشس جزءا] ا ب ج د: جزء، هـ: جزأ، و: أجزاء، ز: جزاًء **29** تنصب] ا د و ک: ينصب **30** شس] د و ز ک: بشس جزءا] ا د: جزء، ب: جزاء، و: أجزاء الشتاء] ب ج د هـ ز: الشتا **31** ومغارب[1]...الصيف] ا و: ومغارب الصيف، ومغارب الشتاء، ز: ومغاربهما **32** لفظا] ز: لفظ **33** المقطوع] ج و: ↓ بدائرة **34** وهو الخطّ] ز: هو الحط لفظا] ز: لفظ الشمال والجنوب] ب ج هـ و ز: الجنوب والشمال **35** بالأفق] ز: + أيضا **36** النهار] ز: النها الثقبان اللذان] هـ: الثقبتان التان، ز: الثقبتان اللذان، ک: الثقبتان اللتان اللذان[1]...المسماران] ا: — اللذان[2]] هـ: الذان **37** بهما] ب ج: — تُثَبَّت] ا ب ج هـ: ثبت، د: يثبتت، و: يثبتان وبهما] ا: وبها تدور] ا ب ج هـ ز ک: يدور والكرة... الحلقة[3]] ب ج هـ: —، و ز: وبالعكس **38** وهما] ب ج هـ و: فهما ثابتان] ز: ثابتا عن] د: من معدّل] ب ج: —، هـ: معدل ↑ فلك النهار متساو] ا: متساوية، د: مُساوةٍ، ز: مساوية **39** فلك] ا ب ج هـ: —، ک: في الهامش الأيمن النقطتان] هـ: الثقبتان، و: النقطًتا اللتان] هـ: التان تتقاطع] ا ب ج و: تقاطع عليهما] ک: عليها الست] ب ج د هـ ز: الستة **40** وبعدهما] و: ×٢، ز: وبعدها فلك البروج] ب ج: —، و: ↓ كلّها متساوية متساو] ا ب ج د و: متساوية، ز: متسوية

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[Among them is] *the meridian circle*: This is the fixed ring on the globe. The globe moves inside it, and it moves on the globe as well. It is also divided into 360 equal parts.

[Among them is] *the horizon circle*: This is the ring of the stand on which the globe is installed and it is likewise divided into 360 equal parts. The numbers corresponding to the (sun) risings in summer, the (sun) risings in winter, the (sun) settings in winter and the (sun) settings in summer are marked on it.

[Among them is] *the East-West line*: This is the line with the terms 'East' and 'West' written at its two extremities, and which divides the horizon circle.

[Among them is] *the meridian line*: This is the line with the terms 'North' and 'South' written at its two extremities, and which divides the horizon.

[Among them are] *the two poles of the equator*: These are the two holes with pegs inside them, by which the ring is fixed on the globe, and on which the ring rotates on the globe and the globe in the ring. These two (poles) are fixed and their distances from all degrees of the equator circle are equal.

[Among them are] *the two poles of the ecliptic*: These are the two points on which the six aforementioned circles intersect each other. They are of equal distance from all degrees of the ecliptic.

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/ب ٣أ/ ومنها منازل القمر: /ب/ وهي الدارات الصغار ⟨في⟩ البروج، المختلفة في العظم
/ك ١٣٤أ/ والصغر؛ المُوقّع عليها أسماء /ك/ الكواكب الثمانية والعشرين الواقعة على فلك
البروج وعلى جنبيه.

ومنها بعض الثوابت: وهي الدوائر الصغار المُوقّع عليها أسماء الكواكب التي في
شبكة الأسطرلاب.

/و ٦٧ب/ ومنها دوائر الميل: وهي الدوائر التي /و/ تتقاطع على قطبي المعدّل.

واعلم أن بعض هذه الرسوم لا يُرسم في بعض ذات الكرسي، وقد يزاد على ما
ذكر في بعضها، والأكثر الاقتصار على ما ذكر.

<1> الباب الأوّل: في معرفة وضع الكرة.

/ج ٦١أ/ وهو أن تضع الكرسي قدَّامك مواجها لِما بين مشرقي /ج/ الجدي والسرطان، وأن
/د ٣أ/ تضع الكرة في الكرسي بحيث /د/ يدخل بعض دائرة نصف النهار جوف الخشبة
الموضوعة على جهة أسفل الكرسي، وأن ترفع القطب الشماليّ من الأفق بقدر عرض
البلد الذي تريد أحكامه. وأنت خبير بأن الأفلاك مستديرة، وأن الحركة الذاتيّة لبعضها
من المشرق إلى المغرب ولبعضها بالعكس؛ وأن الحركة الظاهرة المحسوسة لكلّ
/ب ٣ب/ واحد منها حركة عرضيّة /ب/ شرقيّة بواسطة حركة فلك الأفلاك، وأن أوضاع هذه
/ه ٢٣٥أ/ الحركة تختلف /ه/ باختلاف المواضع؛ فإن الموضع الذي يكون المعدّل في سمت

41 الدارات...البروج] ا: الدارات البرج الصغار، ب ج ه: المدارات البروج الصغار، د: مدارات البروج الصغار، و: المدارات الصغار، ز: مدارت البروج الصغاو، ك: مدارات الصغار ↓ البروج **42** الثمانية...44 الكواكب] ك: في الهامش العلوي **43** جنبيه] ز: جنبه، ك: جنبيها **44** الثوابت وهي] ك: – الدوائر] ا ب ج ه و: – الصغار] أو الصفار؟ **45** الأسطرلاب] ب ج ك: الأصطرلاب، ز: الأسطرلا **46** دوائر] ب ج ه: دائرة التي] ز: – تتقاطع] ب ج ه: تقاطع المعدّل] و: معدّل **47** بعض[1]] ك: ↑ هذه هذه الرسوم] ز: هذا المرسوم يُرسم] ه ز: ترسم **48** بعضها] ز: بعض **50** مواجها] ب ج ه و ز: موجها مشرقي] ز: مشرق **51** الكرة في] ك: في الهامش الأيسر يدخل] ز: تدخل جوف] ه: خرق **52** ترفع] ز: يرفع عرض] ب ج ز: العرض **53** لبعضها] ز: بعضها **54** ولبعضها] ب ج د ه و ك: وبعضها، ز: بعضها الظاهرة] ز: الطاهرة **55** شرقيّة] ب ج د ه و ك: – شرقيّة...56 الحركة] ز: – فلك] ه: ↑ حركة الأفلاك **56** تختلف] ب ج ه: يختلف، و: مختلف باختلاف] ه: ×٢ فإن الموضع] ز: – الموضع] ب: الوضع في] ك: +↑ فيه

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[Among them are] *the lunar mansions*: These are the small houses on the zodiacal signs, of varying size;[6] they bear inscriptions of the names of the 28 stars located on the ecliptic or on its two sides.

[Among them are] *some of the fixed (stars)*: These are the small circles on which the names of the stars are inscribed, which are placed on the astrolabe's grid.

[Among them are] *the circles of declination*: These are the circles that intersect each other at the two poles of the equator.

You must know that some of these drawings are not drawn on some *dhāt al-kursī*, on some others there is more than what has been mentioned, and most (instruments) are restricted to what has been mentioned.

Chapter one: To know how to position the globe.

(To do) this, you place the stand in front of you facing to what is between the risings of Capricorn and Cancer and place the globe on the stand, so that a part of the meridian circle enters the aperture of the wood situated at the lower part of the stand, and elevate the north pole from the horizon as many degrees as the latitude of the city that you want to review.[7] You should be aware that the orbs are circular and that the proper motion for some of them is from the East to the West, and for some others the opposite; and that the perceived apparent motion for each one of them is a transverse motion from the East through the motion of the celestial sphere;[8] and that the modes of this motion differ as location varies; in the place where the equator is on the zenith,

6 lit. 'various in greatness and smallness'.
7 lit. 'its judgment'.
8 lit. 'the sphere of the spheres'.

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الرأس تكون الحركة فيه مستقيمة دولابيّة؛ والموضع الذي يكون المعدّل مائلا عن سمت الرأس تكون الحركة منحرفة حمائليّة؛ والموضع الذي يكون القطب مسامتا للرأس، تكون الحركة فيه رحويّة. فإن أردت أن تشاهد ذلك، فضع قطبي الكرة على دائرة الأفق وأدِرْ الكرة، فإنّك ترى دورانها مستقيما دولابيا، ثمّ ارفع القطب شماليّ بمقدار ما عن الأفق وأدِرْ الكرة، فإنّك ترى دورانها مائلا؛ ثمّ ارفع القطب إلى أن يقع على سمت الرأس وينطبق المعدّل على الأفق، فإنّك ترى دورانها رحويّا، والله أعلم.

<2> الباب الثاني: في معرفة استواء الليل والنهار في خطّ الاستواء.

إذا أردت ذلك، فضع القطب على الأفق، وضع أيّ جزء شئت من أجزاء البروج /ج/ على الأفق، وضع علامة /د/ على جزء /و/ من المعدّل الذي وقع في أفق /ج ٦١ب/
المشرق وعلى جزء منه وقع في أفق المغرب. ثمّ أدِرْ الكرة إلى أن يصير /ب/ ذلك /د ٣ب/ /و ٦٨أ/
الجزء من فلك البروج على الأفق من جهة أخرى، فإنّك تجد الجزء المعلّم عليه /ب ٤أ/
على الأفق من جهة أخرى. وبذلك يُعلم أن قوسي الليل والنهار متساويان.

وطريق آخر: أن تضع الجزء المفروض من البروج على الأفق الشرقيّ، وأن تعلّم على الجزء من المعدّل /ا/ الواقع معه في ذلك الأفق، وأن تدير الكرة إلى أن يقع /ا ٤١/

57 تكون] ا ب ج هـ و ز ك: يكون   دولابيّة] ك: ودولابية   مائلا] ك: +↑ فيه   58 تكون] ا ج د هـ و ز ك: يكون، ب: نكون   الحركة] و: –، ك: + فيه   القطب] ك: +↑ فيه   مسامتا] ب ج هـ: سابقا، ز: مساتتا   59 تكون] ا ب ج هـ و ز ك: يكون   فإن] ز: ف ان   60 فإنّك] ب: –   فإنّك...61 الكرة] ج: في الهامش الأيمن السفلي   دورانها] هـ: دوراتها   دولابيا] ب ج د هـ و ز ك: –   شماليّ] ز: الشمالية   61 دورانها] ب هـ: دوراتها   62 يقع] و: تقع   على[2]] و: عن   دورانها] ب هـ: دوراتها   والله...63 أعلم] ب ج د هـ و ز ك: –   64 خطّ] ز: حط   66 الأفق] ج: +↓ الشرقي   الذي] ب ج د هـ و ز ك: –   وقع] د: ~~وقع~~   67 وقع] د: ~~موقع~~   أدِرْ] و: تدير   68 تجد] ز: ترى   عليه] ز: عليها   69 أخرى] ج: +↑ أيّ من جهة المغرب   قوسي] ب ج هـ: قوس   والنهار] ز: والنها   متساويان] و ك: متساويتان   70 الجزء] ز: جزء   البروج] و: البرج   الشرقيّ] ز: المشرق   71 معه] ز: مه   وأن] ز: أن   يقع] ا: تقع، ب: بقع

58 حمائليّة] تشبه حمائل السيوف

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the motion will be upright rotational, like a wheel; in the place where the equator is inclined to the zenith, the motion will be oblique diagonal, like a baldric;[9] in the place where the pole is on the zenith, the motion will be rotational like a millstone. If you want to see this, put the two poles of the globe on the horizon circle and rotate the globe and you will see its right rolling rotation; then raise the north pole by any distance from the horizon and rotate the globe and you will see its oblique rotation; then raise the pole so that it falls on the zenith and the equator coincides with the horizon and you will see its rotary like a millstone motion, and God knows best.

Chapter two: To know the equality of night and day on the (terrestrial) equator line.

If you want this, place the pole on the horizon and place any degree you want, among the degrees of the zodiacal signs, on the horizon. Put a mark on the degree of the equator that falls on the east horizon and on the degree thereof that falls on the west horizon. Then rotate the globe until this degree of the ecliptic arrives at the horizon from the other direction, so you find the degree that has been marked on the horizon on the other side. In this way, it is understood that the two arcs, of the night and of the day, are equal.

Another way is that you place the given degree of the zodiacal signs on the east horizon and mark the degree of the equator that falls on this horizon with it. You rotate the globe until

9 baldric: a diagonal belt for carrying a sword.

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/هـ ٢٣٦/ /ه/ الجزءان معا على الأفق الغربيّ، وأن تعدّ من ذلك الجزء من المعدّل راجعا إلى
المشرق، فإنّك تجد قف جزءا، وهي التي طلعت في ذلك النهار، ولا شك أنّه
/ز ٨ب/ غربت أجزاءٌ /ز/ بمقدار تلك الأجزاء في النهار؛ فيُعلم تساوي الليل والنهار بالضرورة.

<3> الباب الثالث: في معرفة أطول النهار وأقصره في الآفاق المائلة.

وطريقه أن ترفع القطب الشماليّ عن الأفق بأيّ عدد شئت، وتضع أوّل السرطان
والجدي، وغيرهما في الأوقات، على الأفق الشرقيّ وتعلّم على جزء المعدّل الذي
/ب ٤ب/ وافى الأفق مع الجزء الموضوع. ثمّ تدير الكرة حتّى يصير ذلك /ب/ الجزء على دائرة
/ج ٦٢ا/ نصف النهار أو على /ج/ دائرة الأفق الغربيّ، وتعلم على جزء المعدّل الواقع في
/د ٤ا/ الأفق الشرقيّ في هذا الوقت، وأن تعدّ ما بين العلامتين، فإنّك /د/ تجد أكثر النُهُر
/ك ١٣٤ب/ زمانا نهار أوّل السرطان، وأقلّها زمانا نهار أوّل الجدي، وتجد /ك/ نهار أوّل الحمل
متساويا لليلته، ونُهُر البروج الشماليّة أكثر زمانا من لياليها، والبروج الجنوبيّة بالعكس.

72 الجزءان] ا د: الجزآن، ب ج: الجزأن الغربيّ] ا ب ج د ه و ز: – الجزء] ه: ↑ من **73** قف جزءا] ا: أجزاء، ب ج د و: قف جزء، د: +↓ ١٨٠ **74** أجزاءٌ...النهار] ا: – بمقدار] ب ج: لمقدار في] ز: و فيُعلم] ه: فتعلم، ز: ويعلّم تساوي] ز: يساوي بالضرورة] ز: بالضرةورة **75** الثالث] ز: الثالب **76** أوّل] ج: أقل **77** والجدي] و: أو الجدي وغيرهما] ب: وغير، و ك: أو غيرهما الشرقيّ] ز: المشرق جزء] ز: الجزء **78** وافى] ا: وقع في الأفق...الجزء[1]] و: +↓ من فلك البروج الموضوع] ز: الموضع على...79 أو] ز: – **79** الواقع] ز: المواقع **80** النُهُر] ب ج ه و ز: النهار **81** زمانا نهار[2]] ز: – **82** متساويا] د: مساويا لليلته] ب ج و ه: لليله، د ز: لليلة ونُهُر البروج] ب: والنهر، ج: نهر ↑ والبروج لياليها] ب: ليالها والبروج] ز: –

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the two degrees come together on the west horizon, and count from that degree on the equator back to the East, so you find 180 degrees. These are the degrees that have risen during daytime and, without any doubt, the same quantity of degrees has set during daytime. Thus, the equality of night and day can certainly be understood.

Chapter three: To know the longest and shortest daytime at the oblique horizons.

The way to do this is to raise the north pole from the horizon by any number you want. You put the first point of Cancer, Capricorn and any other degree[10] on the east horizon and put a mark on the degree of the equator that arrives at the horizon with the degree that has been placed (on it). Then you rotate the globe until this degree arrives at the meridian circle or at the circle of the west horizon and put a mark on the degree of the equator that simultaneously falls on the east horizon. You count (the degrees) between the two marks, so you find that the longest daylight (corresponds to) the duration of the daytime at the first point of Cancer and the shortest one to the duration of the daytime at the first point of Capricorn. You find the daytime at the first point of Aries to be equal to its nighttime. The days of the northern signs are longer in duration than their nights; the opposite (happens) with the southern signs.

10 lit. 'any other of the points in time'.

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<4> الباب الرابع: في معرفة الاختلاف بين نهاري يومين في بلد واحد.

وطريقه أن تضع الجزئين على الأفق الشرقيّ وأن تعلّم جزئي المعدّل اللذين /و ٦٨ب/ /و/ معهما في الأفق، وأن تدير الكرة إلى أن يقع الجزءان في الأفق الغربيّ، وأن تعلّم الجزء الواقع في أفق المشرق من المعدّل، وأن تعدّ ما بين العلامتين، وتسقط الأقلّ فيما بين العلامتين من الأكثر؛ فما بقي فهو زيادة أحد اليومين على الآخر، والله أعلم.

<5> /هـ/ الباب الخامس: في معرفة قوس النهار للشمس وسائر الكواكب وتقسيمه إلى /هـ ٢٣٧/ الساعات الزمانيّة والمستوية.

/ب ٥ا/ وطريقه أن ترفع /ب/ القطب الشماليّ بقدر العرض، وتضع الكوكب على الأفق الشرقيّ، وتعلّم جزء المعدّل الذي معه في هذا الأفق، وتدير الكرة إلى أن يصل الكوكب إلى الأفق الغربيّ، ثمّ تعلّم جزء المعدّل الذي وقع في الأفق الشرقيّ؛ فما /ج ٦٢ب/ بين العلامتين /ج/ هي قوس نهار ذلك الكوكب في ذلك اليوم في ذلك البلد، وما /د ٤ب/ بقي من ثلاثمائة وستين جزءا فهو قوس الليل. فإذا /د/ حصل قوس النهار، فخذ لكلّ خمسة عشر جزءا ساعة مستوية، وما لم يبلغ من الأجزاء ساعة، فجزء من ساعة. وإذا قسمت أجزاء قوس النهار إلى اثنى عشر، حصل لك عدد أجزاء الساعة الزمانيّة.

84 وطريقه] ك: في الهامش العلوي وطريقه...الشرقيّ] ا: – الجزئين] ك: جزءى الشمس في اليومين جزئي] ب هـ ز: جزء، ج و: جزئ اللذين] ب ج هـ: الذين، ز: الذي **85** تدير] د: يُدير الجزءان] ا و: الجزآن، ب ج: الجزان، د: الجزأن تعلّم] و ج ز: – **86** أفق] و: الأفق وأن] ب ج هـ ز: + تعلّم تعدّ] هـ: بعد، و: تعدّ بعد، ك: +↑ بعد **87** فيما] د: في ما، و: فما والله...88 أعلم] ب ج د هـ و ز ك: – **89** الكواكب] ج و: الكوكب وتقسيمه] ج: وبقسمته، و: وتقسيمها **90** الزمانيّة] ز: الزمانيته **91** بقدر] ز: بقد الكوكب] د: الكواكب **92** وتدير] ز: تدير يصل] ز: تصل **93** الكوكب] د: الكواكب وقع] ك: ↑ في فما] ب: فيما **94** العلامتين] ج: في نهاية و٦٢ا: العلامتين وفي بداية و٦٢ب: ~~متين~~ ذلك[1]...في[1]] د: – في[1]...اليوم] ز: – **95** جزءا] ا د هـ ز ك: جزء، ب: جزأ، و: جزءً فهو] و: + جزء، ك: فهي الليل] و: الّيل النهار] و: + فقسم قوس النهار وقوس الّيل إلى خمسة عشر حصل ساعة مستوية **96** جزءا] ا د ز ك: جزء، و: جزءً لم] ز: لا فجزء...97 ساعة] ز: – **97** الساعة] د: الساعات

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Chapter four: To know the difference between the (lengths of) daylight of two days in one city.

The way to do this is that you place the two degrees on the east horizon and mark the two degrees of the equator that are with them simultaneously on the horizon. You rotate the globe so that the two degrees fall on the west horizon and mark the degree[11] of the equator that falls on the east horizon. You count (the degrees) between the two marks and subtract the lesser of what is between the two marks from the greater one; the result will be the excess of one day over the other, and God knows best.

Chapter five: To know the daytime arc of the sun and of the rest of the stars and its division into seasonal and equal hours.[12]

The way to do this is to raise the north pole as many degrees as the latitude, and place the star on the east horizon, then to mark the degree of the equator that (falls) on this horizon with it. You rotate the globe until the star arrives at the west horizon. Then you mark the degree of the equator that falls on the east horizon; what is between the two marks is the daytime arc of that star on that day at that city. The remainder, (taken) from 360 degrees, will be the nighttime arc. When you obtain the daytime arc, take for every 15 degrees an equal hour; any excess degrees that do not complete an hour will be part of an hour. If you divide the degrees of the daytime arc into 12, you will obtain the number of degrees of the seasonal hour.

[11] It is necessary to mark the positions of *two* degrees of the equator corresponding to the two degrees of the ecliptic that have reached the west horizon.

[12] In manuscript K, there are some marginal notes explaining the meaning of the seasonal and equal hours and their difference. They are written by the copyist's hand with the indication ملخص and were taken from al-Jaghmīnī's *al-Mulakhkhaṣ fī al-hayʾa al-basīṭa*.

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<6> الباب السادس: في معرفة الاختلاف بين نهاري يوم واحد في بلدين مختلفين في العرض.

وطريقه أن ترفع القطب الشماليّ بقدر عرض أحد البلدين، وتعلّم الجزء الذي مع جزء الشمس في أفق الشرق من فلك المعدّل، وتدير الكرة، وتعلّم جزء المعدّل الذي وافى المشرق عند كون جزء الشمس في أفق المغرب، وتحفظ ما بين العلامتين. /ب/ ثمّ تضع القطب على عرض البلد الآخر، وتكمل العمل المذكور، /ب ٥ب/ وتنقص الأقلّ من الأكثر، فما بقي فهو الاختلاف المطلوب.

<7> الباب السابع: في معرفة ما مضى من النهار /و/ من ساعة مستوية ومعوجة.

/و ٦٩أ/ وطريقه أن تضع جزء الشمس في الارتفاع الذي تطلب ساعته الماضية، وتعلّم جزء المعدّل الواقع في الأفق /هـ/ الشرقيّ. وتدير الكرة حتّى يصير جزء الشمس إلى هذا /هـ ٢٣٨/ الأفق، وتعلّم جزء المعدّل الواقع معه في الأفق؛ فما بين العلامتين /ا/ من الأجزاء هو /ا ٥/ الماضي من النهار. /ج/ فاقسمه /ز/ على الساعة المستوية والمعوجة، بعد أن تعرف /ج ٦٣أ/ أجزاءها بالطريق المذكور. /ز ٩أ/

99 الباب السادس] ز: — السادس] ب: 'السابع' صُحّح في[1]] ز: + معوجة في معوجة **101** الشماليّ] ا ب ج هـ ز: — أحد] د: — البلدين...106 السابع] ز: مكتوب مرّة ثانية في الهامش الأيمن الجزء] ب ج ز: جزء، د: جزء المعدل مع] ب: — **102** أفق] ز: —، ك: الأفق الشرق] د هـ و: المشرق، ز ك: الشرقي من...المعدّل[1]] ا ب ج د هـ ز ك: — **103** الذي] ز: — وافى] ا: وقع في المشرق] ا ب ز: الشرق المغرب] ا: الغرب وتحفظ] ز: ويحفظ **105** وتنقص الأقلّ] و: في الهامش الأيسر الأكثر] ك: كثر ↑ ~~الأقلّ~~ المطلوب] ج د هـ و: المط **106** السابع] ز: في النص: السادس، وفي الهامش الأيمن: السابع من النهار] ب ج هـ ز: — **107** جزء[1]] د: — الشمس] و: + على الأفق الشرقي في] ب: ×٢ تطلب] ا د ز ك: يطلب الماضية] ب: لماضية **108** المعدّل] ج: + ~~الّذى~~ الواقع] د هـ ز: + معه حتّى...الشمس] ا ب ج د هـ ز ك: — إلى...109 الأفق[1]] و: الغربي **109** الأفق[1]] ب: +↓ الشرقي، ك: +حتّى يوافيه جزء الشمس هو] د: فهو، ب: + ~~الاجزاء~~ **110** على] ك: + أجزاء **111** أجزاءها] ا ب ج و: أجزائها، د: أجزائهما، ز: أجزاءىهما بالطريق] ا ب ج: بطريقه، هـ و ز: بطريق المذكور] ز: —

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Chapter six: To know the difference between the daytime (lengths) of the same day in two cities with different latitudes.

The way to do this is to raise the north pole as many degrees as the latitude of one of the two cities and mark the degree of the equator that is on the east horizon, together with the degree of the sun. You rotate the globe and mark the degree of the equator that arrives at the east (horizon) when the degree of the sun is at the west horizon, and note the distance between the two marks. Then you place the pole at the latitude of the other city, complete the aforementioned process, and subtract the lesser from the greater; the remainder will be the required difference.

Chapter seven: To know the time that has elapsed since sunrise[13] in equal and unequal hours.

The way to do this is to place the degree of the sun at the altitude of the required hour[14] and mark the degree of the equator that falls on the east horizon. You rotate the globe, so that the degree of the sun comes to this horizon, and you mark the degree of the equator that falls simultaneously on the horizon; the number of degrees between the two marks will be the daytime that has elapsed. Divide it by (the degrees of) the equal and unequal hour after you determine its degrees[15] in the aforementioned way.

[13] lit. 'what has passed from the daytime'.

[14] lit. 'which its passed hour requires'.

[15] The degrees of the unequal hour are meant here; the way to calculate them is explained in Chapter 5. The degrees of the equal hour are always 15.

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<8> الباب الثامن: في معرفة الطالع، إذا كان ما مضى من النهار من الساعات المستوية أو المعوجة معلوما.

/د ٥ا/ /د/ وطريقه أن تضع جزء الشمس على الأفق الشرقيّ، فتدير الكرة، فتعدّ من أجزاء المعدّل ما يطلع من الأفق، إلى أن يتمّ أجزاء الساعة المعلومة؛ فما وقع حينئذ في هذا الأفق من أجزاء البروج فهو الطالع.

<9> الباب التاسع: في كيفيّة أخذ ارتفاع الشمس في الكرة.

وطريقه أن تأخذ ربع دائرة مساوية لربع الحلقة، وتقسّمها بتسعين جزءا /ب ١٦ا/ /ب/ متساوية، وتكتب عليها الأعداد كما في الحلقة. وتنصب الكرة على أرض /ک ١٣٥ا/ مستوية بالآلة المعروفة، حتّى تكون /ک/ الشمس ظاهرة عليها، نصبا مستويا بالشاقول المعلّق من طرفي الكرسي. ثمّ تنصب على جزء الشمس مقياسا، إبرة أو جسما آخر، ملزقا بشمع. وترفع القطب بقدر عرض البلد، وتدير الكرة تارة والكرسي أخرى، حتّى يظلل المقياس نفسه ولا يقع له ظلّ أصلا. ثمّ تقطع المقياس، وتعلّم موضعه، وتضع الربع المأخوذ على الكرة، بحيث يقع طرفه الذي ابتدأ منه العدد

112 ما] ب: – ما مضى] ز: ماضى **113** أو] ک: و **114** الشرقيّ] و: + وتكمل العمل، ز: الشرق **115** إلى أن] ب: – الساعة] ک: الساعات حينئذ] ب ج د هـ ز: –، و ک: ح / 8 **118** وطريقه] و: فطريقه مساوية] ز: مستاوية وتقسّمها] ا د: وتقسيمها، و: واقسمها، ز: وتقسيمه بتسعين] هـ: تسعين جزءا] ا و ز ک: جزء، د: جزأ **119** متساوية] ز: مستاوية، ب: مكتوب عموديا في الهامش العلوي الأيسر وتكتب] ز: ويكتب، ک: تكتب وتنصب] و: وينصب أرض] و: ↑ على **120** بالآلة] ب: بالأدلة تكون] ا ب ج و ز: يكون مستويا] ز: مستوية **121** تنصب] د: نتنصب، ک: انصب الشمس] و: + من الفلك البروج أو] ز: و **122** جسما] ا ب ج ز: جسم ملزقا] ا ک: ملزق، ب: لمتزق، ج د هـ و ز: ملتزق بشمع] ب: سمع، ج: پمع، ز: شمع وترفع] هـ ز: ويرفع **123** يظلل] د: يضلّل، هـ و ز: تظل نفسه] ب ج: – ولا...المقياس[2] ب ج هـ: – أصلا] د: –، و: + على الكرسي +↓ والكرة **124** وتضع] د: ويتضع، ز: وينضع ابتدأ] ج هـ: ابتدء، ک: ابتداء

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Chapter eight: To know the ascendant, if the elapsed time since sunrise[16] in equal or unequal hours is known.

The way to do this is that you place the degree of the sun at the east horizon and rotate the globe, counting the degrees of the equator that rise from the horizon, until (the number of) degrees corresponding to the known hour is reached; the degree of the zodiac that falls on this horizon at this moment will be the ascendant.

Chapter nine: On the method of obtaining the altitude of the sun on the globe.

The way to do this is that you take a quadrant of a circle, equal to a quarter of the ring, divide it into 90 equal parts and write the numbers on it, as on the ring. You install the globe on flat ground with the well-known instrument,[17] installed upright with a plumb hanging from the two edges of the stand, so that the sun is visible on it. Then you install, on the degree of the sun, a measuring gnomon, a needle or another object, attached with wax. You raise the pole as many degrees as the latitude of the city, and rotate the globe and the stand in turn, until the gnomon casts its shadow upon itself and there is absolutely no shadow from it. Then you cut the gnomon and mark its position, and place the aforementioned quadrant on the globe in such a way that its end, where the numbering begins,

[16] lit. 'what has passed of the daytime'.

[17] This should be a leveling instrument used to make sure the ground is flat.

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/ج ٦٣ب/ على الأفق، ويمرّ بجزء الشمس، وينتهي إلى نقطة سمت الرأس، /ج/ وتنظر أيّ
/و ٦٩ب/ عدد يقع على جزء الشمس، فذلك العدد هو قدر /و/ ارتفاع ⟨في ذلك⟩ الوقت.

وأظنّ أنّه لابد في الارتفاع الغربيّ من ربع آخر، أو من تبديل القطبين ونصب
/هـ ٢٣٩/ المقياس على /هـ/ نظير الجزء.

<10> الباب العاشر: في معرفة الأوتاد الأربعة.

/د ٥ب/ وطريقه /د/ أن تستخرج ارتفاع الشمس، ثمّ تنظر ما وقع على أفق المشرق من أجزاء البروج فهو الطالع، وما وقع تحت حلقة نصف النهار فوق الأرض فهو وسط السماء، وما وقع في الأفق الغربيّ فهو الغارب، وما وقع تحت [كذا] نصف النهار تحت
/ب ٦ب/ الأرض فهو وتد الأرض. وأنت خبير بأنّه إذا عرف /ب/ أحد الأوتاد الأربعة، عرف الباقي منه بأن تضع المعلوم في موضعه وتنظر ما وقع في مواضع الباقي.

<11> الباب الحادي عشر: في معرفة باقي البيوت.

وطريقه أن تدير الكرة على التوالي بقدر أجزاء ساعتين زمانيتين، فما وقع من أجزاء البروج في نصف النهار فوق الأفق فهو ⟨أوّل⟩ التاسع ونظيره ⟨أوّل⟩ الثالث. ثمّ أن تدير

125 ويمرّ] ب ج هـ و ز: وتمرّ، ك: ويمسه بجزء] ز: جزء وينتهي] ب ج د و: وتنتهي سمت] ز: – الرأس] ج: + فذلك العدد هو قدر ارتفاع عدد يقع على جزء الشمس وينتهي إلى نقطة: محاط بنقاط، ك: في الهامش الأيسر وتنظر] هـ: وينظر **126** الشمس] ج: + ~~وينتهي إلى نقطة سمت الرأس~~ هو] ك: وهو **127** من[1]] و: في من[1]...أو] د: من ربع آخر و ↑ من تبديل ربع...من[2]] ب ج هـ: –، ز: ربع آخر تبديل] ز: وتبد القطبين] ب ج د هـ و ز: القطب ونصب] ز: ونصبا **128** على] ا ك: في، هـ: مكتوب مرّة ثانية في بداية ص٢٣٩ نظير] ز: نطر **129** الباب...130 وطريقه] د: مكتوب مرّة ثانية في بداية و٥ب **130** وطريقه] و: فطريقه ارتفاع الشمس] ا ب ج د هـ ز ك: الارتفاع من أجزاء] ز: منه الأجزاء أجزاء] و: + الفلك **131** وما وقع] ز: وصاقع النهار] و: + من البروج من طرف الجنوب وسط السماء] ك: وسط ↑ وتد السمالـء؛ في الهامش الأيسر: وتد السمأ **132** وقع[1]] ب: قع الغربيّ] د: القربي وما وقع[2]] ز: وصاقع تحت[2]...133 الأرض[1]] و: +↓ من فلك البروج **133** الأرض[2]] و: – خبير] ز: اخبير إذا] ب: اذ **134** المعلوم] و: + مثلا مواضع] د ز: موضعه، ك: مواضعه الباقي[2]] ا: الباقية، ز: البواقي **136** على...أجزاء[1]] و: +↓ من المشرق إلى الغرب بقدر] و: مقدار زمانيتين] ب ج هـ و ز: زمانين **137** ثمّ أن] و: –

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falls on the horizon, that it passes through the degree of the sun and that it ends at the point of the zenith. Observe which number is on the degree of the sun; this number will be the measurement of the altitude ⟨at that⟩ time.

I suppose it is necessary for the west altitude (to use) another quadrant, or for the two poles to be exchanged and the gnomon installed at the diametrically opposite degree.

Chapter ten: To know the four centres.

The way to do this is that you find the altitude of the sun. Then observe which, amongst the degrees of the zodiac, falls on the east horizon; this will be the ascendant. What falls below the ring of the meridian above the earth will be the midheaven; what falls on the west horizon will be the descendant; and what falls below the meridian,[18] below the earth, will be the centre of the earth. And you are well-acquainted with this: if you know one of the four centres, you (can) determine the rest of them by placing the known one at its position and observing (the degrees) that fall at the positions of the remaining (centres).

Chapter eleven: To know the rest of the houses.

The way to do this is that you rotate the globe following the order of the zodiacal signs as many degrees as those of two seasonal (unequal) hours; the degree, among the degrees of the ecliptic, that falls on the meridian above the horizon will be the ⟨cusp of the⟩ ninth (house) and its diametrically opposite (degree) the ⟨cusp of the⟩ third one. Then you rotate

[18] It is actually above the meridian ring, since the meridian ring is below the globe at the part of the globe that sits under the horizon.

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الكرة على التوالي بذلك القدر، فما وقع في نصف النهار فهو ⟨أوّل⟩ الثامن ونظيره ⟨أوّل⟩ الثاني. ثمّ أن تضع الطالع المذكور في موضعه الأوّل وأن تدير الكرة على خلاف التوالي بالقدر المذكور، فما وقع في نصف النهار فهو ⟨أوّل⟩ الحادي عشر ونظيره ⟨أوّل⟩ الخامس. ثمّ أن /ج/ تدير الكرة ⟨على خلاف التوالي⟩ بالقدر المذكور، فما وقع في نصف النهار فهو ⟨أوّل⟩ الثاني عشر ونظيره ⟨أوّل⟩ السادس. /ج ٦٤أ/

<12> الباب الثاني عشر: في استخراج جزء كلّ واحد من الكواكب التي في الكرة، وفي معرفة عرضه، وفي معرفة ميله عن المعدّل وسمت الرأس، وفي معرفة غاية /د/ ارتفاعه، /ه/ وفي معرفة ميل جزء /ز/ البروج عن المعدّل. /د ٦أ/ /ه ٢٤٠/

وطريقه أن تدير الكرة حتّى يبلغ الكوكب وجزء فلك البروج إلى وجه حلقة نصف النهار من جهة المشرق، /ب/ فالجزء الذي وافى معه /و/ ذلك الوجه هو جزء ذلك الكوكب ولا يتغير في الأقاليم. /ز ٩ب/ /ب ٧أ/ /و ٧٠أ/

وأجزاء الحلقة التي بين الكوكب وبين الجزء المذكور هو عرض ذلك الكوكب ولا يتغير في الأقاليم. /ا/ وهذا غير صحيح، لأنّ العرض إنّما يؤخذ من دائرة العرض. /٦١أ/

وأجزاء الحلقة التي بين الكوكب وبين المعدّل، هو ميل ذلك الكوكب عن المعدّل، وهذا الميل لا يتغير أبدا.

والأجزاء التي بينه وبين سمت الرأس، أعني تسعين جزءا من الأفق، هو ميله عن سمت الرأس، وباقي الأجزاء هو غاية ارتفاعه. وهذا الميل والغاية يتغيران باختلاف

138 التوالي] ز: توالي النهار] و: + ايضا **139** أن] د: — وأن] و: بان **140** بالقدر] ه و: بقدر فهو] د: ...... **141** أن] و: — **142** فهو] ا ک: هو **144** وفي[1]...الرأس] ا: — عن] ز: من **146** يبلغ] ا: يدخل الكوكب] ب ج د ه و ز ک: الكواكب وجزء] ا ب ج ه ک: أو جزء، د ز: أو جزء من وجه] ا: درجة، د ز: + درجة حلقة] ب: خلقة **147** وافى] ک: + معرفه ذلك[2]] ا: فلك **149** وأجزاء] و: أجزاء وأجزاء...150 الأقاليم] ا: — الحلقة] ب ج: الخلقة الكوكب[1]] ب ج د ه ز ک: الكواكب الكوكب[2]] ز: الكواكب **150** العرض[1]] ب: الغرض **151** الكوكب[1]] ز: الكواكب **152** وهذا] ز: هذا وهذا الميل] ب: وهو الليل **153** وبين] ب: ×٢ الرأس] ز: الدائرة أعني] د: عن، ز: يعنى جزءا] ا ه ز ک: جزء، ب: جزاءً، د و: جزءً من] و: + أجزاء من ميله] ب: ميل **154** وهذا] ب: وهو، ج ه: 'وهذا' مصحّح يتغيران] ز: بتغير

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the globe following the order of the zodiacal signs the same amount of degrees; what falls on the meridian will be the ⟨cusp of the⟩ eighth (house) and its diametrically opposite (degree) the ⟨cusp of the⟩ second one. Then you place the specified ascendant at its initial position and rotate the globe following the opposite order of the zodiacal signs by the aforementioned number of degrees; what falls on the meridian will be the ⟨cusp of the⟩ eleventh (house) and its diametrically opposite (degree) the ⟨cusp of the⟩ fifth. Then you rotate the globe ⟨following the opposite order of the zodiacal signs⟩ by the aforementioned number of degrees; what falls on the meridian will be the ⟨cusp of the⟩ twelfth (house) and its diametrically opposite (degree) the ⟨cusp of the⟩ sixth one.

Chapter twelve: To find the degree of any of the stars that are on the globe, to know its 'latitude', to know its declination from the equator and its deviation from the zenith, to know its maximum altitude and to know the declination of a degree of the zodiac from the equator.

The way to do this is that you rotate the globe so that the star and a degree of the ecliptic reach the face of the meridian ring from the easterly direction; the degree (of the ecliptic) that reaches that face with it will be the degree of that star and this does not change with the latitude.

The degrees of the ring that are between the star and the aforementioned degree will be the 'latitude' of that star, and this does not change with the terrestrial latitude. This (however) is not correct, because the latitude is solely taken on the circle of the latitude.

The degrees of the ring that are between the star and the equator will be the declination of that star from the equator, and this declination never changes.

The degrees between it and the zenith, namely 90 degrees from the horizon, will be its deviation from the zenith; the remaining degrees correspond to its maximum altitude. This deviation and the maximum (altitude) change according to variations

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/ك ١٣٥ب/ عروض المساكن، فلابد من وضع القطب في العرض الذي /ك/ يراد معرفة ذلك فيه.

والأجزاء التي بين جزء البروج والمعدّل، هو ميله عنه، وهذا لا يتغير أصلا.

<13> الباب الثالث عشر: في معرفة سعة مشرق /ج/ كلّ كوكب من الكواكب
/ج ٦٤ب/ المرسومة، أو جزء من أجزاء البروج، وفي معرفة البعد بين مشارق الكوكبين، وفي معرفة البعد بين الكوكبين.

/ب ٧ب/ وطريقه أن تدير الكرة حتّى يصل الكوكب أو الجزء إلى الأفق الشرقيّ، /ب/ فما بين
/هـ ٢٤١/ الكوكب أو الجزء وبين نقطة المشرق من أجزاء الأفق، فهو سعة /هـ/ المشرق
/د ٦ب/ /د/ التي تساوى سعة المغرب لذلك الكوكب أو لذلك الجزء من أجزاء البروج؛
وذلك يختلف باختلاف العروض.

فلذلك يحتاج إلى وضع القطب في عرض البلد وأن تضع العلامة في ممرّي الكوكبين من أجزاء الأفق، فما بين العلامتين من أجزاء الأفق، هو بعد ما بين مشرقي ذينك الكوكبين، وهذا يختلف.

وإن تضع العلامة في ممرّي الكوكبين من أجزاء دائرة نصف النهار، فما بين العلامتين من تلك الأجزاء هو البعد بين الكوكبين، وهذا لا يختلف أصلا.

155 فلابد] ب ج: ولابد وضع] ب: موضع العرض] د ز: الأرض، هـ: +↓~~الأرض~~ يراد] ب ج: تراد **157** جزء] ز: – أصلا] ز: لاصلا **158** الثالث] ب: الثاني، ز: البالب **159** وفي[1]...الكوكبين] ا د ز: – البعد] و: بعد ما مشارق الكوكبين] ك: المشارق لكوكبين **160** البعد] و: بعد ما **161** يصل] د ز: تصل الشرقيّ] ب ج: + للكوكب **162** أو الجزء] ز: والجزء من الجزاء البروج سعة] هـ: مكتوب مرّة ثانية في بداية ص٢٤١ **163** تساوى] ك: يتساوى سعة] ا: عة لذلك[1]] ب: بذلك لذلك[2]] ا: ذلك الجزء] ز: – **165** يحتاج] ب ج: تحتاج إلى] ز: – ممرّي] ك: ممرّ **166** الكوكبين] ا: الكوكبية فما] ك: فبعد ما من[2]...الأفق[2]] ك: – أجزاء[2]...169 من] و: – مشرقي] ز: مشرق **167** الكوكبين] ز: + من أجزاء دائرة النهار يختلف] ز: يحتلف **168** ممرّي] ك: – الكوكبين] ا: الكوكبية نصف] : ا ب ج د ز: – **169** البعد] و: بعد ما، ز: بعد الكوكبين] ز: الكوكب لا] و: – أصلا] و ك: –

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in the latitudes of the regions.[19] The pole must be placed at the latitude for which the certain knowledge is required.

The degrees that are between the degree of the zodiac and the equator correspond to its declination from it (the equator), and this does not change at all.

Chapter thirteen: To know the ortive amplitude of every star among the stars drawn (on the globe), or a degree among the degrees of the zodiac. To know the distance between the risings of two stars and to know the distance between these two stars.

The way to do this is that you rotate the globe so that the star or the degree arrives at the east horizon; the number of degrees of the horizon between the star or degree and the East point will be the ortive / eastern amplitude, which is equal to the occiduous / western amplitude for that star or that degree of the zodiac. This changes as latitude varies.

For this (reason) it is necessary to place the pole at the latitude of the city and put a mark at (each of) the two points of transit of the two stars on the degrees of the horizon. The number of degrees of the horizon between the two marks will be the distance between the risings of these two stars. This is something that varies.

If you put the mark at (each of) the two points of transit of the two stars among the degrees of the meridian circle, the number of degrees between the two marks will be the distance between the two stars, and this never changes.

19 lit. 'places of residence'.

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<14> **الباب الرابع عشر: في معرفة الكواكب التي تطلع معا، وتتوسط معا، وتغرب معا.**

/و ٧٠ب/ واعلم أن الكواكب التي تطلع معا، لا تتوسط /و/ معا، ولا تغرب معا؛ والتي تتوسط معا لا تغرب معا، إلّا في خطّ الاستواء. فإن أردت اليقين، فضع القطب على الأفق وأدِرْ الكرة حتّى يطلع الكوكبان معا. ثمّ أدِرْ حتّى يقعا على وسط السماء معا وعلى أفق المغرب معا.

/ب ٨آ/ /ج ٦٥آ/ ثمّ ارفع القطب /ب/ بقدر ما، وأدِرْ الكرة حتّى يقع أحدهما /ج/ في وسط السماء أو الأفق الغربيّ، فإنّك تجد الكوكب الآخر متجاوزا عنه أو غير واصل إليه. ثمّ انظر إلى الأفق الشرقيّ؛ فإن كان فيه كوكبان فهما يطلعان معا. وكذا انظر إلى /د ٧آ/ وسط السماء؛ فإن كان فيه كوكبان، /د/ فهما يتوسطان معا؛ وكذا الحال في الأفق الغربيّ.

<15> **الباب الخامس عشر: في معرفة جزء طلوع كلّ كوكب من الكواكب المرسومة، /هـ ٢٤٢/ وجزء توسطه، /هـ/ وجزء غروبه في الأقاليم.**

/ز ١٠آ/ وطريقه أن تضع القطب في عرض البلد /ز/ وأن تدير الكرة، فالجزء الذي وقع مع ذلك الكوكب في الأفق الشرقيّ هو جزء طلوعه، والذي وقع معه في نصف النهار هو

170 الكواكب...تطلع] ب د هـ و: الكوكب الذي يطلع، ج: الكواكب الذي يطلع الكواكب...171 أن] ك: – وتتوسط] ب ج د هـ و: ويتوسط وتغرب] ب ج د هـ و: ويغرب معا[3]] و: في كلّ واحد من الأقاليم **171** واعلم] د: اعلم أن] هـ: ×٢ الكواكب] د: الكوكب تطلع] د: يطلع تتوسط[1]] د هـ ك: يتوسط تغرب] ب ج د هـ: يغرب، ب: +↑ولا تغرب تتوسط[2]] ب ج د هـ و: يتوسط **172** معا[1]] ك: – لا] ز: ولا تغرب] ب ج د هـ و: يغرب معا[2]] ب ج هـ: –، د: ↑يغرب خطّ] ز: حط اليقين] ب ز: التعيين، ج د هـ: التعَيُن، و: اليقن فضع] ب ج: وضع **173** يطلع] ا ك: تطلع يقعا] ا ب ج د هـ و ز ك: يقعان **174** أفق] د: الأفق معا] ب: معها **175** القطب] ز: الشمالي يقع] ب ج: تقع **176** الكوكب] ب ج: الكواكب متجاوزا] ب: متجا وزا، وزا في الهامش أو[2]] د: – غير] د: ↑عنه **177** كوكبان] ز: كوكيان معا] و ز: –، ج: ↑يطلعان انظر[2]] ز: انظرا **178** معا] ب ج د هـ و ز: – **180** الكواكب] ز: الكوكب **181** توسطه] ز: توسط وجزء[2]] د: في الهامش الأيسر **182** وأن تدير] د هـ ز: وتدير وقع] د: ~~معه في ......~~ **183** الكوكب] ب ج: الكواكب هو[1]] د: وهو، ج: ~~و~~هو

175 ما] ٤١، أو: ما ⟨شئت من أجزاء⟩ في...176 السماء] الصحيح: في الأفق الشرقي

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Chapter fourteen: To know the stars that rise simultaneously, culminate simultaneously, and set simultaneously.

Be aware that the stars that rise simultaneously do not culminate simultaneously and do not set simultaneously, and those that culminate simultaneously do not set simultaneously unless (we are) on the line of the (terrestrial) equator. If you wish to be certain of this, place the pole on the horizon and rotate the globe until the two stars rise simultaneously. Then rotate (the globe) until they are located simultaneously at the middle of the sky and simultaneously on the west horizon.

Then elevate the pole any number (of degrees you want)[20] and rotate the globe until one of them falls at the middle of the sky[21] or the west horizon, and you will find the other star passing beyond it, or not (yet) arriving at it. Then look at the east horizon; if there are two stars on it, then they rise simultaneously. Similarly look at the middle of the sky; if there are two stars on it, these two culminate simultaneously. The same situation occurs at the west horizon.

Chapter fifteen: To know the degree of rising of any star, among the stars drawn (on the globe), the degree of its meridian transit and the degree of its setting at the (various) latitudes.

The way to do this is to place the pole at the latitude of the city and rotate the globe. The degree that falls on the east horizon with this star is the degree of its rising; (the degree) that falls on the meridian with it is

[20] In all manuscripts, what I have translated as 'any number' is written ما; this could mean 41 (degrees), but in that case ما should be overlined. In the margin of MS D there is a note by a reader: أو أكثر أو أقل منه بقدر العرض سواء كان ('or more or less than it, equal to the measure of the latitude') that implies that ما was understood as 41. In the corresponding chapter Q28 of the treatise of Qusṭā we read كم / ما شئت من أجزاء ('as many degrees as you want').

[21] If two stars culminate simultaneously for an observer on the terrestrial equator, as presented above, then they culminate simultaneously in every latitude. The phrase 'the middle of the sky' has to be changed to 'the east horizon' in order to be astronomically correct. See the discussion in the Commentary.

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جزء توسطه، والذي وقع معه في الأفق الغربيّ هو جزء غروبه. واعلم أن جزء الطلوع وجزء الغروب يختلفان باختلاف العروض، وأمّا جزء التوسط فلا يختلف أصلا.

<16> الباب السادس عشر: في معرفة مطالع البروج، وفي معرفة مطالع الجزء في الفلك المستقيم وغيره.

وطريقه أن تضع القطب على الأفق وتدير الكرة إلى أن يصل أوّل البرج المطلوب /ب ٨ب/ /ب/ مطالعه إلى الأفق الشرقيّ؛ وتعلّم الجزء الذي وافى معه ذلك الأفق من المعدّل، ثمّ تدير الكرة إلى أن يطلع ذلك البرج كلّه وتعلّم الجزء الذي وافى معه ذلك الأفق من المعدّل، فما بين العلامتين فهو مطالع ذلك البرج.

/٧١/ وإن أردت المطالع /ا/ في الآفاق المائلة، فضع القطب في أيّ عرض شئت، /و ٧١ا/ /و/ ثمّ اعمل هذا العمل بعينه. واعلم أنك إذا أخذت مطالع برج في أيّ عرض كان /د ٧ب/ من /د/ خطّ نصف النهار، /ج ٦٥ب/ /ج/ حصل لك مطالع ذلك البرج في الفلك /ك ١٣٦ا/ /ك/ المستقيم.

وطريق معرفة مطالع جزء فلك البروج، أن تضع الجزء الذي تريد مطالعه على أفق المشرق، فأجزاء المعدّل الواقعة بين أوّل الحمل وبين الجزء الذي وافى مع ذلك الجزء من المعدّل هو مطالع ذلك الجزء.

184 توسطه] د: توسط الأفق] ك: – جزء[3] ز: – **186** معرفة[2] ا ب ج د هـ و ز: – في[2] ز: فا **188** الأفق] ج: +↓الشمالي، ز: +الشمالي أوّل] ا ب ج د هـ و ز: – البرج] ب ج هـ و ز: البروج المطلوب] ج هـ و: المط **190** ثمّ...191 المعدّل] ا: – يطلع] د: تطلع البرج] ب ز: البروج وافى...191 المعدّل] ب ز: –، ج: ↑وفي الهامش الأيسر: وافى معه أفق المشرق من أجزاء فلك معدّل النهار **191** البرج] ا ب ج د ز: البروج **193** ثمّ] ب: +~~اعمل~~ اعمل] د: +عمل **194** لك] ب: – البرج] ا د: البروج، ز: – **196** وطريق] ا: وطريقه أيّ، ز: وطريقه مطالع] هـ: – فلك] ز: ذلك أفق] و: الأفق **197** الواقعة] ز: الوافعة الجزء] ز: جزء مع] و: معه **198** من...هو] ك: هي أجزاء

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the degree of its meridian transit; and (the degree) that falls on the west horizon with it is the degree of its setting. Be aware that the degree of rising and the degree of setting change as the latitude varies; as for the degree of meridian transit, this never changes.

Chapter sixteen: To know the ascension (rising times) of the zodiacal signs and to know the ascension of a degree in the right sphere and elsewhere.[22]

The way to do this is that you place the pole on the horizon and rotate the globe until the first point of the sign, for which the ascension is required, arrives at the east horizon. You mark the degree of the equator that has reached that horizon with it; then you rotate the globe until this sign rises entirely and mark the degree of the equator that has reached that horizon with it. The number of degrees between the two marks will be the ascension of this sign.

If you want the ascension in the oblique horizons, place the pole at any latitude you want, then do the same operation. Be aware that if you take the ascension of a sign at any latitude on (i.e. using) the meridian line, you obtain the ascension of that sign in the right sphere.

The way to know the ascension of a degree of the ecliptic is that you place the degree for which the ascension is wanted on the east horizon; the degrees of the equator between the first point of Aries and the degree of the equator that has reached (the east horizon) simultaneously with that degree will be the ascension of that degree.

22 This means that also the ascension in the oblique sphere is examined.

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<17> /هـ/ الباب السابع عشر: في معرفة الكواكب الأبديّة الظهور والأبديّة الخفاء، /هـ ٢٤٣/ والتي تطلع وتغرب من الكواكب المرسومة على الكرة.

وطريقه أن تضع القطب في الأفق، وتدير الكرة إلى أن يصل الكوكب إلى نصف /ب ٩ا/ النهار، وتعدّ بُعده عن القطب بأجزاء حلقة نصف النهار؛ فما كان بعده /ب/ عن القطب الشماليّ مساويا لعرض البلد أو أقلّ، فهو أبديّ الظهور؛ وما كان بعده عن القطب الجنوبيّ مساويا لعرض البلد، فهو يصل إلى الأفق فيغيب في الحال، وما كان أقلّ منه فهو أبديّ الخفاء، وما كان أكثر منه فهو يطلع ويغرب. وما كان أقرب من القطب الشماليّ فزمانه فوق الأرض أكثر، وما كان أقرب من القطب الجنوبيّ فزمانه فوق الأرض أقلّ في المساكن الشماليّة، والله أعلم.

<18> الباب الثامن عشر: في معرفة الكواكب التي تغيب بعد الشمس وتطلع قبله في الليلة الواحدة، وفي معرفة الكواكب التي الليل كلّه فوق الأرض.

/د ٨ا/ وطريقه أن تدير الكرة حتّى تعرف /د/ أبعاد الكواكب وجزء الشمس عن القطب الشماليّ؛ فالتي أبعادها قليلة من بعد جزء الشمس قلّة معتدًّا بها ⟨فوق الأفق⟩ وقريبة من الأفق الغربيّ عند غروب الشمس، فهي تغرب بعد الشمس وتطلع قبله؛ والتي /ج ٦٦ا/ أبعادها /ج/ قليلة من بعد الجزء وقريبة من أفق المشرق عند غروب الشمس،

200 تطلع وتغرب] ب ج: يطلع ويغرب، هـ: تعلع وتغرب، و: لها تغرب وتطلع **201** وتدير] هـ: وتندر الكوكب] ب ج هـ و ز: الكواكب **202** بُعده] هـ: بقدره بأجزاء] ز: أجزاء **203** لعرض] ب: لغرض **204** لعرض] ب: لغرض البلد] د ز: – فيغيب] ب ج هـ ز: فتغيب **205** وما[1]] ز: ×٢ يطلع ويغرب] د ك: تطلع وتغرب **206** فوق] ز: افق الأرض] ب: العرض **207** فوق] ز: افق الشماليّة] ز: الشماليته والله أعلم] ب ج د هـ و ز ك: – **208** وتطلع] ب: وبطلع، ج و: ويطلع **209** الليلة] د: الليل الليل] ا: –، و: في الليل، ك: +↑ في كلّه] ز: كلّها **210** تعرف] و: يقرب، ز: تغرق **211** بعد] ز: – قلّة] و ز ك: فله معتدًّا] ا ب ج د هـ و ز ك: معتدّ **212** عند] ز: عندا تغرب] ب ج: يغرب بعد الشمس] د: + ~~بعد الشمس~~ وتطلع] ب ج و: ويطلع **213** الجزء] هـ: + ... المشرق] ج: +↓ عند غروب الشمس عند...الشمس] ج: ↓ فهي في الليل كلّه، ا ب د هـ و ز: –، ك: في الهامش اليسار: عند غروبها، ل: أدرج في النص

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Chapter seventeen: To know the stars of perpetual apparition,[23] perpetual occultation,[24] and those that rise and set, among the stars drawn on the globe.

The way to do this is that you place the pole on the horizon and rotate the globe so that the star arrives at the meridian. You count its distance from the pole in degrees of the meridian ring. (The star) that is in a distance from the north pole equal to or less than the latitude of the city will be in perpetual apparition. (The star) that is in a distance from the south pole equal to the latitude of the city arrives at the horizon and vanishes immediately; (when the distance) is less than that, (the star) will be in perpetual occultation; and (when the distance) is greater than that, (the star) rises and sets. (The star that) is closer to the north pole, spends a longer time above the earth; for (the star that) is closer to the south pole, the time spent above the earth is shorter in the northern regions, and God knows best.

Chapter eighteen: To know the stars that set after the sun and rise before it in one night, and to know the stars that are above the earth during the whole night.

The way to do this is to rotate the globe until you find the distances of the stars and the degree of the sun from the north pole. Those stars that are significantly closer to the north pole than the degree of the sun is,[25] and lie close to ⟨but above⟩ the west horizon at sunset, will set after the sun and rise before it. The stars that are closer to the north pole than the degree of the sun is,[26] and are close to the east horizon at sunset,

[23] i.e. stars that are always visible.

[24] i.e. stars that are always invisible.

[25] lit. 'Those whose distance is less than the distance of the degree of the sun by a significant reduction'.

[26] lit. 'Those whose distances are less than the distance of the degree'.

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/و ٧١ب/ /هـ ٢٤٤/ /و/ فهي في الليل كلّه فوق الأرض؛ وكلّما كان /هـ/ العرض أكثر، كان التفاوت في التقدم والتأخر في الطلوع والغروب أكثر؛ والله أعلم.

<19> /ب/ الباب التاسع عشر: في معرفة الساعات التي تطلع فيها الكواكب المرسومة على الكرة وتغرب فيها.

/ب ٩ب/

/ز ١٠ب/ وطريقه أن تضع القطب /ز/ في عرض البلد، وتدير الكرة إلى أن يصل جزء الشمس إلى الأفق الغربيّ، وتعلّم الجزء الذي وافى معه في الأفق الشرقيّ من المعدّل. ثمّ تديرها إلى أن يصل الكوكب الذي تريد ساعة طلوعه إلى الأفق الشرقيّ، والكوكب الذي تريد ساعة غروبه إلى الأفق الغربيّ، وتضع العلامة على الجزء الذي وافى معه الأفق الشرقيّ من المعدّل؛ فما بين العلامتين من أجزاء المعدّل فاقسمها على أجزاء الساعة المستوية أو الزمانيّة، يُحصل ساعة الطلوع أو الغروب.

<20> الباب العشرون: في معرفة ساعات طلوع القمر والمتحيرة وساعات غروبها.

وطريقه أن تضع القطب في عرض البلد، ثمّ تعرف جزء القمر والكواكب المذكورة
/د ٨ب/ من دائرة البروج بالزيج أو بغيره، وعرضه، وجهة عرضه. وتدير /د/ الكرة إلى أن يصل الجزء إلى دائرة نصف النهار، وتعدّ من أجزاء نصف النهار من موضع الجزء
/ب ١٠ا/ /ب/ بعدد عرض القمر أو الكوكب في جهة عرضه، وتعلّم على الكرة في الموضع
/ج ٦٦ب/ الذي ينتهي إليه العدد، /ج/ فتلك العلامة هي موضع القمر أو الكوكب. ثمّ تدير

214 كان[1]] ز: كانت **215** التقدم والتأخر] ك: التقديم والتأخير أكثر] ك: ↑ والغروب والله أعلم] ب ج د هـ و ز ك: – **216** تطلع] ب ج: يطلع **217** وتغرب] ا ك: أو تغرب، ب ج هـ: ويغرب، د: ~~او~~ تغرب **218** تضع] ز: تطلع الكرة] ب: الكورة يصل] ز: تصل **219** ثمّ] و: – **220** تديرها] ز: تدير الكرة يصل] ز: تصل الكوكب] ب ك: الكوا~~ك~~كب الذي] ب: الذ الذي...والكوكب] ا: – إلى[2]] ك: ↑ طلوعه والكوكب] ب ج هـ: الكواكب **221** الذي[1]] هـ: التي تريد] ب: – معه] د ز: + في **222** من[1]] ب: – **223** الزمانيّة] ز: الزمانيته يُحصل] ز: ليحصل أو الغروب] ا: والغروب **224** ساعات] ز: ساعة طلوع] ج: + ~~الفجر~~، هـ: + الفجر وساعات] ب ج هـ و: ساعة غروبها] ا ب ج د هـ و ز ك: غروبه **226** من] ز: عن بالزيج] ا ب: بالريح بالزيج...بغيره] د: +↑ مثلا بالتقويم وجهة عرضه] و: وجهته، ك: – **227** الجزء[2]] و: – **228** أو] ز: و الكوكب] ب ج و: الكواكب **229** ينتهي] ا: انتهي إليه] و: – العلامة] ز: العامة هي] ب ج هـ: –

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will be above the earth during the entire night. The greater the latitude, the greater the difference in the advance and delay of the rising and setting, and God knows best.

Chapter nineteen: To know at what time the stars drawn on the globe rise and set.

The way to do this is that you place the pole at the latitude of the city, rotate the globe until the degree of the sun arrives at the west horizon, and mark the degree of the equator that has reached the east horizon with it. Then you rotate (the globe) until the star, for which the time of its rising is required, arrives at the east horizon and the star, for which the time of its setting is required, (arrives) at the west horizon, and place a mark on the degree of the equator that has reached the east horizon with it. Divide the degrees of the equator between the two marks by the degrees of an equal or a seasonal hour and the time of rising or setting is obtained.

Chapter twenty: To know the time[27] of rising of the moon and the planets and the time[28] of their setting.

The way to do this is that you place the pole at the latitude of the city; then you find the degree of the moon and (that of) the specified planets on the zodiac circle (i.e. the ecliptic) by the *zīj* or in another way, its 'latitude' and the direction of this 'latitude'. You rotate the globe until the degree arrives at the meridian circle, count from this position along the degrees of the meridian as many degrees as the 'latitude' of the moon or the planet in the direction of its 'latitude', and mark the position where the number finishes on the globe; that mark will be the position of the moon or the planet. Then you rotate

27 lit. 'hours'.

28 lit. 'hours'.

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/٨١/ /ا/ الكرة إلى أن يصل جزء الشمس إلى الأفق الغربيّ، وتضع /ك/ العلامة /هـ/ على /ك ١٣٦ب/ /هـ ٢٤٥/ الجزء الذي وافى معه الأفق الشرقيّ من المعدّل. ⟨ثمّ تدير الكرة إلى أن يصل علامة القمر أو الكوكب إلى الأفق الغربيّ أو الشرقيّ، وتضع العلامة على الجزء الذي وافى معه الأفق الشرقيّ من المعدل.⟩ ثمّ تقسم ما بين العلامتين من أجزاء المعدّل إلى الساعة المستوية أو الزمانيّة، فما حصل فهي ساعات الطلوع، إن كانت العلامة في /و ٧٢/ الأفق الشرقيّ، أو ساعات الغروب /و/ إن كانت في الأفق الغربيّ.

وهذا الحكم ليس بمطابق للواقع، ومنشؤه عدم الفرق بين جزء الكوكب وبين درجة ممرّه.

<21> الباب الحادي والعشرون: في معرفة ارتفاع ⟨الشمس في⟩ نصف النهار في كلّ يوم وفي ⟨معرفة⟩ أعظم ارتفاع كلّ واحد من الكواكب المرسومة على الكرة.

وطريقه أن تضع القطب الشماليّ على مقدار العرض، وتضع العلامة على جزء الشمس في ذلك اليوم. وتدير الكرة حتّى تصل العلامة أو الكوكب إلى نصف النهار، وتنظر إلى أيّ جهة هو أقرب من الأفق الشماليّ أو الجنوبيّ. فالأجزاء التي بين /ب ١٠ب/ العلامة أو الكوكب /ب/ وبين الأفق من أجزاء نصف النهار في الجهة الأقرب، هي /د ٩ا/ ارتفاع ⟨الشمس في⟩ نصف النهار أو غاية ارتفاع الكوكب، /د/ وذلك يختلف باختلاف المساكن.

230 العلامة] هـ: مكتوب مرّة ثانية في بداية ص٢٤٥، ز: + أو الساعات **234** أو] هـ: — الطلوع] هـ: ~~الطلوع~~ كانت] ب ج: كان **235** ساعات] ز: الساعات **236** ومنشؤه] ا ب: ومنشأه، ج د هـ و ز: ومنشاؤه، ك: ومنشأوه الفرق] ب ج هـ و ز: التفرقة د: الفرقة الكوكب] ب ج هـ و: الكواكب **238** نصف] ك: في الهامش الأيمن: + يعني في معرفة غاية ارتفاع الشمس في ذلك اليوم **239** كلّ] و: + يوم الكرة] ا ب ج د هـ ز ك: الأفق **240** تضع] ب: يقع، ج: يقع +↓ تضع القطب...242 من] ا: ×٢ **241** تصل] ا هـ ز ك: يصل أو] ز: و الكوكب] ب: الكواكب **242** وتنظر] ز: — هو] ك: في الهامش الأيسر الأفق] ا ب ج د هـ ز ك: القطب **243** العلامة] ا: العلامتين الكوكب] د ك: الكواكب في... الأقرب] ك: من الجانب الأقرب ↑ الأفق من أجزاء نصف **244** ارتفاع[1]...النهار] ك: ارتفاعه

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the globe so that the degree of the sun arrives at the west horizon, and put a mark on the degree of the equator that has reached the east horizon with it. ⟨Then you rotate the globe so that the mark of the moon or planet arrives at the west or east horizon, and put a mark on the degree of the equator that has reached the east horizon with it.⟩[29] Then you divide (the number of) degrees of the equator between the two marks by the (degrees of the) equal or seasonal hour; the result will be the time[30] of rising, if the mark was on the east horizon, or the time of setting, if it was at the west horizon.

This rule is not in accordance with reality and its origin does not take into consideration the difference between the degree of the planet and the degree of its transit (mediation).

Chapter twenty-one: To know the midday altitude ⟨of the sun⟩ on every day and to ⟨know⟩ the maximum altitude of any of the stars drawn on the globe.

The way to do this is that you place the north pole according to the degree of the latitude and put a mark on the degree of the sun on that day. You rotate the globe until the mark or the star arrives at the meridian, and observe which direction it is closer to: the north or south horizon. The degrees of the meridian that are between the mark or the star and the closest side of the horizon will be the midday altitude ⟨of the sun⟩ or the highest altitude of the star; this changes as the region varies.

29 This addition is necessary in order that the procedure described be correct. A similar proposition exists in each of the corresponding chapters Q40 (for rising) and Q41 (for setting) in the treatise of Qusṭā.

30 lit. 'hours'.

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<22> الباب الثاني والعشرون: في معرفة الاختلاف بين أعظم ارتفاع الشمس في اليوم الواحد من بلدين مختلفي العرضين.

وطريقه أن تضع القطب على قدر عرض أحد البلدين، وتأخذ أعظم ارتفاع جزء
/ج ٦٧أ/ الشمس بالطريق المذكور /ج/ آنفا. ثمّ تضع على عرض البلد الآخر، وتأخذ أعظم ارتفاع ذلك الجزء، فما وجدت من اختلاف العددين، هو الاختلاف فيما بين أعظم ارتفاع الشمس في ذينك البلدين.

<23> الباب /هـ/ الثالث والعشرون: في معرفة الموضع الذي يكون فيه السنة يوما واحدا،
/هـ ٢٤٦/ ولا يطلع فيه كوكب من الأفق، ولا يغرب أصلا بحركة فلك الأفلاك.

/ز ١١أ/ وطريقه أن تضع القطب على سمت الرأس، فيكون /ز/ عند ذلك البروج الشماليّة أو الجنوبيّة فوق الأفق، وباقيها تحت الأفق. فيكون ستة أشهر نهارا وستة أشهر ليلا،
/و ٧٢ب/ وبعض الكواكب الثابتة أبديّ /و/ الظهور، /ب/ وبعض الكواكب الثابتة أبديّ الخفاء.
/ب ١١أ/

<24> الباب الرابع والعشرون: في معرفة الموضع الذي يكون النهار فيه كد ساعة مستوية.

وطريقه أن تضع القطب على عرض سو جزءا، وأن تدير الكرة دورة تامّة، فإنّك تجد أوّل السرطان لا يغيب أصلا، وأوّل الجدي لا يطلع. فإنّ الشمس، إذا كانت في أوّل

246 بين] ب ج هـ و: من **247** مختلفي] ب ج هـ: مختلفين **248** عرض أحد] ك: العرض لأحد ارتفاع] هـ: ~~الشمس~~ جزء] د ز ك: – **249** أعظم] د: + ~~ارتفا~~ **250** الجزء] ز: + الشمس العددين...فيما] ز: العدد فيما] هـ: فما، ك: فيهما **251** الشمس] ا: – ذينك] ك: ذلك **252** الثالث] هـ: الث الموضع] ب ج هـ ز: موضع يوما واحدا] ب ج د هـ ز: يوم واحد **254** الشماليّة] ز: الشمالي **255** ستة] ز: – أشهر[1]] ز: اشهل نهارا...أشهر[2]] و: – **256** الكواكب[1]] هـ: الكوكب الثابتة[1]] ز: الثابة وبعض[2]] ب: + 'الظهور' محاطٌ بالنقاط وبعض[2]...الثابتة[2]] ز: وبعهها، ك: وبعض الكواكب الخفاء] ز: الخفا **257** يكون] ك: +↑ أطول فيه] ب ج هـ و ز: فيها كد] ج: +↓ ٢٤ **259** سو] ا: فو، د: هو، ز: –، ك: ~~هو~~؛ وفي الهامش الأيمن: سو كه، ست وستون درجة وخمس وعشرون دقيقة جزءا] ا د و ز: جزء، ك: ~~أجزاء~~ تامّة] ز: تامّة **260** يغيب] هـ ز: تغيب يطلع] ب: + أصلا، ج: +↓ أصلا كانت] ب ج هـ و ز: كان

257 كد] ٢٤ **259** سو] ٦٦

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Chapter twenty-two: To know the difference between the greatest altitude of the sun on the same day in two cities with different latitudes.
The way to do this is that you place the pole according to [the amount of] the latitude of one of the two cities and you obtain the greatest altitude of the degree of the sun by the aforementioned method. Then you place (the pole) on the latitude of the other city and obtain the greatest altitude of that degree. The resulting difference between the two numbers will be the difference between the greatest altitude of the sun in these two cities.

Chapter twenty-three: To know the place in which the year is one day and where no star rises from the horizon and no (star) ever sets with the motion of the celestial sphere.[31]
The way to do this is that you place the pole at the zenith; in that (position), the northern or southern zodiacal signs will be above the horizon and the rest of them below the horizon. Thus, there are six months of daytime and six months of nighttime, with some of the fixed stars in perpetual apparition and some of the fixed stars in perpetual occultation.

Chapter twenty-four: To know the place where the daylight is 24 equal hours.
The way to do this is to place the pole at the latitude of 66 degrees[32] and rotate the globe a complete rotation. You will then find that the first point of Cancer never sets and the first point of Capricorn does not rise. Thus, when the sun is at the first point

[31] lit. 'the sphere of the spheres'.
[32] In the right margin of manuscript K, this is corrected as 66;25, both in *abjad* numbers and in words.

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/د ٩ب/ السرطان، تكون الدورة الواحدة التي هي كد ساعة نهارا، /د/ وإذا كانت في أوّل الجدي، تكون الدورة كلّها ليلا.

<25> الباب الخامس والعشرون: في معرفة الموضع الذي يطلع ‹فيه› بعض البروج معكوسا ويغيب مستويا، وبعضها بالعكس.

وطريقه أن تضع القطب على العرض الزائد على سو، فإنّك تجد القوس، التي أوسطها الحمل، الواقعة بين القوس الأبديّة الظهور وبين القوس الأبديّة الخفاء تطلع /ا ٩١/ /ا/ معكوسة وتغرب مستوية، والقوس المقابلة لها تطلع /ج/ مستوية وتغرب معكوسة. /ج ٦٧ب/

<26> الباب السادس والعشرون: في معرفة البلدان التي تصل الشمس فيها على سمت الرأس /هـ/ مرّة واحدة في السنة أو مرّتين. /هـ ٢٤٧/

/ب ١١ب/ وطريقه أن تضع القطب على عرض كد، /ب/ فإن الشمس في أوّل السرطان، تسامت رءوس أهلها، ولا تسامت في غير هذا الوقت أصلا. ولا يكون لشيء ظلّ عند وصول الشمس إلى سمت الرأس.

وإن وضعت القطب على مقدار عرض أقلّ من كد، فإنّ الشمس تسامت رءوس /ك ١٣٧أ/ أهلها في السنة الواحدة /ك/ مرّتين، كما تسامت رءوس أهل خطّ الاستواء مرّتين.

261 تكون] ا ب ج هـ و ز ك: يكون الدورة الواحدة] ب ج: دورة الواحد نهارا] و: نهار، ك: النهار‡ وإذا] و: إذا **262** تكون] ا ب ج هـ و ز ك: يكون **264** معكوسا] ز: معكوسً ا ويغيب مستويا] ب ج هـ: – **265** على[2]] ا: – سو] ا: نو، ب ج: +↓ ٦٦، ك: ~~ما هو~~؛ وفي الهامش الأيمن: سو كه التي] ز: الذي، ب: + او **266** بين] ج: ↓ القوس تطلع] ب ج هـ ز: يطلع **267** وتغرب[1]] د: ويغرب وتغرب مستوية] ز: – المقابلة] ا ب ج د هـ و ز ك: المقابل تطلع] ا ب ج هـ ز: يطلع، د: بطلع مستوية[2]] ا: مستويا وتغرب[2]] ا هـ ز: ويغرب معكوسة[2]] ا ب ج د هـ و ز: معكوسا **268** والعشرون] ج: والعشرين البلدان] ج: + ~~لن~~ تصل] ا ك: يصير، ب ج: بصل فيها] و: – **269** الرأس] هـ: مكتوب مرّة ثانية في بداية ص٢٣٧، و: + فيها **270** كد] ب ج: +↓ ٢٤ **271** رءوس] ك: روس رءوس...تسامت[2]] ز: – لشيء] ز: شيءً **273** أقلّ] و: أول تسامت] هـ و ز: قامت **274** أهلها] ز: اهها مرّتين[1]] ز: مرّه تين كما] ز: – خطّ] ز: حطّ مرّتين[2]] ز: مرّة تين

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of Cancer, there is a unique rotation that produces 24 hours of daylight, and when it is at the first point of Capricorn, the whole rotation will produce night.

Chapter twenty-five: To know the place where some of the zodiacal signs rise in inverted order and set in regular order and some of them the other way around.[33]

The way to do this is that you place the pole at a latitude exceeding 66 degrees.[34] Then you find that the arc which has Aries at the middle, and is located between the arc of perpetual apparition and the arc of perpetual occultation, rises inverted and sets regularly, and the arc that is opposite to it rises regularly and sets inverted.

Chapter twenty-six: To know the cities where the sun reaches the zenith once or twice a year.

The way to do this is that you place the pole at the latitude of 24 (degrees). When the sun is at the first point of Cancer, it rises high over the heads of the inhabitants and it only reaches the zenith at this time. There is no shadow when the sun arrives at the zenith.

If you place the pole at a magnitude of latitude less than 24 (degrees), then the sun rises high over the heads of the inhabitants twice in a year, in the way that it rises high over the heads of the inhabitants of the terrestrial equator twice.

[33] i.e. some of the zodiacal signs rise in regular order and set in inverted order.

[34] Corrected as 66;25 in the right margin of manuscript K.

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وتوضيحه أن تعدّ من الأفق على خطّ نصف النهار ص جزءا، وتضع علامة على
/و ٧٣ا/ الجزء الذي انتهى إليه العدد، فتلك العلامة هي /و/ سمت الرأس. ثمّ تدير الكرة،
بعد وضع القطب في المواضع المذكورة، فإنّك تجد جزءا من أجزاء البروج يجوز
/د ١٠ا/ تحت العلامة؛ /د/ فإذا كانت الشمس في ذلك الجزء، تسامت رءوس أهلها عند
الوصول إلى خطّ نصف النهار.

<27> الباب السابع والعشرون: في معرفة البلدان التي تكون الأظلال فيها في جهة واحدة والتي تكون فيها في الجهتين.

واعلم أن عرض البلد إن كان أقلّ من كد، فظلّه في الجهتين، وإلّا فظلّه في جهة
واحدة. وتوضيحه أن تضع القطب في عرض أقلّ من كد، وتدير الكرة، فإنّك ترى
/ب ١٢ا/ بعض أجزاء البروج يجوز في الجنوب عن سمت /ب/ الرأس، وبعضها يجوز في
/هـ ٢٤٨/ الشمال عنه. والأجزاء التي في الجنوب /هـ/ عن سمت الرأس، إذا /ج/ حلّت
/ج ٦٨ا/ الشمس فيها، يكون الظلّ في الشمال. والأجزاء التي في الشمال عن سمت الرأس،
إذا حلّت الشمس فيها، يكون ظلّها في الجنوب.

وإذا وضعت القطب على عرض كد أو أكثر، فإنّك لا تجد جزءا من أجزاء البروج في الشمال، فلا يكون الظلّ في هذه المساكن إلّا في الشمال؛ والله أعلم.

275 وتوضيحه] و: ويوضيحه خطّ] ز: حطّ جزءا] ا ب ج و ز: جزء، د: جزأ **277** جزءا] ا ب ج و: جزء، ز: – يجوز] ا: يحوز، ز: يجور **278** كانت] ا ب ج د هـ و ز ك: كان رءوس] ك: روس أهلها...279 خطّ] ز: أهها عند وصول حطّ **279** نصف] ج: ↑ النهار **280** والعشرون] ج: والعشرين معرفة] ك: – تكون] ا ب ج د هـ ز ك: يكون **281** الجهتين] ا: جهتين **282** واعلم] ز: فاعلم البلد] ك: البلدان فظلّه[1]] ز: فظلة الجهتين] ج: +↑ اعنى في الشمال والجنوب فظلّه[2]] ز: فظلة **283** وتوضيحه] و: وتوجيهه وتدير] ك: ويدير **284** يجوز[1]] ا: يحوز وبعضها...285 الرأس] ز ك: – يجوز[2]] ا: يحوز **285** حلّت] و: دخلت **286** الظلّ في] ز: ظلّها الرأس] ز: – **287** حلّت] و: دخلت ظلّها] ز: ظّها **288** كد] ب ج: +↓ ٢٤ أو] ز: و جزءا] ا ب ج و ز: جزء **289** الشمال[1]] ز: الشمالي الظلّ] د: – هذه] ب: هذ، ج هـ ز: هذا والله أعلم] ب ج د هـ و ز ك: –

275 ص] ٩٠

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For a demonstration, you count from the horizon on the meridian line 90 degrees and put a mark at the degree where the numbering ends; that mark will be the zenith. Then you rotate the globe, after placing the pole at the aforementioned positions, and you will find that one of the degrees of the zodiac traverses under the mark. If the sun is at that degree, it rises high over the heads of the inhabitants when arriving at the meridian line.

Chapter twenty-seven: To know the cities where the shadows are in one direction and those where they are in both directions.

Be aware that if the latitude of the city is less than 24 (degrees), the shadow there[35] will be in both directions; if not, the shadow there will be in one direction. For a demonstration, you place the pole at a latitude less than 24 (degrees) and rotate the globe, then you will see that some degrees of the zodiac traverse to the south of the zenith and some of them to the north of it. When the sun is located amongst the degrees that (traverse) south of the zenith, the shadow will be to the north. When the sun is located amongst the degrees that (traverse) north of the zenith, the shadow there will be to the south.

If you place the pole at a latitude of 24 or more (degrees), then you will not find any degree of the zodiac north (of the zenith); thus the shadow in these places of residence can only be to the north, and God knows best.

35 'the shadow there': lit. 'its shadow'.

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<28> الباب الثامن والعشرون: في معرفة خطّ نصف النهار.

وطريقه أن تأخذ الارتفاع على الوجه المذكور، وترسم في الأرض خطّا على استقامة
/ز ١١ب/ قطر حلقة نصف النهار، فذلك الخطّ هو خطّ نصف النهار في ذلك /ز/ الموضع؛
لأنّ وضع الكرة حينئذ كوضع الفلك بعينه.

فإن أردت معرفة القبلة، فاعرف قدر الاختلاف بين المدينة ومكة في الطول،
/د ١٠ب/ فانظر في أيّ جهة هو؛ فعدّ من خطّ نصف النهار في تلك الجهة بقدر /د/ تلك
الأجزاء من أجزاء حلقة الأفق، وتعلّم /و/ على الموضع الذي انتهى إليه العدد. وأخرِج
/و ٧٣ب/ في الأرض من مركز حلقة الكرسي السفلانية خطّا مسامتا لتلك العلامة، فذلك
/ب ١٢ب/ /ب/ الخطّ هو خطّ القبلة.

ولا شك في تكلّف هذه الطريقة وعدم شمولها لجميع المساكن، سِيَّما
الاستخراج بالآلة التي وجدت في هذه الديار. فالأولى الاستخراج بالطرق التي
/هـ ٢٤٩/ /هـ/ تُذكَر، إن شاء الله تعالى، في رسالة الربع، والله أعلم.

290 والعشرون] ج: والعشرين النهار] ز: + ص **291** تأخذ] ج: يأخذ خطّا] ز: حطّا **292** حلقة] د: خلقة النهار[1]] ب: النها الخطّ...خطّ] ا: الخطّ، ب ج و: الخطّ خطّ، ز: الحيط الحط هو خطّ] ك: خطّ ↑ الخطّ نصف **293** حينئذ] ب ج د هـ و ز: ح، ك: – الفلك] ب: للفلك، ج: للفلك +↓ للفلك **294** قدر] ب ج: قد مر المدينة] ج: +↓ التي أنت فيها، د: في الهامش السفلي: والمراء من المدينة ليس بمدينة منوّرة بل المدينة التي كنت تريد معرفة قبلتها ومكة] ا: والمكة، ك: + شرفهما الله تعالى **295** من] ا: عن خطّ] ز: حط **296** وتعلّم] د ز: وعلّم **297** حلقة] ز: خلقة خطّا] ز: حطا **298** الخطّ] ز: الحط، ك: – خطّ] ب ج: الخطّ، ز: حط **299** الطريقة] ز: الطريق لجميع] ك: يجمع **300** الاستخراج[2]] ا ك: أن يستخرج، ب ج و: –، د: أن تستخرج بالطرق] ز: بالطرقه التي[2]] هـ: مكتوب مرّة ثانية في بداية ص٢٣٩ **301** تُذكَر] ج د هـ: نذكر والله أعلم] ب ج د هـ و ز ك: –

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Chapter twenty-eight: To know the meridian.

The way to do this is that you take the altitude in the aforementioned way,[36] and you draw on the earth a line that follows the alignment of the diameter of the meridian ring; this line will be the meridian line in that location, because the position of the globe at that time is like the position of the celestial sphere itself.

If you want to know the *qibla*, find out the difference in longitude between the city and Mecca and observe in which direction it is. Count the amount of these degrees (starting) from the meridian line in that direction, in degrees of the ring of the horizon, and put a mark at the position where the numbering ends. Draw a line on the earth from the centre of the inferior ring of the stand in the same direction as this mark; that line will be the line of the *qibla*.

This method is undoubtedly fake and it fails to provide coverage for all of the regions, in particular when the determining (is conducted) using the instrument which is found in these territories. It is better to get results by the methods that will be mentioned in the treatise on the quadrant, God Highest willing, and God knows best.

[36] As mentioned in Chapter 9.

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<29> الباب التاسع والعشرون: في معرفة موضع القمر، وأيّ كوكب شئت من الكواكب السيّارة أو الثابتة في أعظم ارتفاعه.

وطريقه أن ترصد القمر أو الكوكب في أعظم ارتفاعه بالأسطرلاب، أو الربع، أو /ج ٦٨ب/ /١٠١ا/ غيرهما. ثمّ /ج/ تأخذ في هذا الحين ارتفاع /ا/ بعض الكواكب المرسومة على الكرة، وتعلّم على عدد ارتفاعه من أجزاء حلقة الربع. وتضع طرف الربع المُوقّع عليه صَ على نقطة سمت الرأس وطرفه الآخر على حلقة الأفق. وتدير الكرة وطرف الربع الأسفل، حتّى يقع الكوكب المرسوم المذكور تحت علامة الربع، وتنظر أيّ جزء وقع تحت خطّ نصف النهار من أجزاء دائرة البروج، وهو موضع القمر أو الكوكب.

<30> الباب الثلاثون: في معرفة عرض /د/ القمر وكوكب من السيّارة والثابتة /ک/ التي لا تُرسَم في الكرة في الليلة الممكنة أخذ أتمّ ارتفاعه، وفي معرفة بعده عن المعدّل، وبعده عن سمت الرأس.

/د ١١ا/ /ک ١٣٧ب/

وطريقه أن تعرف جزءه بالطريق المذكور آنفا، وتعلّم عليه. وتعرف أعظم ارتفاعه /ب ١٣ا/ وجهته، وتعدّ من أجزاء /ب/ حلقة نصف النهار بقدر أجزاء ارتفاعه في تلك الجهة، وتعلّم حيث انتهى إليه العدد. ثمّ تدير الكرة حتّى يصل جزء القمر أو الكوكب /و ٧٤ا/ /هـ ٢٥٠/ /و/ إلى نصف النهار. فإن وقع ذلك الجزء /هـ/ تحت الجزء الذي علّمت من دائرة

302 والعشرون] ج: والعشرين موضع] د و: مواضع 303 أو] ب ج هـ و: و 304 وطريقه... ارتفاعه] ب ج هـ ک: – أو الكوكب] ا ب ج هـ و: والكوكب أو^2] ب: و 305 تأخذ] ب ج: يأخذ هذا] ک: هذه الكواكب] ز: الكوكب 306 الربع^2] و: – عليه] ک: – 307 وطرفه] ا: وطريقه وتدير] ک: ويدير 308 الكوكب] هـ: كوكب المرسوم] ز: المرسومة المذكور] ز: المذكورة أيّ] ا: إلى 309 خطّ] ب ز: حط وهو] ز: – 310 الثلاثون] ب ج: الثالثون عرض] د ک: + البلد (من غاية ارتفاع كوكب من كواكب الكرة ومن نهاره الأطول وطريقه أن تضع الكوكب المذكور في غاية ارتفاعه من أجزاء حلقة نصف النهار فيحصل العرض وأن تضع القطب على الأفق ورأس /د/ السرطان على الأفق الشرقي د: وسسعى / ک: ونسقت نهار الا) ک: + ستواء إلى. العبارة بين القوسين مشطوبة في د، والنصّ مستمدّ من بداية الباب الثالث والثلاثون. 311 تُرسَم] ب ج هـ و ز ک: يرسم الليلة] ک: ليلة أتمّ] و: اثم، ک: ↑أخذ ارتفاعه] ز: ارتفاع 313 وطريقه] ب: وطريق جزءه] ا هـ ز د: جزئه، ب: جزء، ز: + ~~بالطريق~~ 314 وجهته] ز: وجهة حلقة] د: خلقة أجزاء^2] ز: آخر ارتفاعه] ز: وارتفاعه 315 انتهى] ک: + بيان العدد] ا ب ج هـ و ک: – أو] و: و

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Chapter twenty-nine: To know the 'longitude' of the moon and any planet or fixed star you want, at its greatest altitude.

The way to do this is that you observe the moon or the planet / star at its greatest altitude with the astrolabe, with the quadrant, or in a different way. Then you immediately take the altitude of any one of the stars drawn on the globe, and put a mark on the number of its altitude among the degrees of the ring of the quadrant. You place the endpoint of the quadrant, where 90 has been inscribed, at the point of the zenith, and the other endpoint on the ring of the horizon. You rotate the globe and the lower endpoint of the quadrant, until the aforementioned star drawn (on the globe) falls under the mark on the quadrant and observe which degree of the zodiac circle (i.e. the ecliptic) falls under the meridian line. This will be the 'longitude' of the moon or the planet / star.

Chapter thirty: To know the 'latitude' of the moon and a star, among the planets and the fixed stars which are not drawn on the globe, during a night when it is possible to take its complete (i.e. highest) altitude, and to know its distance from the equator and its distance from the zenith.

The way to do this is that you find its degree in the aforementioned way, and you put a mark on it. You find out its maximum altitude and its direction (to the south or to the north of the zenith). You count as many degrees as its altitude in that direction, in degrees of the meridian ring, and put a mark[37] where the numbering finishes. Then you rotate the globe, until the degree of the moon or star arrives at the meridian. If this degree falls under the degree you marked on the

[37] This mark is put on the meridian ring and corresponds to the maximum altitude of the moon or the star.

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نصف النهار، فلا عرض حينئذ. وإن وقع في ناحية عنه، فلابد أن تعدّ الأجزاء الواقعة من دائرة نصف النهار بين الجزء وبين العلامة؛ فهذه الأجزاء هي عرض القمر أو الكوكب المذكور. ولا يخفي عليك ورود المناقشة بعدم الفرق بين ممرّ الكوكب وبين جزئه. والأجزاء التي بين العلامة وبين المعدّل هو بعده عنه، والأجزاء التي بين العلامة وبين سمت الرأس هو بعده عنه.

<31> /ج/ **الباب الحادي والثلاثون: في معرفة خسوف القمر وكسوف الشمس إن كان يقع في الشهر الذي أنت فيه.** /ج ٦٩ا/

وطريقه أن تعرف ⟨عرض⟩ القمر في ليلة يجـ. فإن كان عرض القمر في أعظم ارتفاعه أكثر من جزء واحد وأربع دقائق، فلا ينخسف القمر؛ وإن كان أقلّ منه أو لا عرض له، فينخسف.

وإن كان عرض القمر الشماليّ في يوم سبع وعشرين في أعظم ارتفاعه أكثر من /د ١١ب/ /د/ جزء وسبع وثلاثين دقيقة أو عرضه /ز/ الجنوبيّ أكثر من ⟨سبع وأربعين⟩ دقيقة، /ز ١٢ا/ فالشمس لا تنكسف، وإلّا تنكسف. /ب/ وهذا إنّما يتصور لو أمكن أخذ أتمّ /ب ١٣ب/ ارتفاعه في اليوم المذكور.

317 حينئذ] ب ج د هـ و ز ك: ح الواقعة] ز: الوافقة **318** النهار] ز: النها فهذه الأجزاء] ك: فهذا الجزء أو...319 الكوكب[1]] ز: ×٢ **319** المذكور] ز: المذكورة ورود] ز: وروء بعدم الفرق] ا: — ممرّ] هـ: قمر **320** جزئه] د ك: جزءه هو...321 العلامة] ز: — **321** الرأس] ز: — **322** الحادي] ج: +و خسوف...الشمس] ا: كسوف القمر وكسوف الشمس، ب ج هـ: كسوف الشمس وخسوف، و: كسوف الشمس وخسوفها، ز: كسوف الشمس وخسوف القمر **323** يقع] ا: — **324** في[1]] ا: +أيّ يجـ] ا: لح، ب ج: ح، د ك: يج، و: ىحـ، ز: — **325** ينخسف] ا: ينكسف القمر] ز: — كان] ز: +عرض **326** فينخسف] ا: فينكسف **327** سبع وعشرين] د ك: كز من] د: مكتوب مرّة ثانية في بداية و١١ب **328** وسبع] ا د ز: وسبعة، ب ج هـ و: سبعة سبع وأربعين] ا ب ج د هـ و ز: —، ك: في الهامش الأيمن **329** تنكسف[1]] ب ج د هـ و ز ك: ينكسف وإلّا تنكسف] ب ج د هـ و ك: وإلّا ينكسف، ز: — أتمّ] و: أثم

324 يجـ] ١٣ **328** سبع وأربعين] من رسالة قسطا ابن لوقا (الباب ٤٧)

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meridian, there is no latitude at that time. If it falls in a position beyond it[38] you must count the degrees of the meridian circle that fall in between the degree and the mark; these degrees will be the 'latitude' of the moon or the specified star. You know well that there is a dispute over (the claim that) there is no difference between the degree of transit (i.e. mediation) of the star and its degree (i.e. longitude). The degrees that are between the mark (on the meridian) and the equator will be its distance (i.e. declination) from it (the equator). The degrees that are between the mark and the zenith will be its distance from it (i.e. its minimum zenithal distance).

Chapter thirty-one: To know if the lunar eclipse and the solar eclipse occur in the current month.

The way to do this is that you find out ⟨the latitude of⟩ the moon in night 13 (of the lunar month). If the latitude of the moon in its maximum altitude is greater than one degree and four minutes, the moon will not be eclipsed; if it is less than this or it has no latitude, then it will be eclipsed.

If the north latitude of the moon on the 27th day at its maximum altitude is greater than one degree and 37 minutes, or its south latitude is greater than ⟨forty-seven⟩[39] minutes, then the sun will not be eclipsed; otherwise it will be eclipsed. And so it is, but consider whether you can take its highest altitude on the specified day.

38 'in a position beyond it' lit. 'on any side of it'.

39 'Forty-seven' minutes exists only in manuscript K as a marginal note. It is also present in the corresponding chapter Q61 of the treatise of Qusṭā on the celestial globe.

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<32> الباب الثاني والثلاثون: في معرفة فضل نهار واحد في عرضين مختلفين والشمس في درجة واحدة.

/هـ ٢٥١/ وطريقه أن تضع القطب في أحد العرضين، والدرجة المفروضة /هـ/ في أفق المشرق، وتعلّم الجزء الذي وافى معه ذلك الأفق من أجزاء المعدّل. ثمّ تضع القطب في العرض الآخر، والدرجة في ذلك الأفق، وتعلّم جزء المعدّل الذي معه في ذلك /و ٧٤ب/ الأفق. فالأجزاء التي بين /و/ العلامتين هي فضل نهار أحدهما على الآخر.

<33> الباب الثالث والثلاثون: في معرفة عرض البلد من غاية ارتفاع كوكب من كواكب الكرة ومن نهاره الأطول.

وطريقه أن تضع الكوكب المذكور في غاية ارتفاعه من أجزاء حلقة نصف النهار، فيحصل العرض.

/ج ٦٩ب/ وأن تضع القطب /ج/ على الأفق، ورأس السرطان على الأفق الشرقيّ وتسقط /١١١/ ⟨قوس⟩ نهار الاستواء، أعني تسعين جزءا، من ⟨قوس⟩ النهار المفروض، /ا/ وما بقي فهو فضل قوس النهار على نهار الاستواء. وتأخذ نصفه وتعدّ بعدده من أجزاء المعدّل مبتدئا من الأفق، وتضع علامة على الجزء المنتهي. ثمّ ترفع القطب الشماليّ مرّة /ب ١٤ا/ /ب/ وتحطّه /د/ أخرى، فأيّ عدد يوافق فيه طلوع رأس السرطان لطلوع العلامة، فهو /د ١٢ا/ عرض ذلك البلد.

ويمكن إجراء هذه الطريقة في رأس الجدي وغيره، بأن تضع القطب على الأفق ورأس الجدي مثلا على الأفق الشرقيّ، وتضع العلامة على الجزء الذي وافى معه

335 جزء] و: الجزء **336** فضل] ا ب ج هـ: فضلة نهار] و: – الآخر] و: + من النهار **337** البلد] و: ↑ من من[2]] هـ: + ~~الكوا~~ **339** المذكور] ز: المذكورة حلقة] د: خلقة **341** تضع] ب: – على الأفق[1]] ك: ~~على~~ ورأس] ب: رأس، ز: ورٔس وتسقط] ج: وتعسط +↓ ثم سقط سٔ النهار **342** جزءا] ا ج و ز: جزء، ب د: جزءً **343** فهو] د: + ~~ما~~ وتأخذ] ز: وتأخذه بعدده] ز: بعده **344** مبتدئا] ا: مبتدأ، ب د هـ ك: مبتداء **345** وتحطّه] ج: +↓ ويحفظه، د: +ا فيه] ب ج د هـ و: – طلوع] د: طلوع **346** ذلك] د: – **347** ويمكن] ز: يمكن، ك: فيمكن هذه الطريقة] و: هذا الطريق **348** العلامة] ك: –

342 تسعين] الصحيح: مائة وثمانين

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Chapter thirty-two: To know the difference of daylight (length) on the same day in two different latitudes, while the sun is at the same degree. The way to do this is to place the pole in one of the two latitudes and the given degree on the east horizon, and mark the degree of the equator that has reached that horizon with it. Then you place the pole in the other latitude and the degree on the same horizon and you mark the degree of the equator that is in that horizon with it. The degrees which are in between the two marks correspond to the difference in daylight of one of them over the other.

Chapter thirty-three: To know the latitude of the city from the highest altitude of a star, among the stars of the globe, and from its longest daytime. The way to do this is to place the specified star at its highest altitude (counting) in degrees of the meridian ring and then the latitude is obtained.

You place the pole on the horizon and the first point of Cancer on the east horizon and subtract the daytime ⟨arc⟩ on the (terrestrial) equator – that is 90 degrees[40] – from the given daytime; the remainder will be the excess of the daytime arc over the daytime of the (terrestrial) equator. You take half of this and count this number of degrees along the equator, starting from the horizon, and put a mark on the final degree. Then you raise the north pole once and you lower it again.[41] The latitude of that city will be the number (of degrees of elevation of the pole) at which the rising of the first point of Cancer coincides with the rising of the mark.

It is possible (to use) the first point of Capricorn, and other (points of the ecliptic), while performing this method, by placing the pole on the horizon and the first point of Capricorn, for example, on the east horizon; you put a mark on the degree of the equator that arrived simultaneously with it

[40] The correct number is 180.
[41] This is a trial and error method for finding the proper position of the globe.

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⟨الأفق الشرقيّ⟩ من المعدّل. وتسقط النهار المفروض عن نهار الاستواء، وتنصف ما بقي. /هـ/ ثمّ ترفع القطب وتحطه حتّى يقع رأس الجدي /ک/ في الأفق وترتفع العلامة عن الأفق بقدر ذلك النصف وعلى هذا القياس. /هـ ٢٥٢/ /ک ١٣٨'/

ا

الحمد لله على التمام، والصلاة على محمد أفضل الأنبياء عليه السلام وعلى آله وأصحابه الكرام.

ب

تمّ الكتاب بعون الله الملك الوهاب سنة ١١٤٩.

من يد العبد الضعيف أحمد بن علي الملقّب بقبوجي، زاد عفو الله له ولوالديه وأحسن إليهما وإليه.

مَن شغل كثيرا بهذا العلم قسا قلبه، بل يجب عليه من الأوقات يتمّ حَريّ (؟).

ج

تمّ الكتاب بعون الله الملك الوهاب سنة أربع وأربعين ومائة وألف.

د

تمّت الرسالة بتوفيق الله تعالى في سنة تسع وخمسين ومائة وألف في ذي القعدة المباركة.

هـ

تمّ في اثنين وأربعين بعد مائة وألف.

تمام أولدى كتبك انتهاسى كركدر كاتبه شركة بهاسى.

349 وتسقط] ک: ونسقت النهار] هـ: نهار عن] هـ: على وتنصف] ز ک: + على **350** ترفع] هـ: يرفع يقع] ز: تعصى وترتفع] ا د هـ: ويرتفع، و: وترفع **351** عن] د: من **353** والصلاة] ا: والصلوة **356** تمّ] ب: تمّت **357** العبد] ب: عبد **361** تمّ] ج: تمّت وأربعين] ج: وأربعون ومائة] ج: مئا

359 يتمّ حَريّ] الكلمتان الأخيرتان غير واضحتين في المخطوطة، يمكن أن تكونا: يتمّ / يمرّ و حَريّ / حدّي / صدى.

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⟨at the east horizon⟩. You subtract the given daytime from the daytime of the (terrestrial) equator and take half of the remainder. Then you raise the pole and lower it, so that the first point of the Capricorn is placed on the horizon and the mark is elevated from the horizon by the amount of this half and according to this analogy.

Colophons and notes after the text of the treatise

1. (A) Praise be to God for the completion, and blessings upon Muḥammad, the most superior of the prophets, peace upon him and upon his family and his noble companions.
2. (B) The book was completed with the help of God the King the Bestower. Year 1149.

   By the hand of the poor slave Aḥmad ibn ʿAlī, called Qabūjī, may God increase the forgiveness for him and his parents and be charitable to them and to him.

   If someone works so hard on this science, his heart becomes cruel, but by the time passing he must be unsurpassed (?).
3. (J) The book was completed with the help of God the King the Bestower, year 1144.
4. (D) The treatise was completed with the guidance of God the Highest, in the year nine and fifty and hundred and thousand (1159 H) in the blessed (month) Dhū al-Qaʿdah.[42]
5. (H) Completed in forty-two after thousand and hundred (1142 H). The books have been completed and the company charge to the copyist is required.[43]

[42] i.e. between 14 November and 13 December AD 1746 (Gregorian).

[43] The last sentence is written in Ottoman Turkish. The transliteration in modern Turkish is 'Temām oldu kütübün intihāsı, gerekdir kātibe şirket behāsı'. I am thankful to Ali Fikri Yavuz for translating this sentence.

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و

سنة ١١٦٠.

شرح الأسطرلاب للحميدي أفندي رحمة الله عليه رحمة واسعة.

ز

تمت سنة ١١٨ محرّم يوم ٢٩. مصطفى أفندي.

ک

قد وقع الفراغ من تنميق هذه الرسالة، وقت الضحوة في رابع شوّال المبارك من سنة ثمان وخمسين ومائة وألف، على يد الفقير، إليه سبحان وتعالى، عمر بن حسين الآمدى، غفر الله لهما ولجميع المؤمنين والمؤمنات؛ آمين.

ر

الحمد لله على التمام، والصلاة على محمد أفضل الأنبياء الكرام، وعلى آله وأصحابه العظام.

وقد وقع الفراغ من تنميق هذه الرسائل الثلاثة المنسوبة بمحمد الشهير باخوين في أوائل شهر رجب المرجب لسنة ٩٦٥.

378 والصلاة] ر: والصلوة

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6. (U) Year 1160.

   Explanation of the astrolabe by Ḥumaīdī / Ḥamīdī Effendi, God's mercy upon him, great mercy.

7. (Z) Completed in year 118 on 29 Muḥarram. Muṣṭafā Effendi.

8. (K) The writing of this treatise has been finished in the morning of the fourth of the blessed (month) Shawwāl of the year 1158, by the hand of ʿUmar ibn Ḥusayn al-Amda, who is in need of Him, the Glorified and Exalted, may God pardon both of them[44] and all believers, men and women; amen.

9. (R) Praise be to God for the completion, and blessings upon Muḥammad, the most superior of the noble prophets, and upon his family and his venerable companions.

   The writing of these three treatises attributed to Muḥammad, famous as Akhawayn, was completed at the beginning of the month Rajab, the respected, of the year 965.[45]

[44] i.e. ʿUmar and his father Ḥusayn.

[45] i.e. the second half of April 1558.

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3. Commentary on the treatise *Dhāt al-kursī* attributed to Ptolemy (treatise P) and comparison with the treatise on the celestial globe by Qusṭā ibn Lūqā (treatise Q)

In this chapter, a commentary on the introduction and each chapter of the treatise *Dhāt al-kursī* (in short, treatise P) is presented with additional figures to facilitate the understanding of the text, to illustrate the method applied, to discuss possible influences and to shed light on some omissions and erroneous statements in the text. In parallel, there is a comparison to the treatise on the celestial globe by Qusṭā ibn Lūqā (in short, treatise Q), to show the close dependence of treatise P on treatise Q, and to prove that the latter is the source treatise of the former.[1]

P Introduction

In the introduction of treatise P, there is a detailed description of the instrument called *dhāt al-kursī*. It is a celestial globe with stand, similar to the instrument depicted in Figure 2.

The instrument includes a horizontal ring resting on the stand which represents the horizon, and another ring perpendicular to the horizon ring and bisecting it, which represents the meridian. Both of the rings have the same internal diameter.

A globe is situated within the internal space of the two rings and it can rotate round the axis that connects the globe with the meridian ring. On the globe, the following elements are depicted (Figures 2–3):

- The ecliptic, divided into 360° and 12 zodiacal signs.
- The six great circles through the first points of the signs and perpendicular to the ecliptic; these circles intersect each other at the two poles of the ecliptic. One of them (through the first points of Cancer and Capricorn) also passes through

Figure 2: Celestial globe. © History of Science Museum, University of Oxford, inv.40716.

[1] For an introductory presentation of these two treatises see Section 1.2 of this book. For the full Arabic text of treatise Q, see Appendix 3.

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the two celestial poles; this is the solstitial colure. It is mentioned that these circles are drawn in red.

- The equator, also divided into 360°, intersects the ecliptic at the two equinoctial points, i.e. the first point of Aries and the first point of Libra.
- The two poles of the equator are marked by holes with pegs inside. They connect the globe to the meridian ring and permit the rotation of the globe.
- Some of the fixed stars are also depicted on the globe. It is mentioned that the names of the stars usually represented on the spider of the astrolabes are also inscribed on the globe.[2]

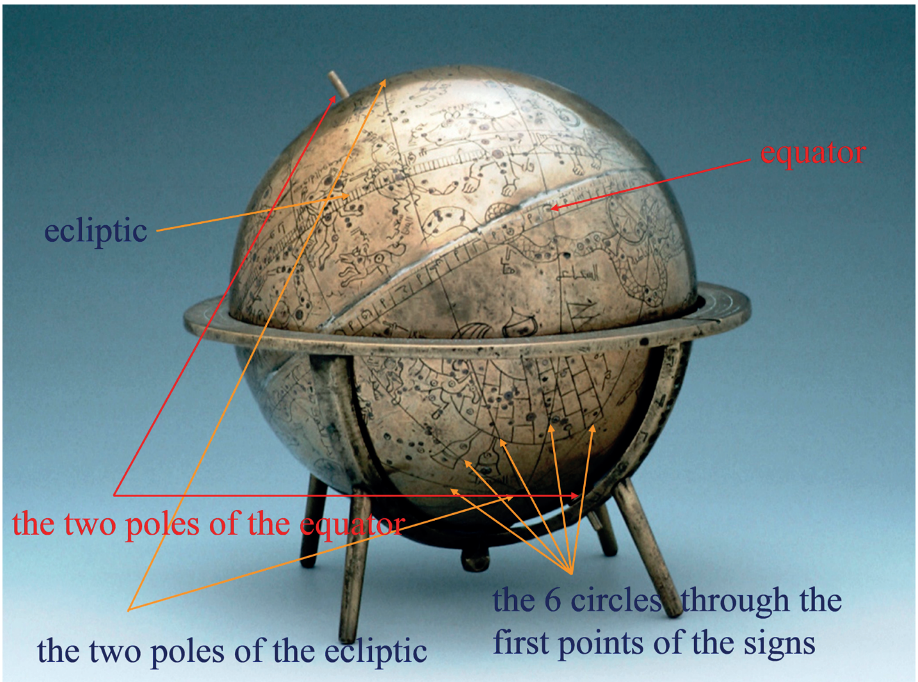

Figure 3: The elements of a celestial globe indicated on the globe dated 764 H / AD 1362–3. © History of Science Museum, University of Oxford, inv.44790.

The above elements had already been described by Geminus (1st c. BC), while describing the circles on the sphere in his treatise *Introduction to Phaenomena*,[3] but Geminus describes only two of the circles through the poles of the ecliptic:

[2] For a complete presentation of the stars depicted on the astrolabes according to the Arabic tradition see Kunitzsch, *Arabische Sternnamen*, pp. 58–96.

[3] Aujac, *Géminos. Introduction aux Phénomènes*, also Evans and Berggren, *Geminos's Introduction to the Phenomena*, and Manitius, *Gemini Elementa astronomiae*; the 'circles on the sphere' are described in Chapter 5.

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the solstitial and equinoctial colures. In treatise P, some additional elements are described:

- the 28 lunar mansions,[4] which are stars or groups of stars situated on the ecliptic, or on its two sides, i.e. to the north or to the south of it (depicted in Figure 4), and
- the circles of declination, which are great circles perpendicular to the equator and intersect each other at the two poles of the equator.

Figure 4: Celestial globe dated 718 H / AD 1318–9.
The 17th–22nd lunar mansions: *Iklīl*, *Qalb al-ʿAqrab*, *Shaula al-ʿAqrab*, *al-Naʿāim*, *al-Balda* and *al-Saʿd al-Dhābiḥ* can be seen on the globe.
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As for the two rings that surround the globe, treatise P states that the horizon circle is the ring of the stand, divided into 360 equal degrees, and that the meridian ring is fixed and also divided into 360 degrees.

On the horizon ring (Figure 5), the meridian line and the East-West line are drawn; at the extremities of the meridian line the terms ‘North’ and ‘South’ are written, while at the extremities of the East-West line, the terms ‘East’ and

4 For a presentation of the lunar mansions see Kunitzsch, *Arabische Sternnamen*, pp. 53–57, and al-Bīrūnī, *The Chronology of Ancient Nations*, pp. 335–65.

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'West' are written. Each of these lines bisects the horizon circle. The positions of summer and winter risings and settings of the Sun are also indicated on the horizon. Their amplitude depends on the latitude of the locality.

The division of the horizon into 360° is used for measuring the azimuths. Geminus and Leontius[5] do not mention this division, since the azimuth was invented later by the Arabs.

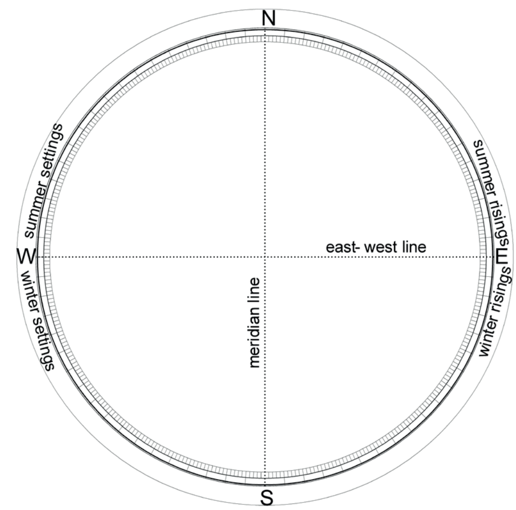

Figure 5: The horizon ring of the celestial globe.

Comparison with treatise Q

The introduction of treatise P corresponds to Chapter Q1. In general, the wording of the two treatises is similar, although there are some remarkable differences:

1. In the description of the celestial globe in the treatise attributed to Ptolemy (treatise P), there are three additional elements in comparison with the treatise of Qusṭā ibn Lūqā (treatise Q): the east-west line (خطّ المشرق والمغرب) and the meridian (north-south) line (خطّ نصف النهار) on the horizon ring of the stand, and the circles of declination (دوائر الميل) through the two celestial poles on the globe.
2. In Chapter Q1, 12 circles through the poles of the ecliptic are mentioned, which separate the zodiacal signs on the ecliptic, while in the introduction of P, six such circles are mentioned and described in a more elaborate way.[6] The correct number of circles is six, since each one of the circles through the poles of the ecliptic intersects the ecliptic

[5] Leontius, *De sphaerae Arateae constructione*, in Maass, *Commentariorum*, pp. 561–67.

[6] Q: اثنى عشر فلكا تفصل بين اثنى عشر برجا ('twelve circles separating twelve zodiacal signs'), P: الدوائر المارة بأوائل البروج ('the circles passing through the beginnings of the zodiacal signs').

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at two points. There are thus 12 points of intersection that define the division of the zodiacal signs on the ecliptic. The red colour of these circles is mentioned only in treatise P.

3. The ecliptic is mentioned in Q1 as the 'circle through the middle of the zodiacal signs' (فلك وسط البروج), a translation of the Ptolemaic ὁ διὰ μέσων τῶν ζῳδίων κύκλος, while in P the more common designation 'circle of the zodiacal signs' (فلك البروج) is used.

Chapter P1: To know how to position the globe

The celestial globe must be positioned correctly in order to give results according to the chosen locality. The user must face the eastern horizon and place the meridian ring in its position into the aperture of the stand.[7] The globe should be surrounded by the meridian ring and attached to it through its axis, so that the north pole is elevated from the horizon as many degrees as the latitude of the chosen locality. At this position, the rotation of the globe simulates the diurnal motion at that locality.

The diurnal motion, as simulated through the celestial globe, is compared to the motion or shape of everyday-life objects. In the place where the equator is on the zenith (φ=0°), the rotation will be upright, like the motion of a wheel (دولاب), as in Figure 6. In the place where the pole is on the zenith (φ=90°), the rotation will be horizontal (*μυλοειδής*), like the motion of a millstone (رحى), as in Figure 7. In the place where the equator is oblique (0°<φ<90°), as in Figure 8, the rotation will be oblique diagonal (حمائليّة), like a baldric (حمالة / جمع: حمائل), a diagonal belt for carrying a sword.

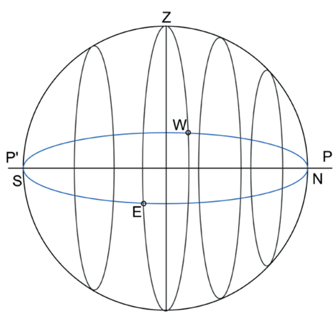

Figure 6: φ=0°

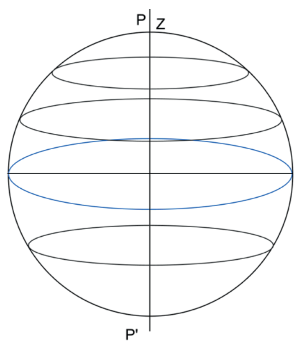

Figure 7: φ=90°

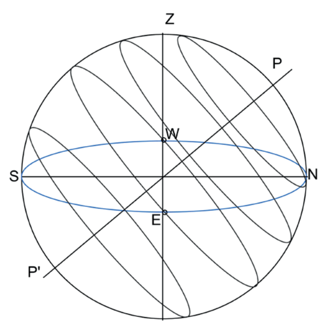

Figure 8: 0°<φ<90°.

Figures 6–8: The diurnal motion at various latitudes.

[7] Depending on the type of the globe, it can be adjusted to the local latitude either by sliding the meridian ring through the two small apertures on the horizon ring, or by fixing the poles of the globe on the appropriate holes of the meridian ring. This is not discussed in the treatises P and Q.

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Comparison with treatise Q

Chapter P1 includes the most important points of Chapters Q2–4, adding some new similes. The description of the diurnal motion as viewed from the poles of the Earth is described in both treatises as similar to the rotation of a millstone: in the introduction of Q in some manuscripts (e.g. B, N) كما تدور الرحى, in Q4 كدوران الرحى and in P2 حركة رحويّة. For the diurnal motion as viewed from the terrestrial equator the term دوران مستقيم (straight-up rotation) is used in Q4, while in P2 the term حركة مستقيمة دولابيّة (straight-up motion, like a wheel) is used. For places between the terrestrial equator and the poles the term دوران مائل (inclined / oblique rotation) is used in Q4, while the term حركة منحرفة حمائليّة (oblique motion like a baldric) is used in P1.

Chapter P2: To know the equality of night and day on the (terrestrial) equator line

This chapter has the didactic purpose to show that the durations of day- and nighttime are equal on the terrestrial equator, for any day of the year. The poles of the globe are placed on the horizon, thus the globe models the celestial sphere as seen from the terrestrial equator. Two methods are presented in Chapter P2:

1. Any desired degree of the ecliptic is placed on the horizon (east or west) and the two degrees of the equator that intersect the horizon are marked; these two degrees of the equator correspond to the right ascension and descension of the chosen degree of the ecliptic. Then the globe is rotated and both degrees of the equator arrive simultaneously at the opposite point of the horizon.
2. Any degree of the ecliptic is placed on the east horizon and the degree of the equator that rises simultaneously is marked; this is the right ascension of the chosen degree of the ecliptic. The globe is rotated and the two degrees come simultaneously onto the west horizon. This corresponds to a rotation of 180° of the globe. During this rotation, 180° of the equator have risen and 180° of the equator have set.

According to the results of both methods, the durations of the day- and nighttime are equal for any degree of the ecliptic, thus for any day of the year. The equality of day- and nighttime at the terrestrial equator is discussed by Geminus[8] and Ptolemy.[9]

[8] Evans and Berggren, *Geminos's Introduction to the Phenomena*, Section 6.23, p. 165.

[9] Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, Section II.6.1, p. 101, and Toomer, *Ptolemy's Almagest*, p. 82.

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Comparison with treatise Q

Chapter P2 contains the same two procedures as Q5, put in the opposite order and presented in a different wording.

Chapter P3: To know the longest and shortest daytime at the oblique horizons

This chapter has the didactic purpose to show that, for any place outside the terrestrial equator, the longest daytime occurs when the Sun is at the first point of Cancer and the shortest one when the Sun is at the first point of Capricorn.

The north pole of the globe is raised by an arbitrary number φ of degrees above the horizon ($0° < \varphi < 90°$), thus the globe models the celestial sphere as seen from any place on earth having latitude φ to the north of the terrestrial equator.

The first points of Cancer, Capricorn and any other degree of the ecliptic are placed on the east horizon and the rising degree of the equator is marked; this degree corresponds to the oblique ascension of the respective degree of the ecliptic for the latitude φ. Then the globe is rotated so that the degree of the ecliptic arrives at the meridian, or the west horizon, and the number of the degrees of the equator that have risen is counted; in the former case this number corresponds to the half daytime arc, whereas in the latter case to the daytime arc of the degree of the ecliptic. Always, the daytime arc of the first point of Cancer will be greater than the daytime arc of any other degree, while the daytime arc of the first point of Capricorn will be less than the daytime arc of any other degree of the ecliptic. Thus the longest daytime corresponds to the day when the Sun is at the first point of Cancer, and the shortest one to the day when the Sun is at the first point of Capricorn.

According to Chapter P3, by the same procedure it can be verified that:

1. when the Sun is at the equinoctial points, the daytime length is equal to that of nighttime;
2. when the Sun is among the northern zodiacal signs, the daytime is longer than the nighttime, and
3. when the Sun is among the southern zodiacal signs, the daytime is shorter than the nighttime.

Comparison with treatise Q

Chapter P3 contains the procedure described in Q8, but in a concise and more general form. The author of treatise P presents two possibilities for comparing daytime lengths, measuring the half daytime arc or the entire daytime arc, while in Q8 only the whole daytime arc is used.

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Chapter P3 also presents the results of Q7 and partially those of Q6.

Chapter Q6 deals with the difference between day- and nighttime lengths for northern and southern zodiacal signs and examines how this difference changes according to terrestrial latitude: the north pole of the globe is raised above the horizon. Any degree of the ecliptic is then placed on the east horizon and the degree of the equator rising on the east horizon is marked (this degree of the equator corresponds to the oblique ascension of the degree of the ecliptic in that latitude). The globe is rotated, so that the degree of the ecliptic comes onto the west horizon. If the degree of the ecliptic belongs to a northern zodiacal sign, then it will set after the corresponding degree of the equator, meaning that the daytime arc will be greater than 180°; this implies that the daytime will be longer than 12 hours, which is the daytime at the terrestrial equator. If the degree of the ecliptic belongs to a southern zodiacal sign, then this degree will set before the corresponding degree of the equator, thus the daytime arc is less than 180°; this means that the daytime will be shorter than the daytime on the terrestrial equator. In a similar procedure, the duration of the nighttime can be studied. The difference between the day- and nighttime on the same day varies with latitude; when the elevation of the north pole is greater, the difference between the day- and nighttime will also be greater.

The results of Chapter Q6 concerning the duration of daytime when the Sun is at the southern and northern zodiacal signs are included in Chapter P3 (in the above-mentioned points 2 and 3). This subject is discussed in Proposition I.4 of the treatise *On Days and Nights* by Theodosius;[10] the translation of this treatise into Arabic is attributed to Qusṭā ibn Lūqā.

Chapter Q7 describes a procedure to verify the equality of day- and nighttime lengths when the Sun is at the equinoctial points. The north pole of the globe is first elevated above the horizon. The first point of Aries (vernal equinox) is then placed on the east horizon and a mark is put on the degree of the equator that simultaneously reaches the (east) horizon. Then the globe is rotated so that the first point of Aries arrives at the west horizon. At this position, the marked degree of the equator has also reached the west horizon, after a 180° rotation of the globe. Likewise, if the globe is rotated so that the first point of Aries arrives at the east horizon, the marked degree of the equator will simultaneously arrive at the east horizon. As the first point of Aries and the marked degree of the equator come together onto the west or east horizon, the equality of day- and nighttime lengths is thus demonstrated. The equality

[10] Kunitzsch and Lorch, 'Theodosius, *De diebus et noctibus*'. Proposition I.4 is on pp. 19–20 and 34 and the attribution of the translation to Qusṭā ibn Lūqā appears on pp. 9, 13, 15, 30. The Greek text of the same treatise is included in Fecht, *Theodosii de habitationibus liber*. *De diebus et noctibus libri duo.*

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is preserved for any elevation of the north pole. The same result is obtained for the first point of Libra (autumnal equinox).

In the text of Chapter Q7, the degree of the equator that reaches the horizon simultaneously with the first point of Aries or Libra seems to be a point that does not belong to the ecliptic.[11] This is not correct, because the equinoctial points are the two points of intersection of the ecliptic with the equator. Thus, when the first point of Aries reaches the east horizon, the same point will be the degree of the equator that reaches the east horizon, and the mark should be put on the first point of Aries; the situation is the same on the west horizon. Exactly the same happens with the first point of Libra.

The author of treatise P eliminated the description of the procedure presented in Q7, including only the conclusion that the day- and nighttime are equal when the Sun is at the equinoctial points; this conclusion could be taken as a result of the procedure explained in Chapter P3.

Chapter P4: To know the difference between the (lengths of) daylight of two days in one city

The north pole of the equator should have been placed according to the latitude of the city, but this is not mentioned. The two degrees x, y of the ecliptic, which correspond to the positions of the Sun on each of the two days, are successively placed on both the east and the west horizon. Thus, the daytime arc $d(x)$ of the degree x of the Sun is estimated as

$$d(x) = \begin{cases} r_2(x) - r_1(x), & \text{if } r_2(x) \geq r_1(x) \\ 360^\circ + r_2(x) - r_1(x), & \text{if } r_2(x) < r_1(x) \end{cases},$$

where $r_1(x)$, $r_2(x)$ are the rising degrees of the equator at the moment of sunrise and sunset respectively; the daytime arc $d(y)$ of the degree y is estimated similarly. The difference between the daylight length of these two days will be $|d(y)-d(x)|$.

Comparison with treatise Q

Chapter P4 corresponds to Q9, but there are some differences:

1. In Q9 it is mentioned that the north pole must be placed according to the latitude of the locality, but in P4 this phrase is omitted.
2. At the end of Q9, the result found in degrees is converted into (equal) hours, by dividing it by 15; this is not mentioned in P4, but in the next

[11] Since the text notes: فيتوافيان جميعا على الأفق الغربي والأفق الشرقي ‘these two reach the east horizon and the west horizon together’.

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Chapter P5 the author explains how to convert degrees of the equator into equal hours and a fraction of an equal hour.

Chapter P5: To know the daytime arc of the Sun and of the rest of the stars, and its division into seasonal and equal hours

The title refers to 'the Sun and the rest of the stars', although in the instructions that follow only the term 'star' (كوكب) is mentioned, probably used collectively for the Sun, planets and fixed stars. For the Sun, the same procedure must be followed, using the degree of the Sun instead of the star.

By the term 'daytime arc of a star', the duration of the motion of the star above the horizon is meant, and by the term 'nighttime arc of a star', the duration of the motion of the star below the horizon. The day- and nighttime arcs can be measured either in degrees of the equator or in equal hours.

The procedure in Chapter P5 is the following: The north pole of the globe is first raised according to the latitude of the locality. The oblique ascension $r_1(x)$ of the star, and the degree $r_2(x)$ of the equator that is rising at this locality when the star is setting are determined using the globe. The difference

$$d(x) = \begin{cases} r_2(x) - r_1(x), & \text{if } r_2(x) \geq r_1(x) \\ 360° + r_2(x) - r_1(x), & \text{if } r_2(x) < r_1(x) \end{cases}$$

gives the daytime arc of the star, while the difference $n(x)=360°-d(x)$ gives the nighttime arc of the star; both arcs are measured in degrees of the equator.

The integer quotient of the division $d(x)/15$ gives the number of equal hours that correspond to the motion of the star above the horizon, while the remainder u of this division gives the fraction of the hour $(u/15)$; thus $4u$ will be the result in minutes.

The quotient of the division $d(x)/12$ gives the number of degrees of one seasonal daytime hour. This refers only to the Sun, however, and not to the stars, because the seasonal hours are defined by means of the Sun; in the text of Chapter P5, this is not clarified.

Comparison with treatise Q

Chapter P5 unifies Chapters Q10, Q12 and Q19. In Chapter Q10, the daytime arc of the Sun in equal hours is estimated, in Chapter Q19 the day- and nighttime arc of a star in degrees of the equator and in Chapter Q12 the degrees corresponding to one seasonal daytime hour of a given day at a given locality are estimated. The procedure described for Chapter P5 is repeated in each of these three chapters, whereas the author of treatise P avoided this repetition by unifying these chapters.

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Chapter P6: To know the difference between the daytime lengths of the same day in two cities with different latitudes

The north pole of the globe is first raised according to the latitude of city A. The oblique ascension $r_1(x)$ of the degree x of the Sun at sunrise, and the degree $r_2(x)$ of the equator that rises at that locality at sunset are found for city A. The difference

$$d_A(x) = \begin{cases} r_2(x) - r_1(x), & \text{if } r_2(x) \geq r_1(x) \\ 360° + r_2(x) - r_1(x), & \text{if } r_2(x) < r_1(x) \end{cases}$$

provides the daytime arc of the Sun for city A.

The same procedure is repeated for city B, giving the daytime arc of the Sun $d_B(x)$ at this city. The difference between the daytime lengths of the same day in the two cities will thus be $|d_A(x)-d_B(x)|$.

Comparison with treatise Q

Chapter P6 describes exactly the same procedure as Q11, but in a concise way.

Chapter P7: To know the time that has elapsed since sunrise in equal and unequal hours

The north pole of the globe should be raised according to the latitude of the locality, although again the description of this step is omitted in treatise P. The degree x of the Sun is placed at the equivalent of its current altitude on the globe[12] and the degree $r_2(x)$ of the equator that rises at that locality at this moment is found. Then the degree of the Sun is placed on the east horizon and the degree $r_1(x)$ of the equator that rises at that locality at the moment of sunrise is determined (this is the oblique ascension $r_1(x)$ of the degree of the Sun). The difference

$$r(x) = \begin{cases} r_2(x) - r_1(x), & \text{if } r_2(x) \geq r_1(x) \\ 360° + r_2(x) - r_1(x), & \text{if } r_2(x) < r_1(x) \end{cases}$$

gives the arc of revolution since sunrise. Dividing it by the degrees of one equal hour (always 15°) or by those of one unequal hour (explained above in Chapter P5), the elapsed time since sunrise in equal or unequal hours, respectively, is determined.

Comparison with treatise Q

Chapter P7 corresponds to Q13 (equal hours) and Q14 (unequal hours), but in Q13–14 the ascendant is known, while in P7 the altitude of the Sun is known. In treatise P the degree of the Sun is placed on the given altitude, while in treatise Q the ascendant is placed on the east horizon. Both methods are equivalent.

12 The quadrant scale (Figure 9) should be used for this purpose, but this is not mentioned in the text. For the use of this scale see the commentary on Chapter P9.

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The rest of the procedure is the same in both treatises. The author of treatise P avoids the repetition of the same method presented in Q13 and Q14. In P7 the term used for the unequal hour is الساعة المعوجة while in Q14 the corresponding term is الساعة الزمانية, which can be translated as 'seasonal hour'.

Chapter P8: To know the ascendant, if the elapsed time since sunrise in equal or unequal hours is known

Here, the opposite procedure of Chapter P7 is followed: the equal or unequal hours are converted into degrees of the equator, the degree of the Sun is placed on the east horizon, and the globe is rotated so that the same number of degrees of the equator rises from the horizon. These degrees correspond to the arc of revolution of the celestial sphere since sunrise. At this position of the globe, the ascendant is obtained as the degree of the ecliptic that rises at that moment.

Comparison with treatise Q

Chapter P8 contains both Q15 (in which the time in equal hours is known) and Q16 (in which the time in unequal hours is known), so that the procedure is again not repeated, as in treatise Q. In treatise Q, it is explained how to convert the equal and seasonal hours into degrees of the equator, but in treatise P this is not explained explicitly, since the correspondence between the degrees of the equator and the time in equal and seasonal hours has been described previously, in Chapters P5 and P7. The description of the procedure in treatise Q is very detailed and clear, while in treatise P it is brief.

Chapter P9: On the method of obtaining the altitude of the Sun on the globe

The globe should be exposed to the Sun, and placed on flat ground, so that its stand is vertical and the horizon ring exactly horizontal. The installation of the globe must be checked using a plumb line. Then the north pole of the globe is placed according to the latitude of the locality, where the Sun's altitude is to be measured. A gnomon in the form of a needle is attached at the degree of the Sun, as a prolongation of the radius of the globe at that point (Figure 10). Then the user must turn the stand and rotate the globe to reach the position at which the needle casts no shadow; this means that the needle is parallel to the sunrays. By measuring the angle that the direction of the needle, subsequently the direction of the sunrays, forms with the horizon, the altitude of the Sun is measured. This angle is measured using a quadrant scale, graduated from 0° to 90° (Figure 9). This quadrant scale must be placed in contact with the globe, so that the graduation of 0° is on the horizon ring, the graduation of 90° is on the zenith and the concave part of the scale passes through the degree of the Sun.

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Figure 9: A Quadrant Scale, c. AD 1700.
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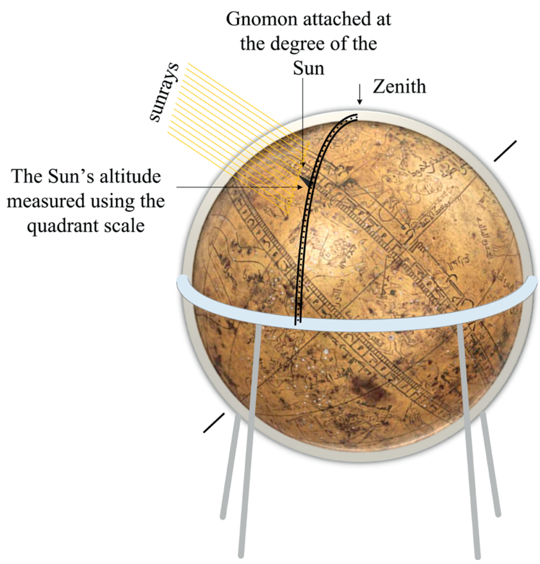

Figure 10: Measuring the altitude of the Sun with the celestial globe.

The position of the celestial globe where the gnomon casts no shadow on the globe can be achieved when the meridian ring is aligned to the local meridian, but this is not mentioned in this chapter.

The last part of the text, concerning the west altitude of the Sun, is not clear and it seems to be erroneous. The altitude can be measured in exactly the same way when the Sun is to the east or the west of the meridian, and there is no need to alter the poles and put the gnomon on the diametrically opposite degree of the Sun as the text suggests. This last part is not included in the respective Chapter Q53 in the treatise of Qusṭā.

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In his treatise on the use of the celestial globe,[13] al-Ṣūfī uses similar methods to find the altitude of the Sun, presented in Chapters I.4 and I.8 of his treatise. At the end of Chapter I.8 he mentions that the altitude can be measured with this method on both the east and the west side. In Chapters I.48–49 he develops methods to determine whether the altitude of the Sun is east or west. In I.48 the gnomon is installed on the degree of the Sun perpendicularly to the surface of the globe and the system is aligned in such a way that the gnomon casts no shadow, as in this treatise; if the degree of the Sun is then to the east of the meridian, the altitude is east, and if it is to the west, the altitude is west.

Comparison with treatise Q

Chapter P9 corresponds to Q53. The procedure in both versions is the same, although with some differences in wording. The author of treatise P has placed this chapter near the beginning of the treatise, because the procedure for measuring the altitude of the Sun is necessary for solving various other astronomical problems, such as those presented in Chapters P7 and P10.

Chapter P10: To know the four centres

The four centres in question are the ascending, upper culminating, descending and lower culminating degrees of the ecliptic.[14] To determine them, the altitude of the Sun is first measured in order for the globe to be positioned according to the current time. Then, the rising degree of the ecliptic is the ascendant (الطالع), the setting degree is the descendant (الغارب), the upper culminating degree, reaching the meridian above the globe, is the midheaven (وسط السماء) and the lower culminating degree, reaching the meridian below the globe, is the centre of the earth (وتد الأرض), also known as *imum coeli*.

Comparison with treatise Q

Chapter P10 includes the methods of Q54, Q17 and Q18. The first part of P10 is almost identical to Q54, with only a few differences in wording. In both P10 and Q54, the four centres are determined using the current altitude of the Sun. In Chapter Q17 the midheaven is determined when the ascendant

13 Al-Ṣūfī wrote a treatise *On the Use of the Celestial Globe* (between 983 and AD 986), which contains 157 chapters arranged in three books. The treatise is preserved in MS Istanbul, Topkapi Saray, Ahmet III 3505,1 (ff. 1–62). A summary of this treatise is presented in Kennedy, 'Al-Ṣūfī on the Celestial Globe'. In the appendix of this article, Kennedy presents the titles of the 157 chapters in English translation and a short summary of the contents of most.

14 The term *κέντρα* meaning 'centres' is used for those four points by Ptolemy in *Ἀποτελεσματικά* (ed. Hübner), pp. 123, 179, 183, 189 and elsewhere, and by Joannes Philoponus, 'Joannis Alexandrini, cognomine Philoponi, de usu astrolabii eiusque constructione libellus' (ed. Hase), p. 141, l. 19–22; the same text appears in Jean Philopon, *Traité de l'astrolabe* (ed. Jarry), pp. 2, 21.

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is known (Q15 and Q16 describe how to find the ascendant), while in Q18 the descendant and *imum coeli* are determined when the ascendant or the mid-heaven is known. The results of Q17 and Q18 are presented in the second part of P10 in a more general way: if one of the four centres is known, then it is placed on its position and the rest of the centres can be determined.

Chapters P10 and P11 are useful for astrology.

Chapter P11: To know the rest of the houses

This chapter deals with domification. At the beginning, the ascendant must be placed at its position on the east horizon, although this is not mentioned. Then the globe is rotated as many degrees as those of two unequal hours, so that the degree of the ascendant reaches the position where it was two unequal hours ago (Figure 11). At this position the upper culminating degree of the ecliptic will be the cusp of the ninth house and the lower culminating degree the cusp of the third house. Then the globe is rotated the same number of degrees in the same direction as before (Figure 12), and at this position the upper culminating degree of the ecliptic will be the cusp of the eighth house and the lower culminating degree that of the second house. Since the ascendant is the cusp of the first house and the descendant the cusp of the seventh house, the first to third and seventh to eleventh houses have been determined.

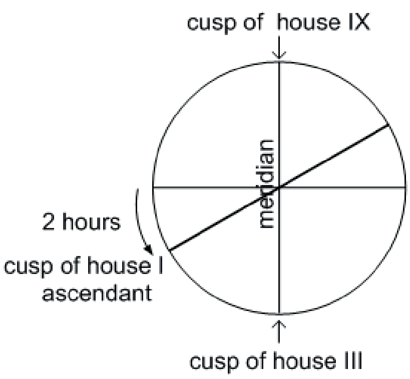

Figure 11

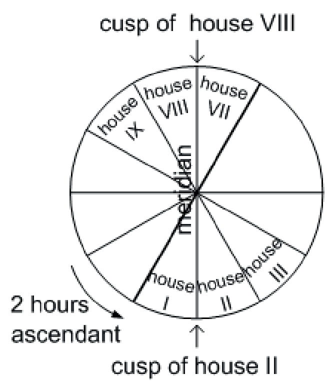

Figure 12

Figures 11–12: Domification.

After that, the ascendant is placed at its initial position on the east horizon and the globe is rotated in the opposite direction as many degrees as those of two unequal hours, so that the degree of the ascendant comes to the position it will reach after two unequal hours (Figure 13). At this position the upper culminating degree of the ecliptic will be the cusp of the eleventh house and the lower culminating degree that of the fifth house. At the end, the globe is

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rotated the same number of degrees in the same direction (Figure 14) and at this position the upper culminating degree of the ecliptic will be the cusp of the twelfth house, and the lower culminating degree that of the sixth house. The last two rotations of the globe therefore determine the fifth to sixth and eleventh to twelfth houses. They are not mentioned in the text, but the steps necessary to determine the rest of the houses are then obvious. Throughout the text, the 'cusp' of the house is not mentioned directly, only the ordinal arithmetic adjectives, second, third, etc., that correspond to each house.

The procedure is similar to methods presented by al-Khwārizmī,[15] ʿAlī Ibn ʿIsā[16] and al-Ṣūfī[17] in their treatises on the astrolabe.[18]

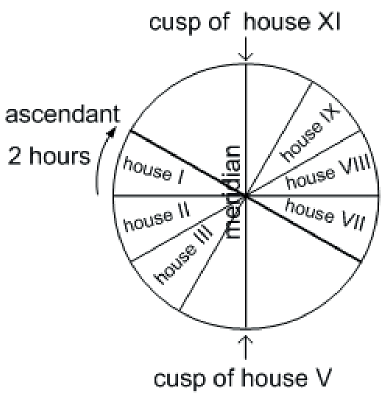

Figure 13

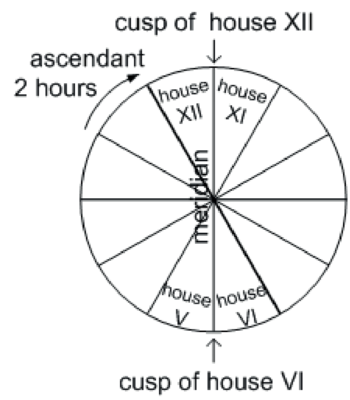

Figure 14

Figures 13–14: Domification.

Comparison with treatise Q

Chapter P11 corresponds to Q55. The method in both treatises is the same, but there are some differences in the wording:

1. In the title of P11 the term بيوت ('houses') is used, while in the title of Q55 the term أوتاد ('centres') is used in most of the examined manuscripts. The term مراكز ('centres') appears in manuscripts F, Z and O, whereas the term بيوت is found only in manuscript N.

[15] In Chapter 31 of the treatise on the astrolabe by al-Khwārizmī, see: al-Khwārizmī, 'Die Verwendung des Astrolabs' (transl. Frank). It can also be found in Chapter 23 (pp. 120–21, 146–47, 171) in Charette and Schmidl, 'Al-Khwārizmī and Practical Astronomy'.

[16] See ʿAlī ibn ʿĪsā, 'L'astrolabe et la manière de s'en servir', pp. 39–40; also ʿAlī ibn ʿĪsā, 'Das Astrolab und sein Gebrauch', pp. 247–48.

[17] See Vafea, *Les traités d'al-Ṣūfī*, pp. 166, 239–41.

[18] For the different methods of casting the houses see North, *Horoscopes and History*.

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2. At the beginning of Chapter Q55, Qusṭā mentions that we must know the ascendant and the degrees of an unequal hour; this phrase does not exist in P11.
3. The direction of the rotation of the globe in the determination of the ninth and eighth houses is described as 'in the order of the signs' (على توالي) in P11, while in Q55 the instruction is to 'rotate the ascendant downwards' (رُدّ الطالع إلى أسفل) in the determination of the ninth house, whilst the direction of rotation is not mentioned at all for the eighth house.
4. The direction of rotation of the globe to determine the eleventh house is described as 'in the opposite order of the signs' (على خلاف التوالي) in P11, while in Q55 the same rotation is described as to 'draw the degree of the descendant downwards' (حطّ جزء الغارب إلى أسفل) in the context of defining the eleventh house.
5. In P11, the third, second, fifth and sixth houses are determined as the diametrical opposites of the ninth, eighth, eleventh and twelfth houses respectively in the text of the determination of the latter, while in Q55, it is the ninth, eighth, eleventh and twelfth houses that are first determined, and their diametrical opposites then listed, with the addition of the pairs of the first and seventh houses (ascendant / descendant) and the tenth and fourth houses (midheaven / centre of the earth).

Chapter P12: To find the degree of any of the stars that are on the globe, to know its 'latitude', its declination from the equator, its deviation from the zenith and its maximum altitude; to know the declination of a degree of the zodiac from the equator

At the beginning a star or a degree of the ecliptic is placed on the meridian, at the position of its upper culmination.[19] In this position, the following information is extracted for the star or the degree.

The degree of mediation of a star, that is the degree of the ecliptic that culminates simultaneously with the star, is determined as 'degree of the star' (جزء الكوكب). The difference of declination between the star and its degree is then determined as 'latitude' (عرض). This is a common practice that some astrolabists followed, preferring the system 'mediation and difference of declination' to the system of coordinates 'ecliptic longitude and latitude'. The author mentions, however, that the latitude found in this way is not correct, and that

19 The position of upper culmination on the meridian is described as 'the star and a degree of the ecliptic reach the face of the meridian ring from the easterly direction'.

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the latitude must be measured on the circle of latitude, although he does not explain how to do this using a celestial globe.[20]

The declination δ (ميل عن معدّل) of a star or a degree of the ecliptic is determined by measuring the degrees of the meridian ring between the star, or the degree of the ecliptic, and the equator.

It is stated that, for a given star, the 'degree of the star' and its 'latitude' do not change with the latitude of the locality, while the declination of the star or the degree of the ecliptic does not change at all. The latter claim shows that the precession of the equinoxes has not been taken in consideration.

The minimum distance of a star from the zenith is taken as its zenithal distance, or – in literal translation – 'its deviation from the zenith' (ميل عن سمت رأس). The complement of this angle is the maximum altitude (غاية ارتفاع) of the star. Both of these angles depend on the latitude φ of the locality, since the maximum altitude is given by the formulas $h_{max}=90°-\varphi+\delta$ for culmination to the south of the zenith and $h_{max}=90°+\varphi-\delta$ for culmination to the north of the zenith, where φ is the latitude of the locality and δ the declination of the star. All the above angles are measured in degrees of the meridian ring.

Comparison with treatise Q

Chapter P12 includes Q20–24 and Q30. Since the method in all of these chapters is to rotate the globe in order to bring the star or the degree of the ecliptic on the meridian at its upper culmination and conduct the measurements on the meridian, the author of treatise P avoids the repetition of the same method and condenses the six chapters in one. In each of the above chapters of treatise Q, it is mentioned whether the measured magnitude depends on the latitude of the locality, similar to treatise P.

In Q20, the degree of a star (جزء الكوكب), which corresponds to its mediation, is determined with the globe, by placing the star on the meridian and observing which degree of the ecliptic comes simultaneously on the meridian; the same procedure is presented at the beginning of P12 with minor differences.

In Q21, the 'latitude' (عرض) of the star is determined, making a distinction between the north and the south latitudes: when the star is closer to the north pole the latitude is north, and when it is closer to the south pole, the latitude is south. It is not specified whether the pole of the equator or of

20 This could, in fact, be achieved by placing the north pole of the globe in the altitude of $90-\varepsilon$ degrees, that is to adjust the globe for the latitude of the arctic circle ($\varphi=90-\varepsilon$), and then rotating the globe so that the north pole of the ecliptic reaches the zenith. In this position, the ecliptic coincides with the horizon, and thus the altitude of the star equates to its ecliptic latitude. The altitude can be measured with the quadrant scale depicted in Figure 9. The point where the quadrant intersects the ecliptic provides the ecliptic longitude of the star.

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the ecliptic is meant, but the latter is the correct one.[21] The same procedure is presented in P12, but without the distinction between north and south latitudes. Furthermore, the author of treatise P criticizes the method as incorrect.

In Q22, the declination (ميل عن خطّ معدّل النهار) of the star is determined, making a distinction between the north and the south declinations, on the basis similarly of proximity to the north or south pole. The same procedure, without the distinction between north and south declinations, is presented in P12.

In Q23, the zenithal distance of a star for any desired locality (ميل عن سمت رأس أهل أيّ بلد شئت) is determined, making a distinction between zenithal distance to the north and to the south of the zenith: when the star is inclined towards the north pole the zenithal distance is to the north, and when it is inclined towards the south pole, then the zenithal distance is to the south. In the beginning, there is an explanation of how to find the zenith on the meridian, but since the meridian ring is always graduated, this procedure is not necessary. It should be mentioned that the star is placed at the position of its *upper* culmination on the meridian; this is mentioned in Chapter Q20 but not in Q23. The same procedure, without the determination of the zenith on the meridian and the distinction between the zenithal distances to the north and to the south of the zenith, is presented in P12.

In Q24, the maximum altitude of any star on the globe for any locality we want (أعظم/ أتمّ ارتفاع في أيّ بلد شئت) is determined in two equivalent ways: (i) by subtracting the zenithal distance of the star from 90°, and (ii) by repeating the method described in the previous chapters and then counting the degrees of the meridian between the horizon and the star. In P12 only the subtraction is mentioned, while the second method is included in Chapter P21 in a more elaborate form. In Chapter Q24, it should have been mentioned that the star is placed at the position of its *upper* culmination on the meridian; in P12 this is mentioned at the beginning covering all cases. The subject presented in Q24 is repeated in Chapter Q43. The transmission of Chapter Q24 into treatise P is shown in the following diagram.

Q24 (2 methods) → Q24i → P12
Q24 (2 methods) → Q24ii → Q43 → P21

In Q30, the declination of any degree of the ecliptic (ميل أيّ جزء من أجزاء دائرة البروج) is determined. Furthermore, it is mentioned that the equinoctial points have no declination, that the declination of the tropical points is 23;33°, and that the declination of the remaining degrees of the ecliptic is less than

[21] For example, if the degree of mediation of a star A is among the southern zodiacal signs, and the star is situated on the meridian between the ecliptic and the equator, its 'latitude' will be to the north, although PA>P'A, where P, P' are the north and south celestial poles respectively.

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23;33º. The method of P12 is the same, presented in a concise way, without mentioning the values of the declination. It is worth noting here the value 23;33º for the obliquity of the ecliptic, which is given as the declination of the tropical points. The same value is used by al-Farghānī (ninth century) in his treatise *al-Kāmil* on the astrolabe.[22]

Chapter P13: To know the ortive amplitude of every star among the drawn stars, or a degree among the degrees of the zodiac; to know the distance between the risings of two stars and to know the distance between these two stars

To determine the ortive / eastern amplitude of a star or degree of the ecliptic, the star or degree is placed at the east horizon, by rotating the globe. The distance of the star or degree from the East point of the horizon, measured in degrees of the horizon, is its ortive amplitude and this is equal to its occiduous / western amplitude. This varies with latitude.[23]

The distance of the two stars is measured on the horizon or the meridian as the difference between the ortive amplitudes or between the declinations of two stars, respectively.

By placing the two stars successively on the horizon and putting marks at the positions of their risings on the horizon, the distance between their rising points can be measured in degrees of the horizon. This depends on the latitude of observation, so the pole has to be placed at the elevation corresponding to the preferred latitude.

By placing the two stars successively on the meridian and putting marks at the positions of the transits of these stars (ممرّي الكوكبين) on the meridian, the distance between the points, where these stars culminate, can be measured in degrees of the meridian ring. This difference does not vary with the latitude, because it is equal to the difference of their declinations.

Comparison with treatise Q

Chapter P13 includes Q25, 26, 27 and 31.

In Q25 the ortive amplitude of a star is determined: the globe is turned so that the star comes to the east horizon and a mark is put at the corresponding degree of the horizon. The globe is then turned again, so that either equinoctial point comes to the east horizon and another mark is put there. The degrees between the two marks provide the ortive amplitude of the star; the direction of

[22] See al-Farghānī, *On the Astrolabe* (ed. transl. Lorch), pp. 70–71.

[23] The text of Chapter P13 seems to have an omission here: The phrase 'This changes as latitude varies. For this reason it is necessary to place the pole at the latitude of the city' should refer both to the determination of ortive amplitude and of the distance between the risings of two stars, but this is not clear enough in the way it is preserved in treatise P.

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this amplitude can be to the north or to the south, depending on the position of the rising of the star on the horizon in relation to the East Point.

In Q31 the ortive amplitude of a degree of the ecliptic is determined; the procedure is similar to that of Q25, without mentioning a second turn of the globe; the East Point on the horizon is specified as the 'degree of the rising of the beginning of Aries' (جزء طلوع أول الحمل). The direction of the ortive amplitude to the north or south is also examined, as in Q25.

In P13 the ortive amplitude of both a star and a degree of the ecliptic are studied simultaneously, avoiding the repetition of the method. The second turn of the globe mentioned in Q25 is omitted in P13, since the equinoctial points rise from the East Point (نقطة المشرق) of the horizon, and this point already exists on the horizon. The direction of amplitude is not examined in P13, but the additional information that the occiduous amplitude is equal to the ortive is presented.

In Q26 the distance between two stars is measured by placing them successively on the meridian and counting the degrees of the meridian between their points of culmination. The same procedure is presented at the end of P13, where the term 'the transits of the two stars' (ممرّي الكوكبين) is used; this term does not appear in Q26.

In Q27 the distance between the ortive amplitude of two stars is measured by placing them successively on the east horizon and counting the degrees of the horizon between their points of rising. The same procedure is presented in P13; the term 'the transits of the two stars' is also used here in P13, but not in Q27.

Both treatises clarify that the measurement of the ortive amplitude on the horizon depends on the latitude of the locality, so the north pole of the globe must be adjusted according to that latitude, while the measurement of the distance on the meridian does not depend on the latitude, so the globe can be adjusted to any latitude.

Chapter P14: To know the stars that rise simultaneously, culminate simultaneously and set simultaneously

For an observer situated at the terrestrial equator (latitude $\varphi=0°$), two stars rising simultaneously have the same right ascension; that is, they belong to the same great semicircle passing through the two celestial poles (Figure 15). Since the celestial poles are situated on the horizon at this locality, the rotation of the celestial sphere keeps the two stars on the same semicircle, thus they culminate simultaneously and set simultaneously. This situation can be simulated with the celestial globe, when the celestial poles are likewise placed on the horizon.

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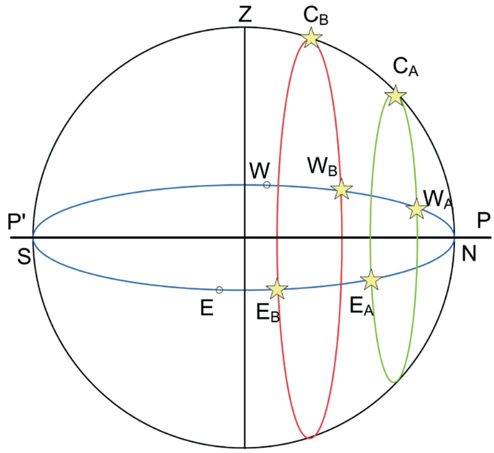

Figure 15: At the terrestrial equator, stars A and B rise simultaneously at points E_A and E_B, culminate simultaneously at points C_A and C_B, and set simultaneously at points W_A and W_B, respectively.

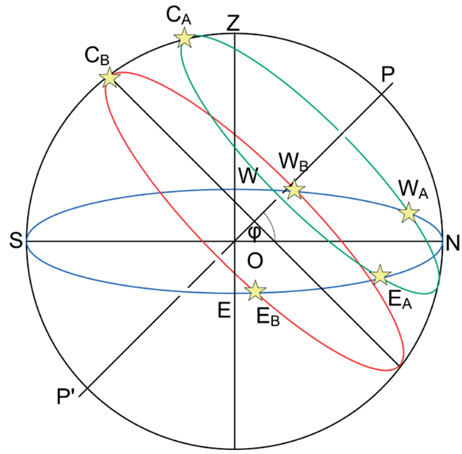

Figure 16: At any latitude $\varphi \neq 0°$, the stars A and B rise at points E_A and E_B, culminate at points C_A and C_B, and set at points W_A and W_B, respectively.

Although, at any place on Earth, stars with the same right ascension – that is, belonging to the same great semicircle passing through the two celestial poles – will culminate simultaneously, for an observer situated at any locality except for the terrestrial equator (latitude $\varphi \neq 0°$), these stars neither rise nor set simultaneously. This happens because, during the rotation of the celestial sphere, this great semicircle never coincides with a part of the horizon, since two points of it – the two celestial poles – do not belong to the plane of the horizon. For the same reason, two stars that rise simultaneously can never culminate simultaneously at any latitude $\varphi \neq 0°$.

Let two stars A and B rise simultaneously, at a locality of latitude $\varphi \neq 0°$, crossing simultaneously the east horizon at points E_A and E_B respectively (Figure 16). These stars transit the meridian at points C_A and C_B and set at the points W_A and W_B of the west horizon respectively. If star A is closer to the north pole than star B, then the arc E_AC_A corresponds to a greater angle than the arc E_BC_B, and the arc C_AW_A corresponds to a greater angle than the arc C_BW_B. The apparent motion of these two stars on the celestial sphere is a circular motion with the same angular velocity, thus star B will arrive at the meridian before star A, and similarly star B will set before star A.

The above phenomena are concisely presented at the beginning of the chapter; then a verification with the celestial globe follows:

In the first case the poles of the globe are placed on the horizon (Figure 15); a rotation of the globe demonstrates that if two stars rise simultaneously, then they culminate simultaneously and set simultaneously.

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The second case is presented as follows: ʿThen elevate the pole any number (of degrees you want) and rotate the globe until one of them falls at the middle of the sky or the west horizon, and you will find the other star passing beyond it or not (yet) arriving at it.'

There is a problem here: if the two previous stars were used, they would culminate simultaneously, since they have the same right ascension. It is obvious that there is an omission in the procedure here: after the north pole is elevated, there must be 'two stars rising simultaneously on the east horizon'; then the globe must be rotated so that one of these stars arrives at the meridian or the west horizon. At that moment, the other star has not yet arrived or has already surpassed the meridian or the west horizon.

Comparison with treatise Q

Chapter P14 corresponds to Q28. Both texts are similar; there are only some differences in wording, while the author of treatise P tried to present the contents of Chapter Q28 in condensed form.

The most remarkable point is that the omission of the phrase 'two stars rising simultaneously on the east horizon' in P14 occurs also in Q28, in all three Cairo manuscripts (A, B and L) and manuscripts N[24] and R (from Istanbul and Paris respectively) of the treatise by Qusṭā, while the text is complete in manuscripts C, D and E (London), H, I and O (Istanbul), K (Damascus), M (Princeton), T (Tirana), U (Hydarabad), Z (Meshhed) and the Latin translation of the same treatise.[25] In manuscript F from Cairo, now in the Manuscript

[24] The manuscript was copied in 661 H / AD 1263, while Constantinople was the capital of the Byzantine Empire, thus it does not originate from Istanbul.

[25] See the second paragraph of chapter Q28 in Appendix 3. The omitted passage is 'الكوكبان على حلقة الأفق. ثمّ أدر الكرة حتّى يصير' and it is written in italic font in the English and Latin translations below.
Translation of the second paragraph of Chapter Q28: 'If you want to know that with the globe, place the north pole on the horizon and rotate the globe, then you see that the stars that come to the east horizon simultaneously, come also to the line of the middle of the sky (meridian) simultaneously, and come to the west horizon simultaneously. Then elevate the north pole from the horizon as many degrees as you want, and rotate the globe until *the two stars* come *on the horizon ring. Then rotate the globe until* one of the two stars *comes* to the ring of the meridian line, then you see the that other star has already surpassed it or has not yet arrived at it; similarly it will be obvious / visible to you, if you rotate the globe until one of the stars comes to the west horizon.'
Note: the two stars that rise simultaneously after the north pole has been elevated cannot be the same two stars that rise, culminate and set simultaneously when the poles of the globe are on the horizon.
The Latin translation of the above extract, as edited by Lorch and Martínez Gázquez, ʿQusta ben Luca', p. 42, l. 541–49, is the following: 'Et cum uolueris hoc scire in spera pone polum septemtrionalem in orizonte et uolue speram. Tunc uidebis quod stelle que sunt in orizonte simul, erunt eciam in ipsa reuolucione spere sub linea meridiei simul. Et erunt eciam super orizonta occidentalem simul. Post hec eleua polum septemtrionalem super orizonta quotcumque gradibus uolueris.

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Library of the University of Pennsylvania, the folio that should contain Chapters 22–29 is missing.

The omission of the phrase in treatise P could thus be related to its omission in certain manuscripts of treatise Q. If the omission in both instances is not coincidental, one might suppose that the author of treatise P used an ancestor manuscript of the Cairo manuscripts, or a related one to manuscript N, having the same omission and did not realize that there was an error, so he summarized the method without correcting the mistake.

Chapter P15: To know the degree of rising of any star, among the stars drawn on the globe, the degree of its meridian transit and the degree of its setting at the various latitudes

The degrees of the ecliptic that rise, culminate and set simultaneously with a star drawn on the globe are determined by rotating the globe so that the chosen star arrives at the east horizon, the meridian ring and the west horizon respectively, and observing which degree of the ecliptic arrives simultaneously with the star at that circle. The degree that culminates simultaneously with the star (the degree of mediation) does not depend on the latitude of the locality, while the other two degrees do. For this reason the globe should be adjusted to the preferred latitude.

Comparison with treatise Q

Chapter P15 is almost identical to Q29, with minor differences in wording. The author of treatise P clarifies in the title that the method concerns only the stars drawn on the globe, which is not mentioned in the title of Q29.

Chapter P16: To know the ascensions (rising times) of the zodiacal signs and the ascension of a degree in the right and oblique spheres (right and oblique ascension)

The ascension (rising times) of any zodiacal sign in the right and oblique spheres is measured using the globe by placing successively the first and last point of the sign on the east horizon, marking the degrees of the equator that arrive simultaneously with these two points on the horizon and counting the number of degrees of the equator between the two marks. When the pole of the globe is on the horizon, a position that corresponds to latitude $\varphi=0°$, the

Et uolue speram donec fuerint *ambe stelle super circulum orizontis simul. Post hec uolue speram donec* sit una 2 stellarum sub circulo meridiano. Tunc uidebis alteram stellam ultra processisse uel citra remansisse. Et idem aparebit tibi cum conuerteris speram donec sit una 2 stellarum super orizonta occidentis'.

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result is the right ascension; when the pole is elevated φ degrees, then the result corresponds to the oblique ascension for a latitude φ. It is also noted that the right ascension can be measured on the meridian ring instead of the east horizon, regardless of the elevation of the pole.

With the same procedure, the ascension of any degree of the ecliptic can be measured, starting from the beginning of Aries, that is the point of the spring equinox, and ending at that degree of the ecliptic.

Comparison with treatise Q

Chapter P16 includes the procedures of Chapters Q32 and Q33, with additional instructions on how to determine the ascension of any degree of the ecliptic. The procedure is described only once in P16, while in Q32 and Q33 it is repeated with all its details three times.

In Q32, the north pole is placed on the horizon and the sign of Aries is used to determine the right ascension on the east horizon. After that, it is stated that the same method can be applied for all other signs. It is then mentioned that the meridian ring can be used for the same purpose and the procedure repeated for any zodiacal sign, replacing the 'east horizon' with the 'meridian ring'. In the latter case, the pole of the globe may have any elevation.

In Q33 the oblique ascension of any sign is measured, using again the same procedure; the only difference is that now the globe is adjusted to a given latitude φ.

The author of treatise P presents all of the above in a concise and smart way, avoiding the repetitions and adding the determination of the ascension for any degree of the ecliptic.

Chapter P17: To know the stars of perpetual apparition, perpetual occultation, and those that rise and set, among the stars drawn on the globe

The poles are placed on the horizon and the globe is rotated so that a star comes to the upper meridian (Figure 17). The distances p, p′ of the star from the north and south celestial poles, respectively, are counted on the meridian ring. For a city having (north) latitude φ, the polar distances are then compared to the latitude:

- If $p \leq \varphi$, which means the star is within arc AN, then the star is of perpetual apparition (always visible) at this latitude.
- If $p' = \varphi$, which means the star coincides with point C, then the star touches the horizon and the rest of the time is below the horizon.
- If $p' < \varphi$, which means the star is within arc SC, then the star is of perpetual occultation (always invisible) at this latitude.

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- If p′>φ (it should be 'p′>φ and p>φ', but only the former condition is mentioned), which means the star is within arc CA, then the star rises and sets.
- For the stars for which p>p′, which means the stars are within arc ZN, their stay above the horizon is longer than below it.
- For the stars for which p′>p, which means the stars are within arc SZ, their stay above the horizon is shorter than below it.

The whole study concerns only northern latitudes.

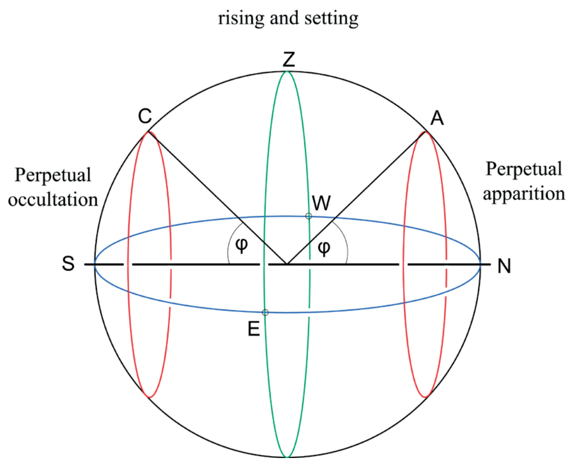

Figure 17: Rising and setting of the stars according to P17.

Comparison with treatise Q

Chapter P17 includes the subjects of Q34 and Q35, but the method presented in P17 is not the same as the methods of Q34 and Q35.

The title of Chapter Q34 announces that it concerns stars of perpetual apparition, but in fact rising and setting stars are also examined in the chapter. For this reason, the north pole of the globe is elevated according to the latitude φ of the locality and the globe is turned a whole rotation (Figure 18). The following possibilities are examined:

1. The stars that reach the meridian between the north pole P and the horizon (circle ENWS) never set, but make circles above the horizon.
2. The stars that arrive at the meridian between the north pole and the equator (circle EBW) rise and set; those closer to the north pole spend

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longer time above earth and those closer to the south pole spend longer time below earth.

The proposition 'the stars that arrive at the meridian between the north pole and the equator rise and set' means that the stars that culminate between points P and B rise and set (where B is the culminating point of the equator); this is not correct, because the stars that culminate between points P and A (where A is the point of the meridian having an elevation of 2φ degrees above the north horizon) do not rise and set, but are always above the horizon. The correct statement is that the stars that culminate between points A and S rise and set.[26]

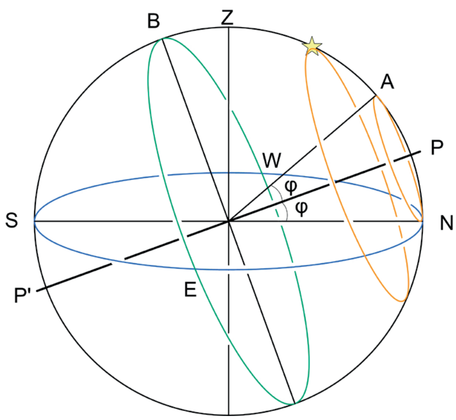

Figure 18: The method of Q34.

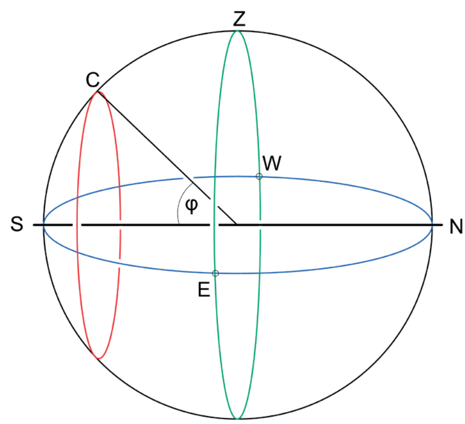

Figure 19: The method of Q35.

The title of Chapter Q35 announces that it concerns stars of perpetual occultation, but again the rising and setting stars are also examined. For this reason, the south pole of the globe is placed on the horizon (Figure 19) and a mark is put on the meridian ring at point C that has an elevation of φ degrees from the south horizon, where φ is the latitude of the city. Rotating the globe, the following possibilities are examined:

1. The stars that reach the meridian between the south pole S and point C never appear in that city.
2. The stars that reach the meridian between point C and the equator (circle EZW) towards the other pole (i.e. within the arc CZN) are visible in this city.

It is also noted that where the latitude is very small, there are few stars of perpetual occultation, and where the latitude is large, there are many of these.

The author of treatise P corrected the error that appears in Q34, and extended the method that appears in Q35 in order to cover all relevant cases.

[26] The Latin translation of treatise Q has also been checked and contains the same information.

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Chapter P18: To know the stars that set after the Sun and rise before it in one night, and to know the stars that are above the horizon during the whole night

The polar distance p_s of the star and that of the degree of the Sun p_d must be first determined. If $p_s<p_d$ and the star is *close* to the west horizon (at point S_1) at sunset, when the Sun is at point D_w (Figure 20), then the star sets (at point S_w) after the Sun and rises before it (the star rises at S_e, and the Sun rises at D_e when the star is at point S_2). The term 'close' is not, however, adequate; the star could be close but below the horizon, implying it has set before the Sun. The term 'approaching' describes the situation better.

If $p_s<p_d$ and the star is close[27] to the east horizon (at point S_1) at sunset, when the Sun is at point D_w (Figure 21), then the star will be above the horizon during the whole night. This does not necessarily mean that the star does not rise and set, but that it may rise close to sunset (at point S_1) and set close to sunrise (at point S_2), when the Sun is at point D_e.

As the latitude increases, the extent to which the rising and setting of the star is either advanced or delayed, in comparison to that of the Sun, will also increase.

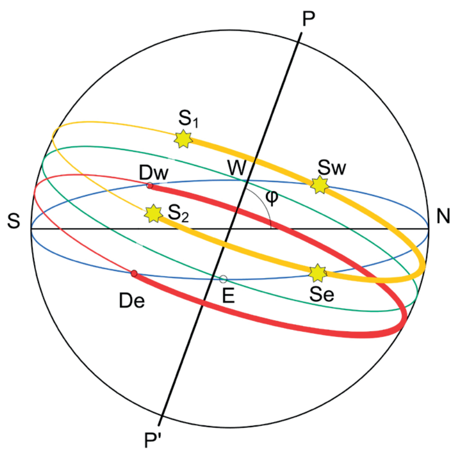

Figure 20

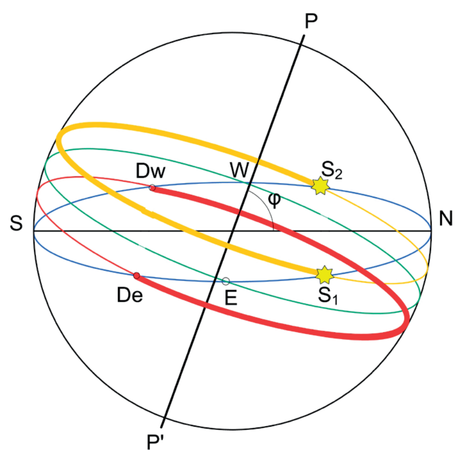

Figure 21

Figures 20–21: Blue circle SWNE: horizon, green circle: equator, yellow circle S_1S_2: the diurnal circle of the star, red circle D_eD_w: the diurnal circle of the degree of the Sun, PP′: the celestial axis.

[27] In this case, the star can be above, on or in a short distance below the horizon. Since stars are not visible at sunset and for some time thereafter, the star will have risen above the horizon at dusk, which can be considered as the beginning of night.

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Comparison with treatise Q

Chapter P18 includes the subjects of Q36 and Q37; the method presented in P18 is more general and mathematically expressed.

Q36 presents a study for the stars that can be seen twice in one night: after sunset on the west side and before sunrise on the east side (Figure 20). In the title, it is explained that this is possible for stars near the north pole, when the Sun is among the southern zodiacal signs.

The north pole is elevated according to the latitude of the locality, and the globe is rotated until the degree of the Sun arrives at the west horizon (at point D_w). The stars that are above the horizon (a star among them is at point S_1), approaching the west horizon, will be visible after sunset that night. Then the globe is rotated and these stars set (the same star sets at point S_w) after the degree of the Sun. By the time the degree of the Sun arrives at the east horizon (at point D_e), the same stars have already risen (the star rises at point S_e) before sunrise (at sunrise the star is at point S_2 above the horizon). Having set after sunset and risen before sunrise, these stars are thus visible twice in the same night.

In Q37 there is a study for the stars that are visible above the horizon during the entire night, on a given day and locality (Figure 21).

The north pole is first elevated according to the latitude of the given locality, and the globe is rotated until the degree of the Sun arrives at the west horizon (at point D_w), observing those stars that reach the east horizon (a star among them is at point S_1). Then the globe is rotated until the degree of the Sun arrives at the east horizon (at point D_e); the stars, among those previously observed, that approach the west horizon (the star is now at point S_2) do not set at this locality at that night and are visible above the horizon the whole night.

The author of treatise P changed the descriptive methods of Qusṭā's treatise, introducing a mathematical expression: the polar distance of the star and that of the degree of the Sun are determined, and the comparison between their values, in addition to the position of the star at sunset, leads to the conclusions.

The author of treatise P also changed the wording, making it more rigorous: In the three first cases of Table 7, references to the visibility of the star are replaced by more accurate references to the setting and rising of the star.[28] In the fourth case, the problem is approached in a more general way, with the range of positions of the stars and the degrees of the ecliptic widened.

28 Determining the visibility of a star is more complicated than ascertaining its position in relation to the horizon. Its visibility depends on various factors, such as its magnitude, altitude at the moment of sunrise or sunset, weather conditions, and so on. These factors are not taken into consideration in treatises P and Q, and thus it is more accurate to state that the star rises before the sun and sets after it, than that the star is visible before sunrise and after sunset.

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	P18	Q36-37
1	the stars that set after the Sun and rise before it الكواكب التي تغيب بعد الشمس وتطلع قبله	the stars that can be seen ... after sunset in the west and ... before sunrise in the east الكواكب التي تُرى ... بعد غروب الشمس في المغرب ... وقبل طلوع الشمس في المشرق
2	the stars set after the Sun الكواكب تغيب بعد الشمس	the stars are visible at the west after sunset الكواكب تكون ظاهرة في المغرب بعد غروب الشمس
3	the stars will be ... above the horizon (lit. earth) during the entire night الكواكب... في الليل كله فوق الأرض	the stars ... are visible above the horizon the entire night الكواكب ... تكون ظاهرة فوق أفق الليل كلّه
4	The stars ... whose distance (from the north pole) is less than the distance of the degree of the Sun (from the north pole) in a significant decrease الكواكب ...التي أبعادها (عن القطب الشمالي) قليلة من بعد جزء الشمس (عن القطب الشمالي) قلّة معتد بها	this is possible for the stars near the north pole, when the Sun is among the southern zodiacal signs هذا يتهيّأ في الكواكب القريبة من القطب الشمالي، إذا كانت الشمس في البروج الجنوبية

Table 7: Comparison between the terminology in P18 and the corresponding Chapters Q36-37

A subject similar to Chapter Q36 and the first part of P18 is discussed in Chapters 14 and 15 of the second book of the treatise *On Risings and Settings* (*Περὶ ἐπιτολῶν καὶ δύσεων – De ortibus et occasibus*) by Autolycus (360-290 BC).[29] In these chapters, he states that for the stars situated to the north of the zodiac circle, if the distance between the degrees of the zodiac that set and rise simultaneously with them is equal to (Chapter 14) or greater than (Chapter 15) one zodiacal sign, then these stars will be seen setting after sunset and rising before sunrise in the same night.[30] The text of Autolycus is as follows:

	Greek text	English translation
II. 14	Τοῖς ἀπολαμβανομένοις ὑπὸ τοῦ ζῳδιακοῦ κατὰ τὰς δύσεις ἐπὶ τὰ πρὸς ἄρκτους, ἐὰν τὰ συνδύνοντα ἀπὸ τῶν συνανατελλόντων ἀπέχῃ ζῳδίου περιφέρειαν, ἐκεῖνα κρύψιν οὐκ ἄξει ἀλλὰ τῆς αὐτῆς νυκτὸς ἑῷά τε ἐπιτέλλοντα καὶ ἑσπέρια δύνοντα φανήσεται.	For the stars that are intercepted by the zodiac on the western side towards the north, if the distance between the degrees of the zodiac which set and rise simultaneously with them is equal to an arc of one zodiac sign, they will not disappear; the same night they will be seen to rise before the sun and to set after the sun.

29 Autolycos de Pitane, *La sphère en mouvement. Levers et couchers héliaques* (ed. transl. Aujac); Mogenet, *Autolycus de Pitane*; and Autolyci, *De sphaera quae movetur liber. De ortibus et occasibus* (ed. Hultsch).

30 Autolycos de Pitane, *La sphère en mouvement* (ed. transl. Aujac), pp. 126–29; Mogenet, *Autolycus de Pitane*, pp. 253–54, and Autolyci, *De sphaera quae movetur* (ed. Hultsch), pp. 146–51. The French translation of the titles of Chapters 14 and 15 by Aujac is on pp. 126 and 128.

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II. 15	Ὅσα τῶν ἄστρων ἀπολαμβάνεται ὑπὸ τοῦ ζῳδιακοῦ κατὰ τὰς δύσεις ἐπὶ τὰ πρὸς ἄρκτους, τούτοις ἐὰν τὰ συνδύνοντα ἀπὸ τῶν συνανατελλόντων ἀπέχῃ πλέον ζῳδίου περιφερείας, ἐκεῖνα οὐκ ἄξει κρύψιν, ἀλλὰ τῆς αὐτῆς νυκτὸς ἑῷα ἐπιτέλλει καὶ ἑσπέρια δύνει ἀπὸ τῆς ἑῴας ἐπιτολῆς μέχρι τῆς ἑσπερίας δύσεως.	For the stars that are intercepted by the zodiac on the western side towards the north, if the distance between the degrees of the zodiac which set and rise simultaneously with them is greater than an arc equal to one zodiac sign, they will not disappear; the same night they rise before the sun and set after the sun, from their heliacal rising until their heliacal setting.

In Chapters 17 and 18 of the second book of the same treatise, Autolycus discusses the case of stars situated to the south of the zodiac circle. For these stars, he states that if the distance between the degrees of the zodiac which set and rise simultaneously with them is equal to (Chapter 17) or greater than (Chapter 18) one zodiacal sign, then these stars could be seen rising after sunset and setting before sunrise in the same night.[31] These chapters do not describe exactly the same situation as Chapter Q37: Autolycus examines the rising and setting of a southern star in the same night, while Qusṭā examines the stars that remain above the horizon the entire night.

It is probable that Qusṭā was influenced by the treatise *On Risings and Settings* by Autolycus, since there is some evidence that he was the translator of this treatise from Greek into Arabic.[32] Further evidence for Autolycus' influence is the use of the terms ظاهر ('visible') and الكواكب التي تُرى ('the stars that are seen') by Qusṭā; similar terms are used by Autolycus, e.g.: τῆς αὐτῆς νυκτὸς ἑῷά τε ἐπιτέλλοντα καὶ ἑσπέρια δύνοντα φανήσεται[33] ('they will be seen rising in the morning and setting in the evening of the same night') and τὸ ἄστρον ἀνατέλλον ὁρᾶται[34] ('the star is seen rising').

[31] Autolycos de Pitane, *La sphère en mouvement* (ed. transl. Aujac), pp. 131–34; Mogenet, *Autolycus de Pitane*, pp. 256–58, and Autolyci, *De sphaera quae movetur* (ed. Hultsch), pp. 154–59. The French translation of the titles of Chapters 17 and 18 by Aujac is on pp. 131–33. An English translation of these titles is as follows:

II. 17: 'For the stars intercepted by the zodiac on the western side towards the south, if the distance between the degrees of the zodiac which set and rise simultaneously with them is equal to an arc of one zodiac sign, on the same night they will be seen to rise immediately after the sun has set and to set immediately before the sun rises. They will disappear for a longer time than the stars on the zodiac.'

II.18: 'For the stars intercepted by the zodiac on the western side towards the south, if the distance between the degrees of the zodiac which set and rise simultaneously with them is greater than an arc of one zodiac sign, they will go from their rising in the dawn to their setting in the dawn, after that to their rising in the evening, then to their setting in the evening. On the same night they will be seen to rise and set from their earlier setting in the dawn until their later rising in the evening. They will disappear for a longer time than the stars on the zodiac.'

[32] According to the manuscript Leiden, Universiteitsbibliotheek, Or. 1031,1 (ff. 1–21), the treatise of Autolycus was translated into Arabic by Qusṭā ibn Lūqā, see Sezgin, *GAS*, vol. VI, p. 73.

[33] From the above-mentioned title of Chapter 14.

[34] Autolycos de Pitane, *La sphère en mouvement* (ed. transl. Aujac), p. 255, l. 9–10.

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Chapter P19: To know at what time the stars drawn on the globe rise and set

The pole is first placed according to the latitude of the locality and the globe is rotated so that the degree of the Sun arrives at the west horizon; at this position, a mark is put on the rising degree d_1 of the equator. The globe is then rotated so that the selected star arrives at the east or the west horizon; at each of these positions a mark is put on the rising degree d_2 of the equator. The difference

$$r = \begin{cases} d_2 - d_1, & \text{if } d_2 \geq d_1 \\ 360° + d_2 - d_1, & \text{if } d_2 < d_1 \end{cases}$$

is the arc of revolution between sunset and the rising or setting of the star, while $r/15$ provides the time of the star's rising or setting in equal hours after sunset and r/n provides the corresponding time in seasonal nighttime hours after sunset, where n is the number of degrees of one seasonal nighttime hour of this night.

Comparison with treatise Q

Chapter P19 includes Chapters Q38 and Q39.

Q38 estimates the time of rising of a star, and Q39 the time of its setting; the procedure in both chapters is similar to that presented in P19. The only remarkable difference is in Chapter Q39, where the hours of setting of the star after sunset are also mentioned as 'the duration of this star's staying above the earth' وهي ساعات مقام ذلك الكوكب فوق الأرض, i.e. the time between the sunset and the setting of this star.

Chapter P20: To know the time of rising of the Moon and the planets and the time of their setting

The pole is placed according to the latitude of the locality and the position of the Moon or planet is found using a *zīj* or another way.

The position of the Moon or the planet is described by its 'degree', its 'latitude' and the direction of the latitude. According to the method described, the 'degree' corresponds to the mediation, namely the degree of the ecliptic that culminates simultaneously with the Moon or planet on this day, while the 'latitude' is the difference of declination between the Moon or planet and its degree of mediation. The direction of latitude is to the north, when the Moon or planet is located north of the ecliptic, or to the south in the opposite case. The position of the Moon or planet is marked on the globe with the following procedure: the user must rotate the globe so that its 'degree' comes to the meridian and then count as many degrees of the meridian as the 'latitude' in the direction of the latitude towards the north or south. After this, the procedure is similar to that described in the previous chapter: the mark corresponding to the position of the Moon or planet is used instead of the star drawn on the globe.

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The arc of revolution between sunset and the rising or setting of the Moon or planet is determined and then divided by the degrees of an equal or seasonal nighttime hour; in this way the time of rising or setting is determined in either equal hours after sunset or seasonal nighttime hours after sunset.

There is an important phrase omitted in the text of all twenty-two manuscripts of treatise P examined (P20 is not included in manuscript N), but present in the treatise of Qusṭā:[35] 'Then you rotate the globe so that the mark of the Moon or planet arrives at the west or east horizon, and you put a mark on the degree of the equator that has reached the east horizon with it'. Without this phrase the procedure is not complete.

The method described corresponds to the rising of the Moon or a planet during nighttime. This method can be adapted to determine the respective time during daytime by placing the degree of the Sun at the east horizon.

At the end of Chapter P20, the author adds the following comment: 'This rule is not in accordance with reality and its origin does not take into consideration the difference between the degree of the planet and the degree of its transit'. The author probably implies that if the *degree* and *latitude* of the Moon or planet were taken as the *ecliptic longitude* and *latitude* respectively, then the procedure could not give correct results; but, in fact, the method for determining the position of the Moon or planet on the celestial globe is correct, when the coordinates *mediation* and *difference of declination* are used.

Since the criticism of the rule seems to be for the coordinates and not for procedure, we may presume that the omission of approximately two lines did not occur in the original text of P20; it might have been an omission in an early copy on which all twenty-three manuscripts depend.[36]

Comparison with treatise Q

Chapter P20 includes Chapters Q40 and Q41. Q40 estimates the time of rising of the Moon or a planet during the night, whereas Q41 the time of their setting during the night; the procedure in both chapters is similar to that presented in P20. In Q41 it is noted that the position of the Moon or the planet can be found through a calendar or *zīj* (بتقويم أو بزيج); in the same chapter, the hours of setting of the Moon or planet after sunset are also mentioned as 'the period of its stay above the earth' فهو ساعات زمانية لمقام ذلك الكوكب فوق الأرض، ووقت غروبه.

[35] The corresponding passage exists in all seventeen manuscripts of the treatise Q that were examined and contain Chapters Q40–Q41, and in the glosses written in the lower and left margin of manuscript D of treatise P, where the whole Chapter Q40 is repeated.

[36] The omission could be caused by *saut du même au même*, since the missing passage starts with the word ثم ('then'), as the phrase after the omission, and ends with : وتضع العلامة على الجزء الذي وافى معه الأفق الشرقي من المعدّل ('and you put a mark on the degree of the equator that has reached the east horizon with it'), as the phrase that precedes the omission.

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Chapter P21: To know the midday altitude of the Sun on every day and the maximum altitude of any of the stars drawn on the globe

The north pole of the globe is placed according to the latitude of the locality and the globe is rotated so that the degree of the Sun or star arrives at the meridian. It must be examined whether the degree of the Sun or star is closer to the north or the south point of the horizon, that is whether the degree of the Sun or star culminates to the north or south of the zenith. Then the degrees of the meridian between the degree of the Sun or star and the horizon are counted, at their closest distance; this means that the counting starts from the south point S of the horizon to the Sun or the star (namely angle $\widehat{SOA}$ in Figure 22), if the culmination is to the south of the zenith, or from the north point N of the horizon to the Sun or star (angle $\widehat{NOB}$ in Figure 22), if the culmination is to the north of the zenith.

The number of degrees thus counted on the meridian provides the midday altitude of the Sun on that day, or the maximum altitude of the star. This altitude depends on the latitude φ of the locality, since the maximum altitude is given by the formulas $h_{max}=90°-\varphi+\delta$ for culmination to the south of the zenith and $h_{max}=90°+\varphi-\delta$ for culmination to the north of the zenith, where δ is the declination of the Sun or the star.

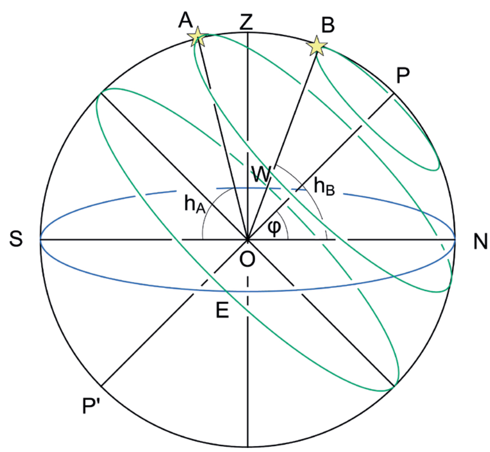

Figure 22: The star A culminates to the south of the zenith Z and the star B culminates to the north of the zenith.

Comparison with treatise Q

Chapter P21 includes Chapters Q42 and Q43. Q42 is concerned with the midday altitude of the Sun, whereas Q43 with the maximum altitude of a star drawn on the globe. The procedure described in both chapters is the same as that in P21.

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The method in Q43 is a more elaborate version of the second method presented in Chapter Q24, which also studies the maximum altitude of a fixed star drawn on the globe. The author of treatise P had included only the first method of Q24 in the corresponding Chapter P12, while the second method of Q24 is presented in P21 in a more elaborate way.

Chapter P22: To know the difference between the greatest altitude of the Sun on the same day in two cities with different latitudes

The maximum altitude of the degree of the Sun is measured on the meridian ring, when the pole of the globe is placed according to the latitude of each city, as described in the previous chapter. The difference of these two altitudes is the difference between the greatest altitude of the Sun in these two cities.

Comparison with treatise Q

Chapter P22 corresponds to Chapter Q44. The procedure is the same in both treatises, but in Q44 the method presented in Q42 is repeated, while in P22 it is mentioned that the measurement of the altitude is conducted according to the aforementioned way.

Chapter P23: To know the place in which the year is one day and where no star rises from the horizon and no star ever sets with the motion of the celestial sphere

One of the poles is placed at the zenith. If the north pole is at the zenith, the northern zodiacal signs will be above the horizon and the southern ones below it. If the south pole comes to the zenith, the southern zodiacal signs will be above the horizon and the northern ones below it. Thus, while the Sun is among the six signs above the horizon, there will be six months of daytime, and while it is among the six signs below the horizon, there will be six months of nighttime.

At this position, any point of the globe rotates on a circle parallel to the horizon and 'its motion will be rotary like the motion of a millstone', as described in Chapter P1.[37] Thus the stars do not rise or set. Although the title of P23 clarifies that no stars rise or set there, the text at the end of the chapter states that 'some of the fixed stars are in perpetual apparition and some of the fixed stars are in perpetual occultation'; this wording does not exclude the case that some stars rise and set. The correct expression

[37] The simile with the motion of a millstone is not repeated in Chapter P23, although it was mentioned in the corresponding Chapter Q46.

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could be 'the fixed stars are either in perpetual apparition or in perpetual occultation'.

Comparison with treatise Q

Chapter P23 includes Chapters Q45 and Q46.

Q45 deals with the place where the whole year is one day: 6 months of daytime and 6 months of nighttime. This place corresponds to a latitude of 90°, but only the case in which the north pole is at the zenith is described.

Q46 refers to the place that the stars do not rise and set, but rotate in a motion like the motion of a millstone, above or below the horizon. Thus the stars are either in perpetual apparition or occultation. Again, only the case in which the north pole is at the zenith is mentioned.

Chapter Q46 and, in part, Q45 apply the first proposition of the treatise *De habitationibus* of Theodosius (*c.* 100 BC)[38] to the celestial globe. The likelihood that Theodosius' treatise directly influenced treatise Q is further substantiated by the fact that the translation of the Greek text of *De habitationibus* into Arabic is ascribed to Qusṭā ibn Lūqā.[39] Chapter Q45 is related to Section 6.15 of Geminus' *Introduction to the Phaenomena*.[40] Both Chapters Q45 and Q46 are also related to Section II.6.39 of Ptolemy's Almagest.[41]

Although only the case of the north pole is mentioned in all of the related treatises (*De habitationibus*, *Introduction to the Phaenomena*, *Almagest*, treatise Q), the author of treatise P included the case where the south celestial pole is situated at the zenith, a position that corresponds to the locality of the south pole on earth.

Chapter P24: To know the place where the daylight is 24 equal hours

The altitude of a point of the celestial sphere in its upper culmination to the south of the zenith is $h_{max}=90°-\varphi+\delta$, while the altitude in its lower culmination is $h_{min}=\varphi-90°+\delta$, where φ is the latitude of the place and δ the declination of this point.

38 The Greek text of the treatise *De habitationibus* of Theodosius is included in Fecht, *Theodosii de habitationibus liber*. The Arabic and the Medieval Latin translations of the same treatise are edited by Kunitzsch and Lorch, *Theodosius, De habitationibus*. An English translation and comments by the authors are also included.

39 See Kunitzsch and Lorch, *Theodosius, De habitationibus*, pp. 9, 16.

40 The corresponding Greek text, as quoted in Manitius, *Gemini Elementa astronomiae*, p. 74, is the following: 6.15: Πέρας δὲ ἐστὶ τις χώρα ἐσχάτη πρὸς ἄρκτον κειμένη, ἐν ᾗ ὁ μὲν πόλος κατὰ κορυφὴν γίνεται, τοῦ δὲ ζῳδιακοῦ κύκλου ἓξ ζῴδια ὑπὲρ τὸν ὁρίζοντα ἀπολαμβάνεται, ἓξ δὲ ὑπὸ τὸν ὁρίζοντα ἀποτέμνεται· ἡ μεγίστη δὲ ἡμέρα παρ' αὐτοῖς ἑξαμηνιαία γίνεται, ὁμοίως δὲ καὶ ἡ νύξ. The English translation coming from Evans and Berggren, *Geminos's Introduction to the Phenomena*, Section 6.15, p. 164, is the following: 'The limit is a certain land lying in the extreme north, where the pole is at the zenith, and where 6 signs of the zodiac circle are cut off above the horizon and 6 are cut off below the horizon: there the longest day is six months long, and similarly the night'.

41 Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp. 116–17, and Toomer, *Ptolemy's Almagest*, p. 90.

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A point of the celestial sphere touches the horizon but does not set when $h_{min}=0°$. In general, in treatises P and Q, the declination of the first point of Cancer is taken as $\delta=24°$;[42] thus this point touches the horizon but does not set when $h_{min}=0° \Rightarrow \varphi-90°+\delta=0° \Rightarrow \varphi-90°+24°=0° \Rightarrow \varphi=90°-24° \Rightarrow \varphi=66°$.[43]

A point of the celestial sphere touches the horizon but does not rise when $h_{max}=0°$. The declination of the first point of Capricorn is taken as $\delta=-24°$; thus this point touches the horizon but does not rise when $h_{max}=0° \Rightarrow 90°-\varphi+\delta=0° \Rightarrow 90°-\varphi-24°=0° \Rightarrow \varphi=90°-24° \Rightarrow \varphi=66°$.

Thus, at the latitude $\varphi=66°$, the first point of Cancer does not set; this means that when the Sun is at this degree, that is the summer solstice, the length of daylight will be 24 hours. Similarly, at the same latitude, the first point of Capricorn does not rise; this means that when the Sun is at this degree, that is the winter solstice, the nighttime will be 24 hours.

The above results can be produced with the celestial globe, when the (north) pole is placed according to a latitude of 66°. At this position, a complete rotation of the globe shows that the first point of Cancer does not set, thus it produces 24 hours of daylight, and the first point of Capricorn does not rise, and thus produces 24 hours of nighttime.

Comparison with treatise Q

Chapter P24 corresponds to Chapter Q47. In Q47, the cases of the first point of Cancer and that of Capricorn are successively examined. The north pole of the globe is elevated 66° from the horizon. At this position, a complete rotation of the globe shows that the first point of Cancer does not set. When the Sun is at this degree, it will be daylight for the time of a day (النهار) and a night (الليل)[44] and so the duration of daylight will be 24 equal hours. When the Sun is at the first point of Capricorn, it does not rise; thus, the night will be 24 equal hours when the Sun enters Capricorn, and 'there will be no daylight at all'. The daylight increases and decreases the whole year 'from 1 hour' (من ساعة) to 24 hours. The above occur at the latitude of 66°.

[42] The declination of the first point of Cancer is equal to the obliquity of the ecliptic ε. The value of ε in Chapters P24, P26 and P27 and the corresponding Chapters Q47 and Q49–52 is rounded off as ε=24°, while in Chapter Q30 it is taken as ε=23;33°.

[43] In manuscript K of treatise P, the value of the terrestrial latitude has been corrected in the margin to 66;25 for both Chapters P24 and P25; this corresponds to ε=23;35°, and reflects an attempt to 'update' the value of the obliquity of the ecliptic.

[44] In the examined manuscripts, the variants زمان/أزمان النهار والليل or زمان الليل والنهار are used; this is the same as the term زمان الليل والنهار (*νυχθήμερον* / 'the time of a night and a day') used by Qusṭā in the Arabic translation of Proposition 12 of Theodosius (see Kunitzsch and Lorch, *Theodosius, De habitationibus*, pp. 64, 66, 68).

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This chapter is related to Section II.6.33 of Ptolemy's *Almagest*.[45] The same problem is discussed by Theodosius in Proposition 12 of *De habitationibus* – *Περί οἰκήσεων*,[46] showing again that Qusṭā was probably influenced by this work as he translated it from Greek into Arabic.

There is a contradiction at the end of Chapter Q47, however. Although the text mentions that at the latitude of 66°, when the Sun is at the first point of Capricorn, 'there will be no daylight at all', then it is written that 'the daylight increases and decreases the whole year *from 1 hour* to 24 hours'.[47] The daylight of 1 hour could reflect influence from Theodosius, who states in Proposition 12: [at these places] 'the Sun at the summer solstice remains above their horizon for the time of a night and a day (*nahār*) and *their day* (*nahār*) *at that time is 30 days* (*yawm*)' (see note 46). In the proof, Theodosius explains that the light of the Sun is visible to them when the Sun traverses an arc of half a sign before the summer solstice and half a sign after it. Since the total arc is one sign, the Sun traverses it in 30 days (*yawm*), so the day (*nahār*) at the entrance of the summer solstice is 30 days (*yawm*).[48]

It is obvious that Theodosius implies here that for 30 days there will be no darkness at all in these localities, although the Sun comes below the horizon, because of the twilight. Similarly, when the Sun is at the winter solstice, al-

[45] Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp. 114–15:
33: 'The parallel where the longest day is 24 equinoctial hours is 66;8,40° from the equator. This is the first of the (parallels) where the shadow goes full circle. For on that parallel, at the summer solstice (and then only), the Sun does not set, so the shadow of the gnomon points towards every part of the horizon [in turn]. There the parallel of the summer solstice is ever-visible, and the parallel of the winter solstice is ever-invisible, since both are tangent to the horizon, on opposite sides. And the ecliptic coincides with the horizon when the spring equinoctial point on it is rising.' (The translation into English comes from Toomer, *Ptolemy's Almagest*, p. 89).

[46] Kunitzsch and Lorch, *Theodosius*, *De habitationibus*, pp. 64–71, 89–91. The translation of Proposition 12 into English, as presented in the above edition, is the following: 'For those whose zenith is equally distant from the visible pole as the tropic is from the equator, the Sun at the summer solstice remains above their horizon for the time of a night and a day [nahār] and their day [nahār] at that time is 30 days [yawm]; at the winter solstice it remains for the time of a night and a day below the horizon, and the remaining days are to the remaining nights in proportion'.

[47] The phrase 'from 1 hour' (من ساعة) appears in twelve of the eighteen examined manuscripts; in manuscript D (f. 153v) this phrase is omitted, in manuscript L almost half of the text of Chapter Q47, including this phrase, is omitted, while in manuscripts C, S, T, U the passage from 'and there will be no daylight at all' until the end of the chapter has been replaced by the text: 'And (the length) of night and day increases according to the position of the Sun among the southern and the northern zodiacal signs in that latitude'. In the Latin translation of the treatise by Qusṭā, a corresponding phrase appears: 'Et ideo curn sol intrauerit primum gradum Capricorni erit *nox 24 horarum equalium sine die*. Et augebitur et diminuetur dies in aliis diebus anni *ab hora una* usque 24 horas' (see Lorch and Martínez Gázquez, 'Qusta ben Luca', p. 52, l. 808–10).

[48] Kunitzsch and Lorch, *Theodosius, De habitationibus*, p. 91.

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though the Sun does not rise above the horizon, the twilight gives a feeling of daylight, the duration of which is estimated as 1 hour by Qusṭā.

The author of treatise P unifies the study of the two solstitial points and omits the last proposition of Q47 referring to the 1 hour of daylight in the winter solstice at latitude φ=66°.

Chapter P25: To know the place where some of the zodiacal signs rise in the inverted order and set regularly and some of them the other way around

In this chapter, the order in which the zodiacal signs rise and set at a terrestrial latitude φ greater than 66° is examined.[49] Of the zodiacal signs that do rise and set at that latitude, those situated from the winter solstice to the summer solstice rise in the opposite order of the signs and set in their regular order, while those situated from the summer solstice to the winter solstice rise in their regular order, and set in the opposite order.

1st point of sign	longitude λ	declination δ	latitude φ of perpetual apparition	latitude φ of perpetual occultation
Aries	0	0	±90	±90
Taurus	30	11;40	+78;20	−78;20
Gemini	60	20;30	+69;30	−69;30
Cancer	90	23;51	+66;09	−66;09
Leo	120	20;30	+69;30	−69;30
Virgo	150	11;40	+78;20	−78;20
Libra	180	0	±90	±90
Scorpio	210	−11;40	−78;20	+78;20
Sagittarius	240	−20;30	−69;30	+69;30
Capricorn	270	−23;51	−66;09	+66;09
Aquarius	300	−20;30	−69;30	+69;30
Pisces	330	−11;40	−78;20	+78;20

Table 8: Perpetual apparition and occultation of the zodiacal signs depending on the latitude of the locality.

In northern or southern latitudes greater than 90°−ε,[50] there are some zodiacal signs that do not rise or set; these signs are either always visible or always invisible. The boundary latitude, where the first point of each zodiacal sign becomes always visible or always invisible, is presented in Table 8.[51] In this table, the dec-

[49] In manuscript K, this value has been corrected in the margin as 66;25 for both Chapters P24 and P25.

[50] In Chapter P25, 90°−ε is taken as 66°.

[51] At a northern latitude φ, any point of the celestial globe whose distance from the north celestial

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linations of the first points of the signs are taken according to Ptolemy's *Almagest*,[52] rounded off to the nearest minute. For the latitude of a terrestrial pole, the two equinoctial points rotate on the horizon, without rising or setting.

For northern latitudes greater than 90−ε (Figure 23), the degrees of the ecliptic having declination δ>90°−φ are always above the horizon (the arc between light grey arrows), while those with declination δ<φ−90° are always below the horizon (the arc between black arrows). The two degrees having declination δ=90°−φ (light grey arrows) touch the north point of the horizon but do not set, while the two degrees having declination δ=φ−90° (black arrows) touch the south point of the horizon and do not rise.

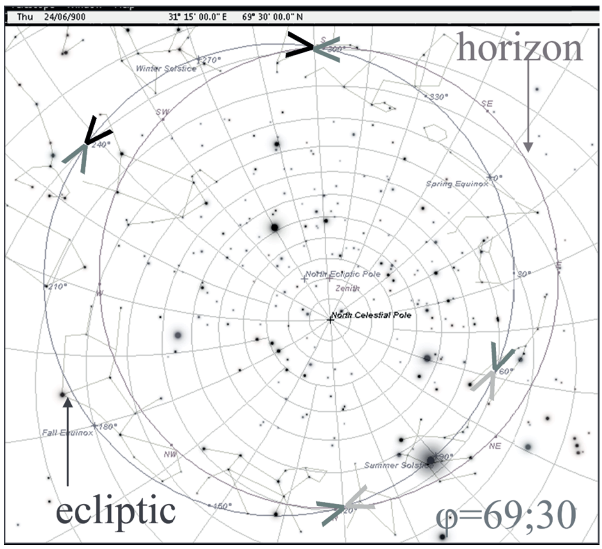

Figure 23: For latitude φ=69;30 N, the arc of the ecliptic between the light grey arrows does not set, that between the black arrows does not rise, and the two arcs between the dark grey arrows rise and set.

The degrees of the ecliptic with declinations that permit them to rise and set have the following particularity:

On the east side, those having ecliptic longitude λ, such that 90°<λ<270° (that is from the summer solstice to winter solstice) rise in the regular order.

pole is p≤φ is always visible and does not rise or set; this is equivalent to 90°−δ≤φ, where δ is the declination of this point. Similarly, any point of the celestial globe whose distance from the south celestial pole is p′≤φ is always invisible and does not rise or set; this is equivalent to 90°+δ≤φ, where δ is again the declination of this point. The opposite happens at southern latitudes.

[52] Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, Chapter I.15, pp. 80–81, and Toomer, *Ptolemy's Almagest*, p. 72.

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On the west side, the rest of the degrees, from winter to summer solstice, set in the regular order of the signs (Figure 24).

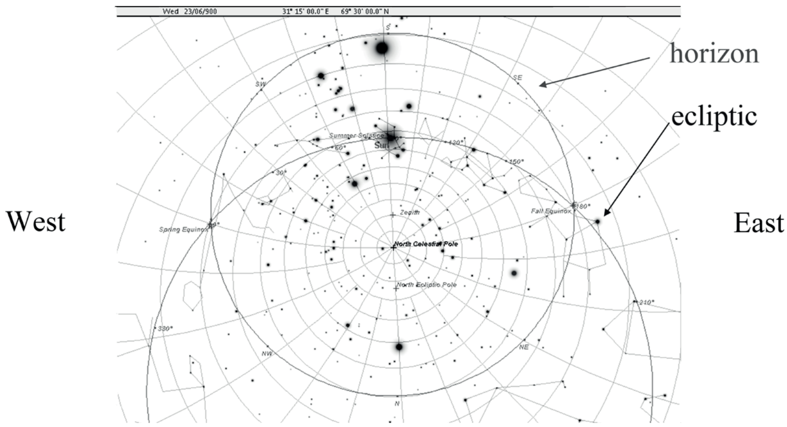

Figure 24: The degrees having ecliptic longitude λ such that 90°<λ<270° rise in the regular order, while those for which 270°<λ<360° or 0°<λ<90°set in the regular order.

On the east side, the degrees having ecliptic longitude such that 270°<λ<360° or 0°≤λ<90° (that is from winter solstice to summer solstice) rise in inverted order, while, on the west side, the rest of the degrees, from summer solstice to winter solstice set in the inverted order of the signs (Figure 25).

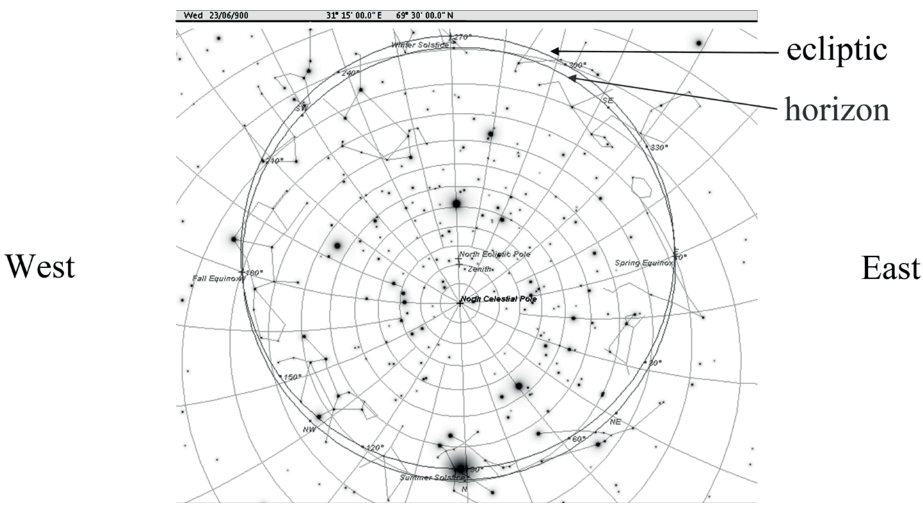

Figure 25: The degrees having ecliptic longitude λ such that 90°<λ<270° set in the inverted order of the signs, while those for which 270°<λ<360° or 0°≤λ<90° rise in the inverted order. (Figures 23–25 have been created using the software *Voyager 4.5.*)

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This happens because, at these latitudes, the north pole Π of the ecliptic, which culminates simultaneously with the degree of the ecliptic corresponding to the winter solstice σ', comes to the south of the zenith, while moving from east to west (Figure 26). In this case, on the eastern hemisphere, the distance of the more northerly degrees of the ecliptic from the zenith is less than the distance of the more southerly degrees of the ecliptic from the zenith. This results in the more northerly degrees of the ecliptic rising first, with the more southerly ones following, and in turn causes the signs from the winter solstice to summer solstice ($270° < \lambda < 360°$ or $0° \leq \lambda < 90°$) to rise in their inverted order. At the same time, on the western hemisphere, the more southerly degrees of the ecliptic set first, and the more northerly ones follow; resulting in signs from the summer solstice to winter solstice ($90° < \lambda < 270°$) to set in inverted order. While the north pole Π of the ecliptic moves from west to east (Figure 27), it remains to the north of the zenith, thus the zodiacal signs from the summer solstice to winter solstice ($90° < \lambda < 270°$) rise in their regular order and the signs from the winter to summer solstice ($270° < \lambda < 360°$ or $0° \leq \lambda < 90°$) set in their regular order. The opposite occurs in the southern hemisphere of the earth, but this is not mentioned.

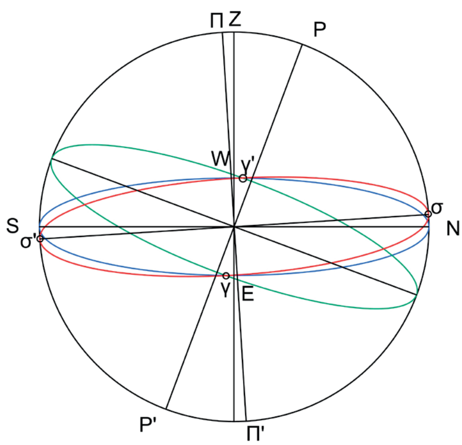

Figure 26: Rising and setting of the signs in the inverted order.

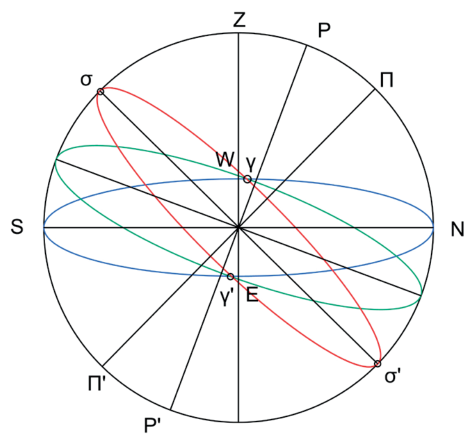

Figure 27: Rising and setting of the signs in the regular order.

Chapter P25 is related to Proposition 4 of the treatise *De habitationibus* of Theodosius,[53] where the simultaneous rising and simultaneous setting of six

[53] Kunitzsch and Lorch, *Theodosius, De habitationibus*, pp. 26–31, 78–79. The title of Proposition 4 in English translation, as presented in the above edition, is the following: 'For those whose zenith is as distant from the visible pole as one of the two tropics is from the orb of the equator, six [zodiacal] signs rise and set together'.

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zodiacal signs is proved for a terrestrial latitude equal to 90°−ε, where ε is the obliquity of the ecliptic. As already mentioned in the commentary of Chapters P23 and P24, this treatise of Theodosius had been translated into Arabic by Qusṭā ibn Lūqā.

Ibn al-Haytham (born *c.* 965, Basra, Iraq, died *c.* 1040, Cairo, Egypt),[54] in his treatise *On the Configuration of the World* هيئة العالم,[55] describes the case of latitude 90°−ε, where once a day the ecliptic coincides with the horizon; at that moment, six zodiacal signs rise simultaneously and six zodiacal signs set simultaneously. He then refers to the latitude of 90°, where half the zodiac circle never rises and the other half never sets. Between these two latitudes, a certain part of the ecliptic (بعض دائرة البروج) is always visible and its diametrically opposite is always invisible. The two arcs between these two parts rise and set; the arc (القوس) that has the point of vernal equinox as midpoint rises inverted (منكوسًا) and sets regularly (مستويًا) in this horizon, while the arc that has the point of autumnal equinox as midpoint rises regularly and sets inverted.[56]

Another Latin translation of the treatise of Ibn al-Haytham is preserved in the work of Stephen of Antioch *Liber Mamonis*, accompanied by his commentary.[57] Stephen not only presents the results of Ibn al-Haytham, but he also explains why the inverted risings and settings occur.

Comparison with treatise Q

Chapter P25 is a generalized version of Chapter Q48, the title of which is 'To know the place where Taurus rises before Aries'. Chapter Q48 states the following: At the latitude φ=78° North, the sign of Taurus precedes Aries in the rotation of the globe (الثور يتقدم الحمل في دوران الكرة), Aries has set but Taurus has not set (الحمل قد غاب والثور لم يغيب), and Aries rises after Taurus (الحمل

[54] The dates and locations are mentioned in Lorch, 'Ibn al-Haytham'.

[55] The Arabic text of the treatise is included on ff. 101r–116v of a *Compendium of Texts on Mathematics and Optics mostly by Alhazen* (ابن الهيثم), British Library: Oriental Manuscripts, IO Islamic 1270, in the Qatar Digital Library, see https://www.qdl.qa/en/archive/81055/vdc_100023619742.0x000001. A Latin translation of this treatise, known as *Liber Aboali*, was edited in Millás Vallicrosa, *Las traducciones orientales*, pp. 285–312. There is also another Latin translation of this treatise, with the title *Liber de celo et mundo*, edited by Mancha, 'La versión alfonsí', pp. 133–97. I am thankful to Prof. Dag Nikolaus Hasse who advised me of the existence of this Latin translation.

[56] The corresponding Arabic text of the treatise by Ibn al-Haytham is located on f. 107v of the manuscript London, British Library, IO Islamic 1270, while the same text in Latin translation is in Millás Vallicrosa, *Las traducciones orientales*, p. 297.

[57] Grupe, *The Latin Reception of Arabic Astronomy and Cosmology in Mid-Twelfth-Century Antioch*, pp. 211–12. I am thankful to Dirk Grupe who acquainted me with this work of Stephen of Antioch and Ibn al-Haytham.

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يطلع تاليا للثور). All of these take place because Taurus does not set, but Aries sets at this latitude.

The author of treatise P is not restricted to the content of Q48, but rather refers to a general ascertainment concerning the order of rising and setting of the zodiacal signs at any latitude greater than 66° (North); nonetheless he does not allude to the reason why the signs rise or set in inverted order.

Chapter P26: To know the cities where the Sun reaches the zenith once or twice a year

A demonstration of the Sun culminating at the zenith using the globe is presented in this chapter. It is mentioned that there is no shadow at the moment that the Sun reaches the zenith. The following cases are discussed in the text:

1. When the Sun is at the first point of Cancer, it reaches the zenith of the cities that have latitude $\varphi=24°$ (north). This happens once a year.
2. For the cities with latitude $0°<\varphi<24°$ the Sun reaches their zenith twice a year.
3. For the cities on the terrestrial equator ($\varphi=0°$), the Sun arrives at their zenith twice a year, when it is at the first point of Aries and at the first point of Libra; these two positions are not mentioned explicitly in the text.

To find when this happens, the degree of the meridian that corresponds to the altitude of 90 degrees, that is the zenith, must first be determined and marked. Then the poles of the globe are adjusted to the position corresponding to the given latitude φ, and the globe is rotated so that a degree of the ecliptic traversing under the zenith mark is determined. When the Sun is in that degree, then it culminates at the zenith of the locality having latitude φ.

Since the maximum altitude of the Sun for culmination to the south of the zenith is $h_{max}=90-\varphi+\delta$, the Sun arrives at the zenith when $h_{max}=90°$, namely when $\delta=\varphi$. So, if the latitude of a locality is known, the declination of the Sun that produces its culmination at the zenith of this locality can be directly determined.

In Chapter II.6, Sections 1–7 of the *Almagest*, Ptolemy examines the latitudes where the Sun culminates at the zenith, being those from the terrestrial equator to the seventh parallel through Syene.[58]

Comparison with treatise Q

Chapter P26 includes Q49, Q50 and Q52.

Chapter Q49 examines the general case that the Sun transits across the zenith of a locality with latitude less than 24°, as outlined in the following pro-

[58] Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp. 102–08, and Toomer, *Ptolemy's Almagest*, pp. 82–85.

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cedure. The pole of the globe is first placed at a latitude less than 24° and the position of the zenith on the meridian is marked, after measuring 90° on the meridian starting from the horizon. When the globe is rotated, a degree of the ecliptic will traverse under this mark. The Sun transits across the zenith, when it is on this degree. The chapter ends with the note that this happens for latitudes between 1 (*sic*) and 24°. There is no discussion of whether the Sun arrives at the zenith once or twice a year.

Chapter Q50 examines in which cities there is no shadow at some moment within the year, and determines the day and time that this occurs. It starts by explaining that there is no shadow when the Sun arrives at the zenith, and that this can happen only on the meridian. The procedure of Q49 is then repeated and the degree of the ecliptic that culminates at the zenith is determined. At noon on the day that corresponds to this degree of the ecliptic there is no shadow in this city, the latitude of which is less than 24°. There is no mention that there are two degrees of the ecliptic that reach the zenith for a latitude $\varphi<24°$.

Chapter Q52 examines in which cities the Sun reaches the zenith once or twice a year and when this occurs. When the latitude is 24°, the Sun reaches the zenith once: when it enters the first point of Cancer for northern latitude, and when it enters the first point of Capricorn for southern latitude. When the latitude is less than 24°, the Sun reaches the zenith twice: when it is on a degree of the ecliptic or on its 'counterpart in declination' (نظيره في الميل).[59] Then a verification using the globe follows, the procedure being the same as the one of Chapters Q49 and Q50.

The author of treatise P brought together the above three chapters, presenting the common procedure just once, in the last paragraph of P26. The culmination of the Sun at the zenith and the absence of shadow are studied together, thus avoiding repetition. The case in which the Sun reaches the zenith, when it is at the first point of Capricorn, for a southern latitude of 24° is not mentioned in P26, although it is included in Q52.

Chapter P27: To know the cities where the shadows are in one direction and those where they are in both directions

For a locality of latitude φ, if $\varphi<24°$ then the shadows (at noon) can be in two directions; otherwise (if $\varphi\geq24°$), the shadows (at noon) are in one direction. Both cases can be verified with the globe.

59 The term في الميل (in declination) has been encountered in only three (O, F and Z) of the seventeen Arabic manuscripts of Q that were examined and include this phrase; in manuscript N, the phrase 'when it is on a degree of the ecliptic or on its counterpart' has been omitted (f. 113r). When this term is not present, the meaning of the counterpart is not clear. The Latin translation clearly states that it is the degree equidistant from the beginning of Cancer or that of Capricorn: 'cum sol fuerit in uno duorum graduum zodiaci equidistancium principio Cancri uel principio Capricornio' (Lorch and Martínez Gázquez, 'Qusta ben Luca', p. 54, l. 865–66).

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In the first case, the pole is placed according to a latitude $\varphi<24°$. While rotating the globe, some degrees of the ecliptic traverse to the south of the zenith, and others to the north of it. For the former degrees, the corresponding shadows point towards the north and for the latter, the shadows point towards the south.

In the second case, the pole is placed according to a latitude $\varphi\geq 24$. While rotating the globe, there is no degree of the ecliptic that traverses to the north of the zenith, and thus the shadow points always towards the north.

In Chapter II.6 of the *Almagest*, Ptolemy examines the latitudes where the shadow is in both directions,[60] or in one direction,[61] and also when the shadow turns in a full circle.[62]

Comparison with treatise Q

Chapter P27 corresponds to Chapter Q51. In Chapter Q51 the cases where the latitude is either less or more than 24° are independently described, but the wording does not include the latitude $\varphi=24°$, as in P27. In the case that the latitude is greater than 24°, the Latin translation includes both cases of northern and southern latitude. The Arabic manuscripts present different variants at this point; some of them mention that the shadows will be to the north, and others to the south. Perhaps this is an indication that both cases of north and south latitudes had been included in the initial text, but I have not found both cases in any of the examined manuscripts.[63] Then it is explained that when the Sun is at the zenith there is no shadow; when it is to the north of the zenith, the shadows will be to the south; when the Sun is to the south of the zenith, the shadows will be to the north. At the end, there is a verification using the globe of the case when the latitude is less than 24°, similar to the first case presented in P27.

60 From the equator to the 6th parallel. Ptolemy uses the term *ἀμφίσκιος* for the parallel where the noon shadow can be in both directions (Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp. 102–07, and Toomer, *Ptolemy's Almagest*, pp. 82–85).

61 From the 7th to 32nd parallels. Ptolemy uses the term *ἑτερόσκιος* for the 'one-way-shadow' parallel (Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp. 107–14, and Toomer, *Ptolemy's Almagest*, pp. 85–89).

62 From the 33rd parallel to the north pole. For the parallel where the shadow goes full circle, Ptolemy uses the term *περίσκιος* (Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, pp, 114–17, and Toomer, *Ptolemy's Almagest*, pp. 89–90).

63 In manuscripts A, C, D, N, R, S, T and U, it is mentioned that 'When the north pole is elevated more than 24°, the shadows are to the north'; in manuscripts B, E, H, I, L and M, 'When the north pole is elevated more than 24°, the shadows are to the south'; in manuscripts F, Z and O 'When the pole is elevated less than 24°, the shadows are to the south'. Only the statement of the first group of manuscripts is correct. The erroneous statements of the other two groups could be caused either because of copying errors (*to the south* instead of *to the north*, and *less* instead of *more*), or by *saut du même au même*. In the latter case the text should be: 'When the north pole is elevated more than 24°, the shadows are to the north. When the south pole is elevated more than 24°, the shadows are to the south'. I have included this version in the Arabic text of Chapter Q51 in Appendix 3.

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The author of treatise P has added a second case in the part on verification with the globe, to show that for a latitude $\varphi \geq 24°$ the shadow will be always to the north.

Chapter P28: Determination of the meridian line and the *qibla*

In the procedure for measuring the Sun's altitude (Chapter P9), the needle casts no shadow when the globe is completely aligned to the celestial sphere; the meridian ring of the globe will then be aligned to the local meridian. Thus the meridian line can be determined according to the direction of the meridian ring, by drawing on the ground a straight line parallel to the horizontal diameter of the meridian ring.

The determination of the azimuth of the *qibla* (Figure 28) is conducted using the local meridian SN found above and the arc SQ, including its direction towards the east E or the west W; this arc is described as 'difference in longitude between the city and Mecca' (قدر الاختلاف بين المدينة ومكة في الطول). On the horizon ring, one must count as many degrees as this difference shows, starting from the meridian towards the given direction, and put a mark at the end. The line drawn on the ground from the centre O of the lower circular base of the globe to the direction of this mark Q provides the direction of the *qibla* in that city.

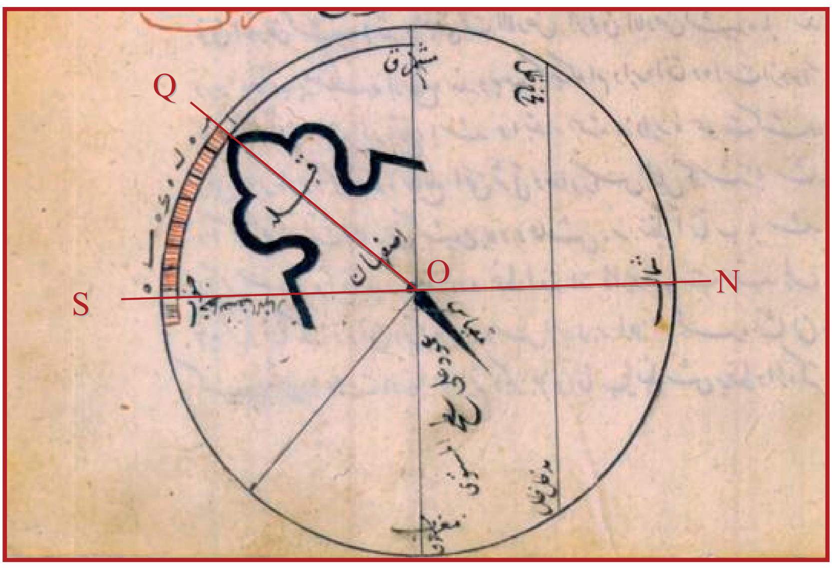

Figure 28: Determination of the azimuth of the *qibla*. The background is an extract from the *Risāla dar samt-i qibla* (anonymous and undated), MS Paris, BnF, pers. 169,6, f. 42r.[64]

[64] The directions East (مشرق) and West (مغرب) are depicted inverted in the diagram of the manuscript.

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The procedure described is explained in Figure 29. On the celestial globe adjusted to the latitude φ of the locality in question, let the circle CDEW be the equator, P and P′ the celestial poles, SENW the horizon circle, Z the zenith of the locality, M the zenith of Mecca, the circle PZSP′N through the poles and the zenith be the local meridian, and the circle PMDP′ be the meridian corresponding to the zenith of Mecca.

The difference that needs to be known, according to the method presented, is the arc SQ (or NQ), where S is the south point of the horizon and Q the intersection of the great circle through the zeniths of the two cities and the horizon. This difference is known as 'difference in inclination' and corresponds to the angle between the great circle arc joining the locality with Mecca and the local meridian; this angle is the same as that between the great celestial circle ZMQ through the zeniths of the city and Mecca, and the local meridian PZSP′N; the Arabic term for this angle is *inḥirāf al-qibla* انحراف القبلة.[65] The term 'difference in longitude' *al-ikhtilāf fī al-ṭūl* (الاختلاف في الطول) between the city and Mecca, which is used here, is not correct, because the difference in terrestrial longitude between the two cities corresponds to the arc CD of the equator, and it is not measured on the horizon.

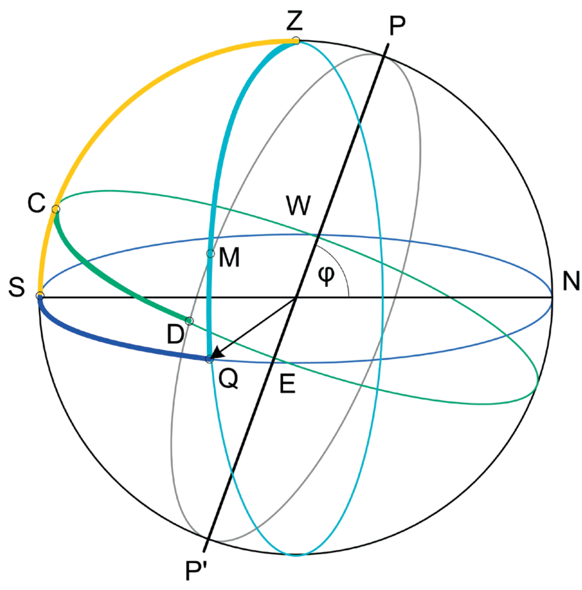

Figure 29: Determination of the *qibla*.

[65] See King, 'Ḳibla'. The transfer of the problem from the terrestrial to the celestial sphere is mentioned on pp. 83–84, while the term *inḥirāf al-ḳibla* (انحراف القبلة) is mentioned on p. 83.

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At the end of Chapter P28, the author of treatise P has added a comment, mentioning that this method is false and of limited use, and it is better to use another method to find the *qibla*. He avoided correcting the method, and referred to the treatise of the quadrant that he was going to write. He could simply have replaced the word ʿlongitude' with ʿinclination / azimuth' and then the method would be correct.

Comparison with treatise Q

Chapter P28 includes the methods of Q56 and Q57. In Q56 the meridian line is determined after measuring the altitude of the Sun with the globe. The procedure is the same as in the first part of P28, with some differences in wording. In Q57 the direction of the *qibla* is determined. The procedure is the same as that in the second part of P28, with few differences in wording.

Chapter P29: To know the 'longitude' of the Moon and of any planet or fixed star you want, at its greatest altitude

Although the term 'longitude' is mentioned in the title, this chapter deals, in fact, with the determination of the mediation of a celestial body, such as the Moon, any planet or any fixed star not drawn on the globe; all of these cases are studied together. Since the degree of mediation of a celestial body is the degree of the ecliptic that reaches the meridian simultaneously with it, the celestial body is observed when it reaches its highest altitude, in order that the moment of its upper culmination can be determined. Furthermore, observing the Moon and planets on the meridian minimizes the parallax in longitude in most cases.[66] At the moment when the celestial body C reaches the meridian PZSP′N (Figure 30), the altitude of a star F, chosen among those drawn on the celestial globe, is measured; this altitude will be used for positioning the globe in accordance to the celestial sphere at that moment. For positioning the globe, the north pole of the globe must first be elevated according to the latitude of the locality, but this is not mentioned in the text. Then a mark corresponding to the altitude of star F is put on a quadrant scale,[67] graduated from 0° to 90°. This quadrant is placed on the celestial globe in such a way that the endpoint corresponding to the graduation of 90° is on the zenith Z and the other endpoint is on the horizon ring SENW. Then the globe must be rotated and the lower endpoint B of the quadrant placed at the appropriate position, so that the star F comes under the mark of the quadrant. The quadrant must be placed either on the east or the west hemisphere of the globe, depending on whether the star is before or after its upper culmination, otherwise the

66 The longitude component of the parallax is maximum at the horizon and zero at the highest point of the ecliptic, see Kennedy, 'Parallax Theory in Islamic Astronomy'.

67 The quadrant scale has been described in Chapter P9 and is depicted in Figure 9.

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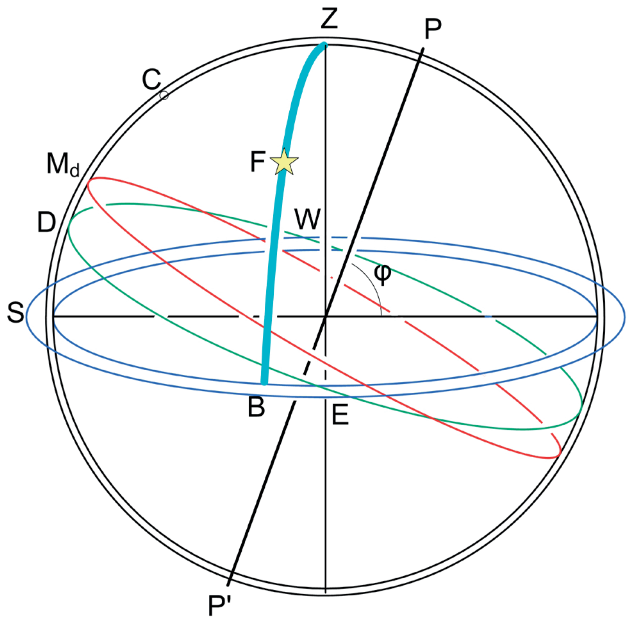

Figure 30: Determining the degree of the ecliptic M_d that culminates simultaneously with the Moon or a planet.

globe will not be positioned correctly; the differentiation is not mentioned in the text of P29. At this position, while the globe represents the celestial sphere at the moment of culmination of the celestial body C, the degree M_d of the ecliptic that reaches the meridian ring is determined; this degree is mentioned as the 'longitude' of the celestial body, but actually it is the degree of its mediation.

Comparison with treatise Q

Chapter P29 unifies Chapters Q58 and Q62. Chapter Q58 concerns the 'longitude' (mediation) of the Moon and planets, and Q62 the 'longitude' (mediation) of the fixed stars not drawn on the globe.

The wording of Chapter P29 is almost identical to Q58, but the title of the latter mentions that the 'longitude' could be determined in a night during which it is possible to measure the maximum altitude of the Moon or planet. In Chapter Q62, the same procedure as in Q58 is described for the fixed stars that are not drawn on the globe. In both chapters, as in P29, there is no mention that the globe must be placed according to the latitude of the locality and that the quadrant should be on the east or west hemisphere, depending on the position of the star.

Chapter P30: To know the 'latitude' of the Moon, of a planet and of a fixed star among those not drawn on the globe, in a night during which it is

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possible to measure its maximum altitude, and to know also its declination from the equator and its zenithal distance.

The cases of the Moon, a planet and a fixed star not drawn on the globe are described in the same procedure: The degree of 'longitude' of the celestial body is determined (according to Chapter P29) and a mark M_d is put at its position on the ecliptic on the globe (Figure 31). The maximum altitude of the celestial body and its direction to the north or south of the zenith is determined; then this altitude is taken on the meridian ring and a corresponding mark M_a is put on the meridian. Then the globe is rotated, so that mark M_d arrives at the meridian. If M_d is located exactly under M_a, then the degree of the ecliptic has the same maximum altitude as the celestial body, thus the celestial body is located on the ecliptic. If M_a is to the north or south of M_d, then the celestial body has a 'latitude' M_dM_a in that direction; the 'latitude' is equal to the number of degrees of the meridian between the two marks.

At the same position of the globe, the degrees of the meridian ring between M_a and the equator (circle EDW) correspond to the declination (arc DM_a), and the degrees between M_a and the zenith (arc ZM_a) to the minimum zenithal distance of the celestial body.

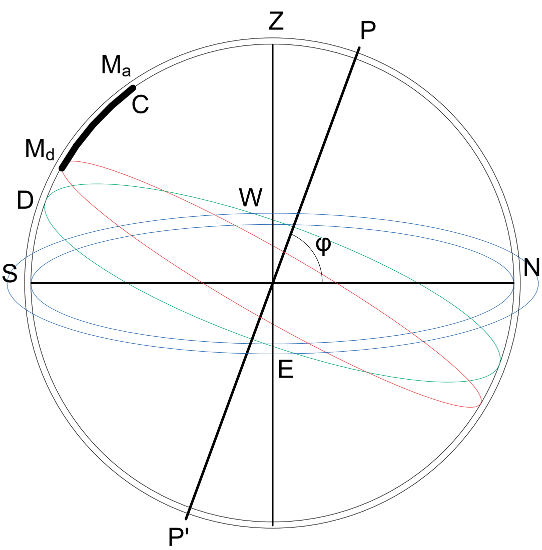

Figure 31: Determining the difference of declination between the Moon or a planet and the degree of the ecliptic M_d that culminates simultaneously with it.

The author of the treatise mentions that 'there is a dispute over the claim that there is no difference between the degree of transit of a star and its degree (of longitude)'. It is clear that according to the procedure of P30 the difference

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between the declination of the degree of transit (mediation) and that of the celestial body in question is determined, not the ecliptic latitude of it. The methods of this treatise are in accordance with the specific system of coordinates 'mediation and difference of declination'.

Comparison with treatise Q

Chapter P30 unifies Chapters Q59, Q63, Q64 and Q65.

In Chapter Q59 the 'latitude' of the Moon or a planet is determined, during a night in which its maximum altitude can be measured. The degree of 'longitude' of the Moon or planet is determined as in Chapter Q58, and indicated by a mark on the ecliptic. The maximum altitude of the Moon or planet and its direction (to the north or south of the zenith) are found and a mark is put on the meridian ring corresponding to the position of its maximum altitude, retaining the direction of the altitude. Then the globe is rotated so that the degree of 'longitude' comes to the meridian. If the degree falls under the mark of maximum altitude on the meridian, then the Moon or planet has no latitude, and it is located on the ecliptic. If the degree falls on any side of the mark, its direction is observed and the degrees of the meridian between the degree and the mark are counted. These degrees correspond to the 'latitude' of the Moon or planet in that night, in the direction found with respect to the ecliptic.

In Chapter Q63 the 'latitude' of a star among the fixed stars not drawn on the globe is determined with the globe; the procedure of Chapter Q59 is repeated for a fixed star.

In Chapter Q64 the distance (declination) of a fixed star, among those not drawn on the globe, from the celestial equator is determined using the globe. The procedure described in Q59 is followed until the celestial globe is rotated so that the degree of the star comes to the meridian. The degrees of the meridian between the mark on the meridian and the celestial equator correspond to the distance of the star from the equator. In both Chapters P30 and Q64, there is no discussion about the direction of the declination to the north or south.

In Chapter Q65 the zenithal distance of a fixed star, among those not drawn on the globe, is determined with the globe for any locality. The zenith and the position of the maximum altitude of the star are marked on the meridian; the degrees between these two marks provide the zenithal distance of the star in that locality.

The author of treatise P avoided repeating the procedure and managed to obtain the 'latitude', declination and zenithal distance of the celestial body by applying the procedure only once.

Chapter P31: To know if the lunar eclipse and the solar eclipse occur in the current month

To predict a lunar eclipse, the latitude b of the Moon must be known at its maximum altitude in the *night* of the 13th day of the lunar month. This could be

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found as described in Chapter P30, but this is not written in the text of Chapter P31. If $|b|<1;04°$,[68] then there will be a lunar eclipse, if $|b|>1;04°$, then there will be no lunar eclipse. There is a special mention of the case where $b=0$; in this case there will be a lunar eclipse. The case where $|b|=1;04°$ is not discussed.

To predict a solar eclipse, the latitude b of the Moon must be known at its maximum altitude on the 27th *day* (يوم) of the lunar month. If $b>1;37°$ or $b<-0;01°$ ($b<-0;47°$ according to manuscript K), then there will be no solar eclipse, if $0°\leq b\leq 1;37°$ or $-0;01°\leq b\leq 0°$ ($-0;47°\leq b\leq 0°$ according to manuscript K), then there will be a solar eclipse.[69]

In the treatise of Qusṭā the limit of the south latitude of the Moon for a solar eclipse is *47 minutes*, but in 20 of the 22 studied manuscripts that include Chapter P31, it is reduced to *(one) minute*. It is possible that the number 47 was once written in P31, but omitted later by a copying error. In manuscript K, there is a marginal note that restores the omitted '47' in words.[70] The original text could have been أو عرضه الجنوبي أكثر من **مز** دقيقة. Since the number 47 written as مز is similar to the previous word من 'from / than', it might have been deleted accidentally. A trace of such a symbol for the number '47' can be seen in manuscript O, where a symbol like 'مر' is found in the position of 'مز' described above.

The prediction of eclipses is treated at an elementary level, without taking into consideration important parameters, such as the lunar parallax and the distance between the earth and Moon.

The author of treatise P criticizes Qusṭā's reference to measuring the latitude of the Moon on the 27th day of the lunar month in the way described in Chapters P30 and Q59. This measurement should be conducted at the moment of upper culmination of the Moon, but on the 27th day this occurs in daylight, while the Moon is invisible because of its proximity to the Sun. The latitude of the Moon on this day could be calculated or taken from tables, but not directly measured at its culmination.

Comparison with treatise Q

Chapter P31 unifies Chapters Q60 and Q61.

In Chapter Q60 the prediction of a lunar eclipse is discussed, when the latitude of the Moon is known.

In Chapter Q61 the prediction of a solar eclipse is discussed, knowing the Moon's latitude b and its direction to the north or south. If $b>1;37°$ or $b<-0;47°$, then there will be no solar eclipse; if $-0;47°<b<1;37°$, then there

[68] The latitude b is considered $b>0$ when it is northern, or $b<0$ when it is southern.

[69] The case where $b=0$ is implied in the statement 'if the north / south latitude of the Moon … is greater than … the Sun will not be eclipsed; otherwise it will be eclipsed'.

[70] The number 47 (سبعة وأربعين) is written in the hand of the copyist in the right margin of f. 137v. This number could have been added after comparison with the corresponding Chapter 61 from the treatise of Qusṭā ibn Lūqā.

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will be a solar eclipse. The wording here does not include the cases where the latitude of the Moon is b=1;37° or b=−0;47°. There is a special mention of the case where b=0; then a solar eclipse will always occur.

The author of treatise P follows the same procedures as Qusṭā, using almost the same wording in many phrases. Qusṭā noted in both Chapters Q60 and Q61 that the latitude of the Moon could be found as previously described (in Chapter Q59); this implies that the difference of declination, as in Chapters P30 and Q59, is meant by the term latitude here. There is one remarkable difference concerning the limit of the south latitude of the Moon that allows a solar eclipse, but this is probably a copying error in the transmission of treatise P.

Chapter P32: To know the difference of daylight length on the same day in two different latitudes, while the Sun is on the same degree

The title of this chapter is equivalent to the title of Chapter P6. Although the title mentions the 'difference of daylight', the procedure actually determines half of the difference of daylight.

The procedure described in P32 is the following: The pole of the globe is adjusted to one of these latitudes φ_1 and the globe rotated so that the given degree of the Sun reaches the east horizon; the rising degree of the equator is marked (this degree provides the oblique ascension r_1 at latitude φ_1). Then the same procedure is repeated for the other latitude φ_2 and the other rising degree of the equator is also marked (this degree provides the oblique ascension r_2 of the degree of the Sun at latitude φ_2). The number of the degrees of the equator between the two marks is stated to be the difference of daylight length. This number could be expressed as r_2-r_1.

Justification of the procedure: When the given degree of the Sun comes to the meridian, the degree α of the equator that culminates simultaneously will be the same for all latitudes, because it corresponds to the right ascension of the degree of the Sun. Then the rising degree of the equator will be α+90°, if α<270° (or α+90°−360°=α−270°, if α>270°), because the meridian and horizon divide the equator into four equal parts in all of the latitudes. Thus, half the daylight of the given degree at latitude φ_1 in degrees of the equator will be $\frac{d_1}{2} = \alpha + 90° - r_1$.[71] Similarly, half the daylight of the same degree at latitude φ_2 will be $\frac{d_2}{2} = \alpha + 90° - r_2$. The difference $\frac{d_1}{2} - \frac{d_2}{2} = \alpha + 90° - r_1 - (\alpha + 90° - r_2) = r_2 - r_1$ provides the difference of half daylight at these two latitudes.

There is no corresponding chapter in treatise Q, since the method of Q11 is the same as that of P6. The only exception is manuscript M, which contains at

[71] The condition $\alpha + 90° - r_1 \geq 0° \Leftrightarrow r_1 - \alpha \leq 90°$ is always valid for any degree of the ecliptic in the northern hemisphere that rises and sets.

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the end (f. 12) three unnumbered chapters, among them a chapter corresponding to P32 in a modified form.

Chapter P33: To know the latitude of the city from the highest altitude of a star, among the stars of the globe, and from its longest daytime (نهار)

1. Determination of the latitude of a city from the highest altitude of a star

When the maximum altitude of a star drawn on the globe is known, the globe must be positioned in such a way that the star reaches this maximum altitude counted on the meridian ring of the globe. It is important to place the star to the south or north of the zenith on the globe, according to its real position, but this is not mentioned explicitly in the text. There is also no mention of how the latitude of the city is obtained: the elevation of the north pole, counted on the meridian ring, can directly provide the latitude sought.

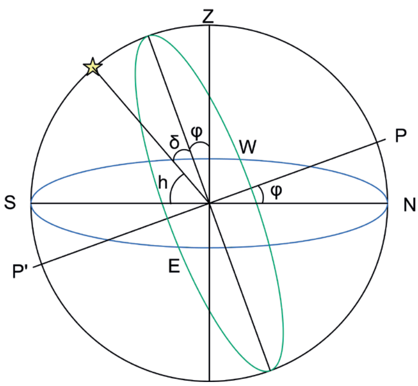

Figure 32

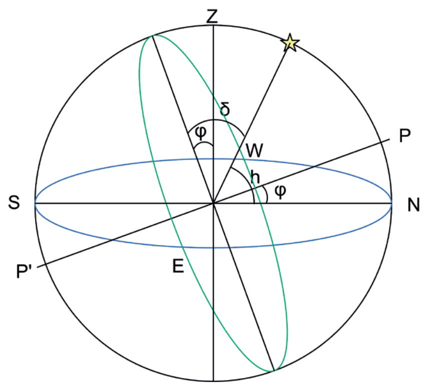

Figure 33

Figures 32–33: Determination of the latitude of the city from the highest altitude of a star, when the star culminates to the south of the zenith (Figure 32) or to the north of the zenith (Figure 33).

The terrestrial latitude, where a certain star reaches a given maximum altitude, is unique when it is known that its culmination is either to the south or north of the zenith. For culmination to the south of the zenith, the maximum altitude is $h=90°-\varphi+\delta$ (Figure 32). Knowing the declination δ of the star, we may find the latitude as $\varphi=90°-h+\delta$. For culmination to the north of the zenith the maximum altitude is $h=90°+\varphi-\delta$ (Figure 33). Knowing δ, we may find the latitude as $\varphi=h+\delta-90°$.

2. Determination of the latitude of the city from its longest (or shortest) daylight

There are two methods presented here. The first uses the point σ of summer solstice, the first point of Cancer. The poles are placed on the horizon, thus

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the globe represents the situation on the terrestrial equator (Figure 34). The point σ is put on the east horizon; the point of the equator that rises at this moment has right ascension α=90°. Daylight on the terrestrial equator is 12 hours for all degrees of the ecliptic and this corresponds to a daytime arc of 180°. The longest daylight in a locality in the northern hemisphere (φ>0°) occurs at the summer solstice and this corresponds to a daytime arc d_φ>180°. The difference between the daytime arcs at latitude φ and the equator is $d_\varphi - 180°$, while its half is $k = (d_\varphi - 180°)/2$. A mark is put at the point of the equator with right ascension α=90°−k; this point rises simultaneously with the summer solstice σ at this latitude φ. Then the north pole of the globe is elevated, so that this point and point σ are located on the east horizon (Figure 35); at this position of the globe, the degrees of the elevation of the pole counted on the meridian ring provide the latitude of the city.

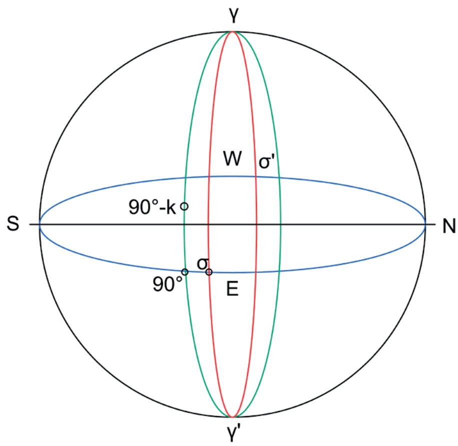

Figure 34

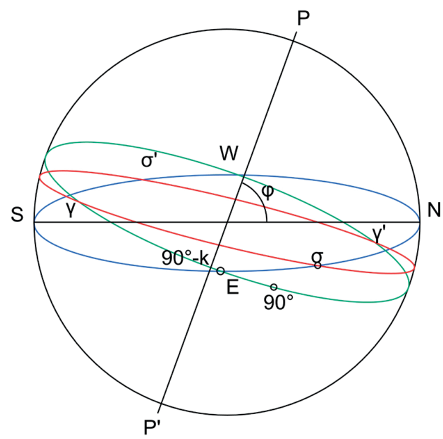

Figure 35

Figures 34–35: Determination of the latitude of the city from its longest daylight.

In the second method, the latitude is determined by knowing the shortest daylight; for this reason the point σ' of the winter solstice, the first point of Capricorn, is used. The poles are placed on the horizon, thus the globe simulates the situation on the terrestrial equator (Figure 36). The point σ' is then put on the east horizon; the point of the equator that rises at this moment has right ascension α=270° and a mark must be put on this point.

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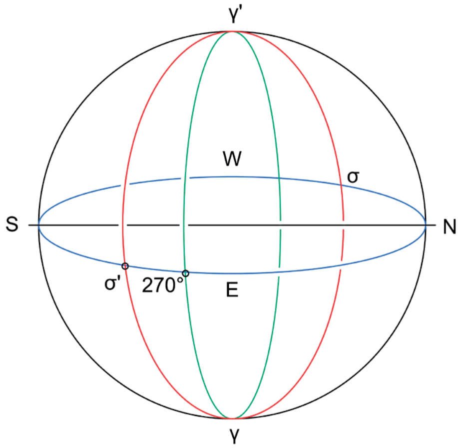

Figure 36

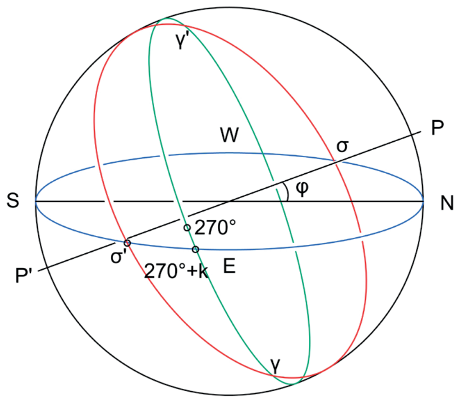

Figure 37

Figures 36–37: Determination of the latitude of the city from its shortest daylight.

Daylight on the terrestrial equator is 12 hours, which corresponds to a daytime arc of 180°. The shortest daylight in a locality in the northern hemisphere (φ>0°) corresponds to a daytime arc d_φ'<180°. The difference between the daytime arcs at the latitude φ and the equator is 180°–d_φ', while its half is $k = (180^\circ - d_\varphi')/2$.

The north pole of the globe must then be elevated, so that σ′ remains on the horizon, whilst the point of the equator with right ascension α=270° has covered a distance of $k = (180^\circ - d_\varphi')/2$ degrees above the horizon (Figure 37). This procedure is equivalent to what would be expected if the procedure described in the first method had been applied, namely putting a mark at the point of the equator with right ascension α=270°+k and then raising the north pole, so that this mark and σ′ are placed on the east horizon. The point with right ascension α=270°+k rises simultaneously with the winter solstice σ′ at this latitude φ. The latitude of the city is obtained by counting the degrees of elevation of the pole on the meridian ring.

The text mentions that this method can be applied for any other degree of the ecliptic.

There is no corresponding chapter to P33 in treatise Q, except for manuscript M, which contains at the end (f. 12) three unnumbered chapters, among them two chapters corresponding to P33.2 and P33.1 in a modified form. Most probably, these chapters are a later addition.

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The above methods for determining the latitude of the locality are presented in Chapters II.6 and II.2–3 of the treatise of al-Ṣūfī on the celestial globe.[72]

In al-Ṣūfī's Chapter II.6 the latitude is determined by means of the highest altitude of a star drawn on the globe. The position of the star at its upper culmination is marked on the meridian ring. The maximum altitude of the star is measured by an astrolabe or other means, then the pole of the equator is slowly raised, until the mark reaches the measured altitude in the direction the star was observed, to the north or south of the zenith (Figures 32–33). The elevation of the north pole of the globe provides the latitude of the locality.

In Chapter II.2 the latitude is determined by means of the hours of the longest day. Twelve hours are subtracted from the number of the hours (h) and minutes (m) of the longest day. The result will be $h-12$ hours and m minutes. For each of the remaining hours we take 7.5 degrees, and for every 8 minutes we take 1 degree; the sum of these degrees corresponds to the number k. The poles of the equator are placed on the horizon, and a mark is put at the degree of the equator that comes to the east horizon simultaneously with the first point of Cancer (Figure 34). A second mark is put on the degree of the equator that has a distance equal to k degrees from the first mark, in the direction opposite to the order of the zodiacal signs. Then the north pole is raised above the horizon and the globe is rotated so that the second mark comes to the east horizon together with the first point of Cancer (Figure 35). The elevation of the north pole will be the latitude of the locality. The same method can be used for any degree of the ecliptic with daytime longer than 12 hours.

Both the author of treatise P and al-Ṣūfī use the same number k in the method using the longest day. The following proof shows the equivalence: Since 1 equal hour or 60 minutes correspond to a rotation of 15°, 60/15=4 minutes correspond to a rotation of 1°. The longest daytime of h hours and m minutes corresponds to a daytime arc

$$d_\varphi = h \cdot 15^\circ + \left(\frac{m}{4}\right)^\circ \Leftrightarrow \frac{d_\varphi}{2} = h \cdot \frac{15^\circ}{2} + \left(\frac{m}{4 \cdot 2}\right)^\circ \Leftrightarrow \frac{d_\varphi}{2} = h \cdot 7.5^\circ + \left(\frac{m}{8}\right)^\circ,$$

and subtracting 90° we obtain

$$\frac{d_\varphi}{2} - 90^\circ = h \cdot 7.5^\circ - 12 \cdot 7.5^\circ + \left(\frac{m}{8}\right)^\circ \Leftrightarrow \frac{d_\varphi - 180^\circ}{2} = (h - 12) \cdot 7.5^\circ + \left(\frac{m}{8}\right)^\circ,$$

which shows the equality of the number k in the first method of Chapter P33.2 and Chapter II.2 by al-Ṣūfī.

In Chapter II.3 the latitude is determined by means of the hours of the shortest day. The number of hours (h) and minutes (m) of the shortest day is subtracted from 12 hours. Then the method is similar to that of Chapter II.2, with the following differences:

[72] Al-Ṣūfī, *On the Use of the Celestial Globe*, in MS Istanbul, Topkapi Saray, Ahmet III 3505,1, ff. 21r–22r; also Kennedy, 'Al-Ṣūfī on the Celestial Globe', pp. 66–67.

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1. The first point of Capricorn is used instead of the first point of Cancer,
2. The second mark is put counting *k* degrees from the first mark following the order of the zodiacal signs.

The number *k* in the second method of Chapter P33.2 is equal to the number *k* used in Chapter II.3 by al-Ṣūfī. The proof is analogous to that presented for the longest day. Although the methods presented in the above chapters by al-Ṣūfī and those in Chapter P33 are equivalent, they are only explained in detail in the former.

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4. Conclusions

4.1 Comparison between the treatises P and Q

The author of the Arabic treatise *Dhāt al-kursī* attributed to Ptolemy (here referred to as treatise P) explains in the preface that he had as his source 'the treatise of Qusṭā'. He declares that he is going to make the treatise more concise, but also outline additional ways in which the globe can be used. Detailed comparison between treatise P and the *Treatise on the Celestial Globe* by Qusṭā ibn Luqā (here referred to as Q) reveals that the former indeed follows the latter closely and is based on it. All chapters of treatise Q have been used in treatise P, with Chapters P32–33 as new additions.[1] The author of treatise P tried to make the text concise, avoiding repetitions, and improving some of the methods and the terminology. Some of his criticisms of coordinates and methods, however, are unjustified.

The conclusions of the comparison are presented below.

1. The author of treatise P avoided the tiring repetitions of treatise Q by collecting chapters on similar subjects that use the same procedures, and unifying them. He also condensed the detailed descriptions of the source treatise (eg. P3/Q8, P6/Q11, P8/Q15–16, P16/Q32–33 and P22/Q44). Thus, the length of treatise P became almost half the length of the treatise by Qusṭā ibn Lūqā.

   In few cases, there are important omissions in treatise P. For example:

   - In Chapters P4 and P7 there is no mention that the north pole of the globe must be elevated according to the local latitude, although this is stated in the corresponding Chapters Q9 and Q13 of treatise Q.
   - In P11, which deals with domification, it is not mentioned that the ascendant and the degrees of an unequal hour should be known, although this was stated at the beginning of the corresponding Chapter Q55.
   - In P26, there is no mention of the case of latitude of 24° South where the sun reaches the zenith when it is at the first point of Capricorn, although this was included in the corresponding Chapter Q52.

[1] The correspondence between the chapters of the two treatises is presented in Appendix 2.

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2. The author of treatise P also tried to ameliorate the methods of the source treatise, to include more general cases, to correct errors and to introduce mathematical expressions. For example:
   - In P17, he transformed the method of Q35 and extended it in order to cover all cases concerning the stars with mathematical reasoning, and corrected the error that appears in Q34.
   - In P18, he presented a more general and rigorous method. A comparison between the polar distances of the star and of the degree of the Sun, when the position of the star at sunset is known, replaces the descriptive methods of Q36 and Q37.
   - In P23, he studies the cases in which either the north or the south celestial pole is at the zenith, while in Q45–46 only the former case had been examined.
   - In P25, he presents the general case of rising and setting of the zodiacal signs at a latitude greater than 66°, while in Q48 only the specific case for latitude φ=78° North was presented.
   - In P27, the wording includes the latitude φ=24° in the case that the shadows are in one direction, while the wording of the corresponding Chapter Q51 does not include this latitude. The author of treatise P added a second case in the section concerning verification with the globe, to show that for a latitude $\varphi \geq 24°$ the shadow will always be to the north.

3. He not only included all subjects from treatise Q but also enriched his treatise by adding new topics:
   - In P16, the study of the ascension of any degree of the ecliptic is introduced, which was not included in the corresponding Chapters Q32–33.
   - In P32, half the difference of daylight on the same day is determined for two different latitudes. The method is different from that of the related Chapters P6/Q11, where the difference of daylight is studied under the same conditions.
   - In P33, the latitude of a city is determined from the highest altitude of a star or the longest / shortest daylight; there is no corresponding chapter in treatise Q.

4. In some cases, the author of treatise P used more elaborate and accurate terminology and better wording compared to treatise Q. For example:
   - In the description of domification in Chapter P11, he uses the term 'houses' (بيوت) instead of the term 'centres' (أوتاد) used in Q55. He

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also replaces the phrases ‘rotate the ascendant downwards’ and ‘draw the descendant downwards’ with the more elegant ‘rotate the globe following the order of the signs’ and ‘rotate the globe following the opposite order of the signs’ respectively.

- In determining the distance between two stars in P13, he uses the term ‘the transits of the two stars’ (ممرّي الكوكبين) for the points where the two stars cross the horizon or the meridian; this term does not appear in the corresponding Chapter Q26.
- In Q4, diurnal motion at a latitude φ=90° is compared to the motion of a millstone (رحى). The author of treatise P repeats this simile in Chapter P1 and extends the comparison: The diurnal motion at a latitude φ=0° is compared to the motion of a wheel (دولاب), whilst the motion in the intervening latitudes is compared to a baldric (حمالة / جمع: حمائل), a diagonal belt for carrying a sword.
- In the title of Chapter P15, there is clarification that the method concerns only the fixed stars drawn on the globe; this was not included in the title of the corresponding Chapter Q29.
- The author of treatise P uses both terms ‘unequal’ (معوجة) in P7–8 and ‘seasonal’ (زمانية) in P5 and P19–20 for the hours, while Qusṭā uses the term ‘seasonal’ (زمانية) exclusively throughout his treatise; the latter is the translation of the Greek term ‘*καιρικαὶ* (*ὧραι*)’ into Arabic.

5. The author of treatise P criticizes the use of the coordinates ‘mediation and difference of declination’, but he does not provide an alternative solution:

   - In P12, he follows the method of Q21 for determining the ‘latitude’ of a star, but then mentions that the latitude found in this way is not correct, and that ‘the latitude is solely taken on the circle of the latitude’. The method of P12 and Q21 provides the difference of declination between the star and its degree of mediation, concisely described here as ‘latitude’.

   - In P20, he follows the method of Q40–41 for determining the time of rising or setting of the Moon or a planet, but then mentions that the method does not consider the difference between the degree of the planet and the degree of its transit. Similarly, in P30, he follows the method of Q58–59 and Q62–63 for determining the ‘latitude’ of the Moon, a planet or a fixed star not drawn on the globe, and then men-

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tions that 'there is a dispute over the claim that there is no difference between the degree of transit of a star and its degree (of longitude)'. In both cases, the degree of mediation is used, called 'the degree of transit' by the author of treatise P, and concisely described as 'longitude' in the commentary of Chapters 29-30. The methods of P20 and P30 are correct when the coordinates 'mediation and difference of declination' are used instead of the ecliptic longitude and latitude.

6. Although the author of treatise P criticizes some methods of treatise Q, he does not propose alternatives in these cases:
   - In P28, he follows the method of Q57 for determining the azimuth of the *qibla*, using the term 'difference in longitude' as in Chapter Q57, but then mentions that this method is false and that it is better to use another method to find the *qibla*. He avoids correcting the method, although he could simply have replaced the word 'longitude' with 'inclination' or 'azimuth' to do so.
   - In P31, he follows the method of Q61 for finding whether a solar eclipse will occur. In Q61, it is noted that the necessary 'latitude' of the Moon can be determined as described previously, alluding to Q59, where the maximum altitude of the Moon should be measured. The author of treatise P uses the 'latitude' of the Moon without explaining how to find it, and at the end he wonders how the maximum altitude of the Moon could be measured on the 27th day of the lunar month. Again, though, he does not present any solution, e.g. finding the 'latitude' using a *zīj* or calculating it.

7. There are two cases where the commentaries of the author of treatise P on methods presented in treatise Q are not, in fact, correct:
   - At the end of Chapter P9, following the method of Q53 for measuring the Sun's altitude, when the altitude of the Sun is to the West (i.e. after midday), he suggests using another quadrant scale or altering the two poles and installing the gnomon at the diametrical opposite of the degree of the Sun. This is not correct, however, because this method gives results in both cases, when the Sun is either before or after its meridian transit.
   - At the end of Chapter P20, on determining the time of rising or setting of the Moon or a planet following the method of Q40–41, he mentions that 'This rule is not in accordance with

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reality and its origin does not take into consideration the difference between the degree of the planet and the degree of its transit'. The method of Q40–41 using the coordinates 'mediation and difference of declination', however, does give correct results.

The commentaries discussed in points 5, 6 and 7, above, written at the end of each chapter (in P9, P20, P28 and P31) or at the end of the certain procedure (in P12 and P30), show an inconsistency with the method that has just been presented by the author. This fact points to the possibility that these comments were later additions by a commentator that have been incorporated into the text. As it is mentioned in Section 4.3 below, several omissions and copying errors common to all manuscripts show that all studied manuscripts come from the same exemplar which was not the autograph, thus these commentaries might have been incorporated at the stage of copying this common exemplar. However, the reference to the treatise of the quadrant that is included in the commentary at the end of chapter P28 reduces this possibility, at least for this comment, since it is formulated as a statement by the author.

4.2 Possible sources

According to the evidence presented in the commentary and the comparison between treatises P and Q, the possible sources of these treatises are shown in Table 9. The treatise *On the Configuration of the World* by Ibn al-Haytham (AD 965–1040) may have influenced the author of treatise P to write Chapter P25, since he dramatically changed the corresponding Chapter Q48, adding descriptions that appear in Ibn al-Haytham's treatise. Chapters II.2–3, 6 of the *Treatise on the Celestial Globe* by al-Ṣūfī were also a probable source for Chapter P33, which was not included in treatise Q. Qusṭā ibn Lūqā was undoubtedly influenced by those works of Theodosius and Autolycus that he had himself translated from Greek into Arabic, and was definitely acquainted with Ptolemy's *Almagest*. He probably also used the work *Introduction to the Phaenomena* by Geminus, because in Chapter 5 of this work, there is a detailed description of a celestial globe with stand, similar to that described by Qusṭā.[2]

[2] This work of Geminus was attributed to Ptolemy in an Arabic translation of it, considered as lost nowadays. This is evident from two Latin translations by Gerardus Cremonensis and by Abrahamus de Balmes with titles such as *Sperica Ptolomei* and *Ptholomei Liber introductorius in Almagesti*, etc. These translations come from Arabic manuscripts (that of Abrahamus de Balmes via a Hebrew intermediary translation), where the arrangement of the chapters and some of the contents are different from those in the Greek text and the Latin translations based on it; see Todd, 'Geminus and the Ps.-Proclan Sphaera', pp. 16–21. However, this fact is not related to the attribution of treatise P to Ptolemy; the author clearly mentions Qusṭā as his source in the in-

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Treatise P	Treatise Q	Possible sources of treatise Q	Possible additional sources of treatise P
Introduction	Q1	Geminus, *Phaenomena* 5	
P2	Q5	Geminus, *Phaenomena* 6.23 / Ptolemy, *Almagest* II.6.1	
P3	Q6	Theodosius, *De diebus et noctibus*, I.4	
P18	Q36	Autolycus, *De ortibus et occasibus*, 14, 15	
P18	Q37	[Autolycus, *De ortibus et occasibus*, 17, 18]	
P23	Q45–46	Theodosius, *De habitationibus* 1 / Geminus, *Phaenomena* 6.15 / Ptolemy, *Almagest* II.6.39	
P24	Q47	Theodosius, *De habitationibus* 12 / Ptolemy, *Almagest* II.6.33	
P25	Q48	Theodosius, *De habitationibus* 4	Ibn al-Haytham, *Configuration of the World*
P26	Q49–50,52	Ptolemy, *Almagest* II.6.1–7	
P27	Q51	Ptolemy, *Almagest* II.6.1–32	
P33	-		Al-Ṣūfī, *Celestial Globe*, II.2–3,6

Table 9. Possible sources of the treatises P and Q.

4.3 Possible date and place of compilation

There are some important omissions and copying errors, common to all 23 studied manuscripts of treatise P.[3] This is evidence that all of these manuscripts stem from the same exemplar, which was a descendant of the original.

In determining the compilation date of treatise P, we must take into consideration the following: The earliest dated extant manuscript was copied in AD 1558, while the earliest reference to the treatise is that in *Kashf al-ẓunūn* by Ḥājjī Khalīfa (d. AD 1657). Concerning the sources of treatise P: Qusṭā ibn

troduction. On the other hand, Qusṭā had access to Greek manuscript sources, as his extensive translation work attests, so he could not depend on Arabic translations that attribute Geminus' work to Ptolemy.

[3] For example: P4: 'the degree' instead of 'the two degrees'; P11: omission of the phrase 'following the opposite order of the zodiacal signs' in the determination of the cusp of the eleventh house; P14: omission of a phrase that leaves the procedure after the elevation of the north pole incorrect; P18: omission of the phrase 'above the horizon'; P20: omission of approximately two lines that obscures the procedure; P31: omission of the word 'latitude' in the first line of the procedure and of the number '47' for the minutes of south latitude that permit a solar eclipse (the latter is only included as a marginal note in manuscript K and as a symbol like 'مـر' in manuscript O); P32: 'the difference of daylight' instead of 'half the difference of daylight'; and P33: 'ninety' instead of 'one hundred eighty'.

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Lūqā died *c.* AD 912, al-Ṣūfī wrote his treatise on the celestial globe between 983 and 986 AD, while Ibn al-Haytham died in AD 1040. Thus, treatise P must have been compiled between the eleventh and the first half of the sixteenth century AD.

The quadrant, mentioned by the author in Chapter P28, was already known since the ninth century, since Abū Jaʿfar Muḥammad ibn Mūsa al-Khwārizmī wrote some treatises on its construction and use, but the instrument became more popular starting from the twelfth century, in particular in Egypt and Syria, and became one of the most popular portable instruments of the Muslim astronomers in the fifteenth century. This period of time is consistent with the above-mentioned time range.[4]

There is a strong possibility that the treatise P was compiled in Egypt, based on the following evidence:

1. There are seven manuscripts of treatise P in the Dār al-kutub in Cairo, while the manuscript from the Library of the University of Riyadh (MS Ḥ), is said to originate from the Egyptian Dār al-kutub.[5] This manuscript and the manuscript from the National Library of Albania (MS Ṭ) are very similar to the manuscript Cairo, Dār al-kutub, Mīqāt Ṭalʿat 202,2 (MS U). Also the manuscript from Rabat (MS Kh) stems from the same exemplar as MS D from Cairo, and MS F, now in the Princeton University Library, is closely related to MS D.
2. There are eight manuscripts in the Süleymaniye Library and one in the Beyazit State Library in Istanbul, which was the capital of the Ottoman Empire at the time all of these manuscripts were copied. The similarity between manuscripts K, L and M from the Süleymaniye Library with D, J, and A, respectively, from the Dār al-kutub could provide evidence that these manuscripts were copied in Cairo and then transferred to the capital.
3. The fact that there is a common omission of a line in Chapter P14 in all of the twenty-two examined manuscripts of treatise P that contain P14,[6] and in Chapter Q28 in all three Cairo manuscripts (A, B and L) of treatise Q, points to the probability that the author of treatise P used an ancestor manuscript of the Cairo manuscripts of Q that had the same omission and summarized the method without being aware of this. The same passage has been omitted in the manuscript Paris, BnF, arabe 7244,1 (MS R) copied in 1188 H / AD 1774, which is of western

[4] See King, *al-Khwārizmī and New Trends*, in particular p. 29; King, 'A Vetustissimus Arabic Treatise'; Charette, *Mathematical Instrumentation*, in particular Sections 1.2 and 1.3; and Charette and Schmidl, 'al-Khwārizmī and Practical Astronomy', pp. 128–29, 131–32, 154–55 and 157–58.

[5] Note on the information sheet of the manuscript in the Library of the University of Riyadh.

[6] Chapter P14 is not included in manuscript N.

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> Arabic origin, and the manuscript Istanbul, Topkapi Saray, Ahmet III 3505,5 of treatise Q (MS N), copied in 661 H / AD 1263.[7] At that time, Constantinople was the capital of the Byzantine Empire, and this fact eliminates the possibility that the manuscript originated from this city. It arrived at Istanbul later and was included in the library of Sultan Bāyazīt II and later in the library of Sultan Ahmet III.[8] The provenance of this manuscript is unknown.[9] The text of Chapter Q28 is complete in manuscripts C, D, E (London); Z (Meshhed); H, I and O (Istanbul); K (Damascus), M (Princeton), U (Hydarabad), T (Tirana) and the Latin translation of the same treatise. In manuscript F, originating from Cairo but now stored in the Manuscript Library of the University of Pennsylvania, the folio that should contain Chapters Q22–29 is lost.

However, if the author of the treatise was Akhawayn (see below), the treatise could have been compiled elsewhere. Akhawayn's wanderings are not known, we only know that he taught in Istanbul and Bursa.

4.4 The attribution of the treatise to Akhawayn

In three manuscripts (R, S and T) the treatise is attributed to Akhawayn, who died between 899 and 904 H (AD 1493–1498). Manuscript R (Princeton) was copied in 965 H / AD 1558 and is the oldest extant manuscript, thus this early attribution should be taken into consideration seriously. The date of Akhawayn is consistent with that of the above manuscript and the time range for the compilation of the treatise discussed in the previous section.

As discussed in Section 1.5 above, bio-bibliographical sources of the sixteenth and seventeenth centuries attest that Akhawayn wrote some works related to Islamic theology and a *Treatise explaining the Sine Quadrant* based on the work of ʿAṭāʾ Allāh al-ʿAjamī. Since the beginning of the twentieth

7 None of the three Cairo manuscripts (A, B, L) could be descendants of manuscript N of treatise Q, since they contain some passages omitted in manuscript N.

8 See note 79 in Section 1.2 above.

9 At the time the manuscript was copied (661 H / AD 1263), the Mongols had conquered a great part of the territories where Arab civilization had flourished, devastating the land, slaughtering the inhabitants and destroying libraries. This fact can exclude some important cities as possible origin of this manuscript: Baghdad and the territory around it were conquered by Hulegu and the Mongols in 1258 and massive massacres and destructions followed. Also, the territory of Sham, including Damascus, was under the threat of the Mongols, even after the battle of ʿAīn Jālūt in 1260, and Damascus suffered from hunger during the years 1261–1262. On the other hand, Cairo cannot be excluded, since 1263 was within a period of prosperity under the reign of the Mamluk sultan al-Ẓāhir Rukn al-Dīn Baybars, who, later in 1277, established the Ẓāhirīya Library in Damascus. Also, Maragha cannot be excluded, since the famous observatory was established there by al-Ṭūsī in 1259. See al-Maqrīzī, *Histoire des Sultans Mamlouks* (transl. Quatremère), vol. I.

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century, further astronomical treatises have been attributed to him, because he appears as the author in some manuscripts. His name is written in the title or the colophon of some transcriptions of the treatises *Dhāt al-kursī* and *al-Rubʿ al-jāmiʿa*, in the dedication or statement of ownership in the manuscript of the *Notes on the Commentary on the Mulakhkhaṣ by Qāḍī Zāde*, whereas it is included in the main text solely in the *Problems in the Science of Astronomy* (MS Vienna Cod. A. F. 418).

The existence of a treatise on the quadrant by Akhawayn supports the possibility that he could be the author of the treatise *Dhāt al-kursī*, since the author of treatise P mentions in Chapter P28 that he was going to write such a treatise. The comparison of the style of writing in the *Problems on the Science of Astronomy*, in the Cairo manuscript of Akhawayn's *Note on the Sharḥ al-tajrīd*[10] and in the prefaces of the notes on the *Mulakhkhaṣ* and the treatises *al-Rubʿ al-jāmiʿa* and *Dhāt al-kursī* show that all of them contain parts written in a form of rhymed prose, known in Arabic as *sajʿ*. However, this was a common style of writing in many works in the Arabic literature between the eighth and the end of the nineteenth century, thus this fact cannot be used as evidence for the authorship by Akhawayn.[11]

The doubts about the authorship of the treatise *Dhāt al-kursī* remain, since it is not cited among Akhawayn's works in the early bio-bibliographical sources, and the attribution to Akhawayn appears in only three of the twenty-three studied manuscripts of the treatise. Moreover, as discussed in Section 1.5, his name has been deliberately removed from some manuscripts, or added to others. The existence of the name of the author, in particular out of the main text of the work, cannot itself prove the authorship if not supported by other evidence. Since he was professor at the *Ṣaḥn-i Thamān* in Constantinople / Istanbul and other madrasas, he should have used some course books either written by him or other scholars; it is possible that some of his students wrote his name at the beginning or the end of the manuscripts they used, even not of his works, and then it was transmitted to subsequent manuscripts.

4.5 Possible relation to Ptolemy

There are some elements in the *Treatise on the Celestial Globe* that may relate it to Ptolemy.

The celestial globe and its use were certainly known in Ptolemy's time. A detailed description of the celestial globe with stand is preserved, for example, in Chapter 5 of Geminus' *Introduction to the Phenomena*,[12] written approximately

10 Akhawayn, *Note on the Sharḥ al-tajrīd*, in Cairo, al-Azhar Library, Tawḥīd 321,2.

11 Personal communication from Saeed al-Wakeel, Professor of Arabic Literature and Criticism at the Faculty of Arts, Ain Shams University, Cairo.

12 Evans and Berggren, *Geminos's Introduction to the Phenomena*, pp. 149–59.

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two centuries before Ptolemy. Ptolemy, aiming for a type of globe that could be used eternally without becoming out of date due to the precession of the equinoxes,[13] had himself developed an improved celestial globe, the so called precession globe, but this is a different type from that described in treatise P (see Section 1.3).

In Chapters 2, 23, 24, 26 and 27 of treatise P, there are some traces of Ptolemaic influence, pertaining especially to the characteristics of the various terrestrial latitudes presented in *Almagest* II.6. These are discussed above, in the corresponding sections of the commentary.

Both treatises P and Q include some non-Ptolemaic elements, such as: the determination of the *qibla*, the domification (12 astrological houses), the division of the horizon into 360°, which corresponds to the notion of the azimuth, and the use of the coordinates 'mediation' and 'difference of declination' for the stars.

It is clear that the treatise *Dhāt al-kursī* (treatise P) should be considered among the *pseudepigrapha* and not as a genuine work of Ptolemy for the following reasons:

1. Treatise P has as its source the *Treatise on the Celestial Globe* by Qusṭā ibn Lūqā, as is evident from the overlap in content between the two treatises, outlined in the detailed comparison above, and the explicit mention of the name Qusṭā as well.[14] The possible sources of treatise Q and the additional ones of treatise P are presented in Table 9 on p. 170.
2. The treatise *Dhāt al-kursī* is not mentioned among the works of Ptolemy until the mid-seventeenth century AD, with Ḥājjī Khalīfa being the first to mention it as such in his work *Kashf al-ẓunūn*, written between 1648 and 1657.[15]
3. The treatise contains non-Ptolemaic elements, listed above in Section 4.5.
4. The globe described is neither the precession globe, nor the armillary sphere 'astrolabe' invented by Ptolemy,[16] for which we would expect

[13] This globe is described in Chapter VIII.3 of the *Almagest*, see Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part II, pp. 179–85, and Toomer, *Ptolemy's Almagest*, pp. 404–07. Since the relative positions of the fixed stars change due to their proper motion, which was unknown in Ptolemy's time, the globe cannot actually be used eternally.

[14] The complete name appears only in manuscript A, while in the rest of the manuscripts it is written as 'Qusṭ'.

[15] Kātip Çelebi, *Keşf-el-zunun* (eds Yaltkaya and Bilge), vol. I, col. 865; Kātip Çelebi, *Kashf al-ẓunūn* (ed. Flügel), vol. III, p. 399. For the date of compilation see Gökyay, 'Kātib Čelebi'. For further discussion see the Introduction (Section 1.1).

[16] Ptolemy, *Syntaxis mathematica* (ed. Heiberg), part I, Chapter V.1, pp. 350–54 and vol. II, Chapter VIII.3, pp. 179–85, and Toomer, *Ptolemy's Almagest*, pp. 217–19 and 404–07.

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him to have developed an accompanying manual. This fact affirms that the presence of Ptolemy's name in the title refers to the treatise itself and not the instrument described in it.

5. The attribution of the treatise to Ptolemy was made according to the titles of manuscripts A, B and M, but his name is not mentioned at all throughout the texts of treatises P and Q. The reference to Ptolemy in the title could thus have been added erroneously by someone who found the traces of Ptolemy's work (*Almagest* II.6); who thought that Qusṭā's treatise was perhaps a translation of a work by Ptolemy; who attempted to lend more value to this treatise; or who simply wanted to emphasize the astronomical content of the treatise, or to denote the Greek origin of the celestial globe with stand.

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Appendix 1

Treatise on the Use of the Celestial Globe with Stand by Qusṭā ibn Lūqā: Table of contents in English translation

The titles of the 65 chapters in English translation

1. To know the drawings (which are on) the globe and their names
2. On the installation of the globe
3. To know the shape of the sky, its configuration (هيئتها) and its motion
4. To know the difference in the motion of the sky at any locality
5. To know the cause (علّة) of the equality of night and day on the (terrestrial) equator line
6. To know the difference between night- and day-time length in every region
7. To know the equality of night- and day-time lengths when the sun enters the first point of Aries and the first point of Libra in all regions
8. To know the longest and shortest daytime in all regions
9. To know the difference between the (lengths of) daylight of any two days at any locality you want
10. To know the number of daytime hours at any locality on any day you want
11. To know the difference between the daylight lengths on a given day at two given localities with different latitudes
12. To know the time-degrees of the seasonal hours at any locality and on any day you want
13. To know the time that has elapsed since sunrise in equal hours, if the ascendant is known
14. To know the time that has elapsed since sunrise in seasonal hours, if the ascendant is known
15. To know how to find the ascendant, if the elapsed time since sunrise in equal hours is known
16. To find the ascendant, if the elapsed time since sunrise in seasonal hours is known
17. To know the midheaven, if the ascendant is known
18. To know the descendant and the centre of the earth, if the ascendant or the midheaven is known
19. To know the daytime arc of any star you want among the stars drawn on the globe
20. To find the (corresponding) degree of the ecliptic for each one of the stars that are on the globe

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21. To know the 'latitude' of any star you want, among the fixed stars that are drawn on the globe
22. To find the declination from the equator for any star you want, among the fixed stars that are on the globe
23. To find the deviation from the zenith of any locality you want for any star you want, among the fixed stars that are drawn on the globe
24. To know the maximum altitude of each one among the fixed stars that are on the globe at any locality you want
25. To find the ortive amplitude of any star you want, among the stars that are on the globe at any locality you want
26. To find the distance between any two stars you want among the stars that are on the globe
27. To find the distance between the risings of any two stars you want among the stars that are on the globe at any locality you want
28. To know the stars that rise simultaneously from the horizon, those that set simultaneously, and those that culminate simultaneously, at all of the latitudes
29. To know the degree of rising of each one of the fixed stars, that of its setting and that of its meridian transit at all of the latitudes
30. To find the declination of any degree of the zodiac you want
31. To know the ortive amplitude of any degree you desire among the degrees of the zodiac, at any locality you want
32. To find the ascension (rising times) of the zodiacal signs in the right sphere
33. To find the ascension (rising times) of any zodiacal sign you want at any latitude you want
34. To know the stars that do not set at any locality you want, among the stars drawn on the globe
35. To know the stars that are never visible at any locality you want, among the stars of the globe
36. To know the stars that are seen twice in one night: early at night after sunset on the west side and early morning before sunrise on the east side. This is possible for stars near the north pole, when the sun is among the southern zodiacal signs
37. To know the stars, among the stars drawn on the globe, that are visible above the earth during the entire night, at a given night and locality
38. To find at what time any star you want, among the stars drawn on the globe, rises at any night and any locality you want
39. To find at what time any given star, among the stars drawn on the globe, sets at any night and any locality you want
40. To know the time of rising of the moon or any planet you want, at any night and any locality you want

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41. To find the time of setting of the moon or any given planet, at any night and any locality you want
42. To know the midday altitude ⟨of the sun⟩ at any locality and on any day you want
43. To know the maximum altitude of each one of the stars drawn on the globe at any locality you want
44. To know the difference between the greatest altitude of the sun on the same day in two localities with different latitudes
45. To know the place in which the entire year is one day, six months long daytime without night, and six months long night-time without daylight
46. To know the locality where no star ever rises and no star ever sets, but the visible stars are always visible there, and the invisible stars are always invisible
47. To know the place where the daylight is 24 equal hours
48. To know the place where Taurus rises before Aries
49. To know the place where the sun reaches the zenith
50. To know the localities in which there is no shadow at all at some moment within the year, and at which day and time this occurs
51. To know the localities where the shadows are in one direction and those where the shadows are in two directions, and the time when the shadows will be to the south and the time when they will be to the north
52. To know the localities where the sun reaches the zenith once a year and those where it reaches the zenith twice, and at what time during the year this occurs
53. On obtaining the altitude of the sun with the globe at any time you want
54. To know the four centres using the globe
55. To find the rest of the centres
56. To find the meridian line at any locality and any time you want
57. To know the azimuth of the *qibla* at any locality and any time you want
58. To find the 'longitude' of the moon and any planet you want, in a night during which it its possible to measure its maximum altitude
59. To find the 'latitude' of the moon or any planet you want, in a night during which it its possible to measure its maximum altitude
60. To know if a lunar eclipse occurs in the current month
61. To know if a solar eclipse occurs in the current month
62. To know the 'longitude', in degrees of the ecliptic, of any star you want among the fixed stars that are not drawn on the globe
63. To find the 'latitude' of any star you want among the fixed stars that are not drawn on the globe

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64. To know the distance from the equator (declination) of any star you want among the fixed stars that are not drawn on the globe
65. To know the distance between any star you want, among the fixed stars that are not drawn on the globe, and the zenith at any locality you want

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Appendix 2

Correspondence between the chapters of the Arabic manuscripts of treatise Q, its Latin translation* and treatise P

Q	Q_A	Q_B	$Q_{C/H/K/L/M/N/O/R/U/Z}$	Q_D	Q_E	Q_F	Q_S	Q_T[1]	Latin	P
1	1	1	1	1	1	1	1	1	1	Introd
2	2	2	2	2	2	2	2	2	2	1
3	3	3	3	3	3	3	-	3	3	1
4	4	4	4	4	4	4	-	4	4	1
5	5	5	5	5	5	5	-	5	5	2
6	6	6	6	6	6	6	3	6	6	3 -
7	7	7	7	7	7	7	4	7	7	3 -
8	8	8	8	8	8	8	-	8	8	3
9	9	9	9	9[2]	9	9	-	9	9	4
10	10	10	10	9	10	10	5	10	10	5
11	11	11	11	11	11	11	-	no number	11	6
12	12	12	12	12	12	12	6	11	12	5
13	13	13	13	13	13	13	-	12	13	7
14	14	14	14	14	14	14	-	13	14	7
15	15	15	15	15	15	15	7	14	15	8
16	16	16	16	16	16	16	8	15	16	8
17	17	17	17	17	17	17[3]	9	16	17	10
18	18	18	18	18	18	18	10	17	18	10
19	19	19	19	18[4]	19	19	-	18	19	5
20	20	20	20	19	20	20	-	20	20	12
21	21	21	21	20	21	21	-	21	21	12
22	22	22	22	21	22	22[5]	-	22	22	12
23	23	23	23	22	23	-	-	23	23	12
24	24	24	24	23	24	-	-	24	24	12
25	25	25	25	24	25	-	-	25	25	13
26	26	26	26	25	26	-	-	26	26	13

* As edited by Lorch and Martínez Gázquez

[1] In MS T, the numbers of the chapters are written in Arabic numerals in red colour at the beginning of the chapters. However, in some chapters the numbers have been omitted, thus there is a difference in chapter enumeration.

[2] The title is that of Chapter Q9, but the explanation corresponds to Chapter Q10. Both the explanation of Chapter Q9 and the title of Chapter Q10 are omitted.

[3] Written as 'seventh'.

[4] Only the number of the chapter is repeated as 18; the title and the explanation correspond to Chapter Q19.

[5] Only the first half of the text of this chapter is preserved, because a folio is missing.

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Q	Q_A	Q_B	$Q_{C/H/K/L/M/N/O/R/U/Z}$	Q_D	Q_E	Q_F	Q_S	Q_T	Latin	P
27	27	27	27	26	27	-	-	27	27	13
28	28	28	28	27	28	-	-	28	28	14
29	29	29	29	28	29	-	11	29	29	15
30	30	30	30	29	30	30	12	30	30	12
31	31	31	31	30	31[6]	31	13	31	31	13
32	32	32	32	31	31	32	14	32	32	16
33	33	33	33	32	32	33	15	33	33	16
34	34	34	34	33	33	34	-	34	34	17
35	35	35	35	34	34	35	-	35	35	17
36	36	36	36	35	35	36	-	36	36	18
37	37	37	37	36	36[7]	37	-	37	37	18
38	38	38	38	37	37	38	-	38	38	19
39	39	39	39	38	38	39	-	39	39	19
40	40	40	40	39	39	40	-	40	40	20
41	41	41	41	40	40	41	-	41	41	20
42	41a	42	42	41	41[8]	42	16	42	42	21
43	42	42a	43	42	42	43	-	43	43	21
44	43	43	44	43	43	44	-	44	44	22
45	44	44	45	44	44	45	17	45	45	23
46	45	45	46	45	45	46	-	no number	46	23
47	46	46	47	46	46	47	18	46	47	24
48	47	47	48	47	47	48	19	no number	48	25
49	48	48	49	48	48	49	20	47	49	26
50	49	49	50[9]	49	49[10]	50	23	48	50	26
51	50	51	51	50	50	51	24	49	51	27
52	51	52	52	51	51	52	25	50	52	26
53	52	53	53	52	52	53	-	51	53	9
54	53	54	54	53	53	54	-	54	54	10
55	54	55	55	54	54	55	-	55	55	11
56	55	56	56	55	55[11]	56	21	56	56	28
57	56	58	57	56	56[12]	57	22	57	57	28
58	57	59	58	57	57	58	-	58	58	29
59	58	60	59	58	58	59	-	59	59	30
60	59	61	60	59	59	60	-	60	60	31

[6] The last eight words of Chapter 31 and the title with the first six words of the explanation of Chapter 32 are both omitted. Thus, Chapter 31 contains both Chapters Q31 and Q32 except for the omission mentioned above.
[7] Written as Chapter 33 in the title.
[8] Written as الباب الخادي عشر والأربعين.
[9] The whole Chapter 50 is written twice on f. 10r of manuscript M.
[10] Written as Chapter 59 in the title.
[11] Written as Chapter 15 in the title.
[12] Written as Chapter 16 in the title.

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Q	Q_A	Q_B	$Q_{C/H/K/L/M/N/O/R/U/Z}$	Q_D	Q_E	Q_F	Q_S	Q_T	Latin	P
61	60[13]	62	61[14]	60	60	61	-	61	61	31
62	62	63	62	61	61	62	-	62	62	29
63	63	63	63	63	62	63	-	63	63	30
64	64	64	64	64	63	64	-	64	64	30
65	65	65	65[15]	65	64	65	-	65	65	30
66	66[16]	-	-	-	-	-	-	-	-	
67	67	-	-	-	-	-	-	-	-	5

13 Written as الباب الوني والستون.
14 Written as Chapter 60 in MS N.
15 In manuscript M, there are three additional unnumbered chapters after Chapter 65. These chapters are different from those in manuscript A and correspond to Chapters P32, P33.2 and P33.1 of the treatise P.
16 In the manuscript A of treatise Q there are two additional chapters numbered as 66 and 67.

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Appendix 3

Treatise on the Use of the Celestial Globe with Stand by Qusṭā ibn Lūqā: Arabic text

Since the treatise *Dhāt al-kursī* attributed to Ptolemy is based on the *Treatise on the Use of the Celestial Globe with Stand* by Qusṭā ibn Lūqā, as it is shown in Chapter 3 above, it is necessary for the reader to have access to the whole text of this treatise in order to compare these two works in every detail. Since only the Latin translation of this treatise has been published,[17] I present here a transcription of the Arabic text.

The manuscripts examined present many variants; in some of them the second-person singular is used for the description of the procedures, in others the first-person plural; also special expressions are consistently used in certain groups of manuscripts. There are manuscripts where the introduction or the list of chapters has been omitted. Also, the introduction appears in various patterns. The chapter numbering presents many differences, which are presented in Appendix 2. The above problems would complicate a critical edition of this text, which is not the principal treatise of this book. For this reason, I decided to present a transcription based on a few manuscripts.

I have used the manuscript O / و (Istanbul, Topkapi Saray, Ahmet III, 3475,1) as the main source for the transcription. This is a complete and carefully copied manuscript, with few omissions and grammatical errors. I have replaced only the problematic points of manuscript O with the corresponding points from manuscript Z / ز (Meshhed, Holy Shrine, 5595,1), which is strongly related to manuscript O but less carefully copied, or from manuscript N / ن (Istanbul, Topkapi Saray, Ahmet III 3505,5). The latter appears to be the oldest of the examined manuscripts, but it contains several grammatical errors and there is quite a number of omissions. In very few cases I have used the manuscripts:

A / ا: Cairo, Dār al-kutub, Mīqāt Ḥalīm ʿarabī 7;
B / ب: Cairo, Dār al-kutub, K ʿarabī 3824,13;
C / ج: London, British Library, Stowe Orient 10,6;
F / ف: Philadelphia, University of Pennsylvania, LJS 412,1 and
L / ل: Cairo, Central Library of Islamic Manuscripts, 3071,7.

The introduction presented in the transcription is that of manuscripts O and Z. In the apparatus, only the variants replacing those of manuscript O are mentioned, not all the variants from the other manuscripts.

17 Lorch and Martínez Gázquez, 'Qusta ben Luca. De sphera uolubili', in *Suhayl* 5 (2005).

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List of abbreviations in the transcription

Meaning	**Symbol**
addition	+
omitted	–
written twice	2×
the word هذا is struck through	~~هذا~~
a word or a phrase not included in the text	〈…〉
change of folio in MS و	/و/
f. 3r	3ا
f. 3v	3ب

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/ن 95ا/ # /ن/ كتاب العمل بالكرة الفلكيّة ألفه قسطا بن لوقا اليونانيّ

/ن 95ب/ /و ز ن/ بسم الله الرحمن الرحيم وبه نستعين

/و 1ب/
/ز 1ب/ كتاب العمل بالكرة لقسطا بن لوقا البعلبكيّ لأبي الصقر إسماعيل بن بُلبُل

ذكرت، أعزّك الله، الكرة الفلكيّة والعمل بها، وما رأيت من ظهور اختلاف مطالع الشمس ومغاربها فيها، وطول النهار وقصره، واختلافه في المدن باختلاف مواضع /و 2ا/ المدن من الأرض، وغير ذلك مما يظهر فيها ظهورا بيّنا، وأُمِرتُ /و/ بتأليف كتاب في ذلك يَظهر به كلّ الأعمال والحركات التي في الكرة، وإيضاح ذلك بأوجز ما يكون من اللفظ وأجمعه للمعاني، فسارعت إلى أمرك جعلني الله، فداك حبا مني لإشارتك والتماسا لمحبتك إذ كنت أرى طاعتك كالفرض اللازم عليّ، والحق الواجب عليّ. وقدّمت في أوّل الكتاب أبواب كلّ ما ذكرته فيه من الأعمال بأعداد /و 2ب/ /و/ صيرتها عليها ليسهل عليك استخراج أيّ باب شئت منها ويقرب مأخذه، وعلى الله توكّلي وهو ثقتي ورجائي وبه أستعين.

/ن 96ا/ /ن/ الباب الأوّل: في معرفة رسوم الكرة وأسمائها.

الباب الثاني: في نصب الكرة.

الباب الثالث: في شكل السماء وهيئتها وحركتها.

الباب الرابع: في معرفة اختلاف حركة السماء على كلّ واحد من البلدان.

/و 3ا/ الباب الخامس: /و/ في معرفة علّة استواء الليل والنهار في خطّ الاستواء.

الباب السادس: في معرفة اختلاف الليل والنهار في كلّ واحد من المساكن.

الباب السابع: في معرفة استواء الليل والنهار عند دخول الشمس أوّل الحمل وأوّل الميزان في جميع المساكن.

الباب الثامن: في معرفة أطول النهار وأقصره في جميع المساكن.

/و 3ب/ الباب التاسع: في معرفة الاختلاف بين نهار أيّ يومين /و/ شئنا وفي أيّ بلد شئنا.

/ن 96ب/ الباب العاشر: في معرفة /ن/ ساعات النهار في أيّ يوم شئت وفي أيّ بلد شئت.

2 ن: وبه نستعين] و ز: – **3** لوقا] و: +قا و ز: البعلبكيّ] ن: اليوياني إسماعيل] ن: إسمعيل، و ز: – ن: بُلبُل] و ز: بلبل **9** عليّ] و ز: لي **10** في أوّل] و: لي أول، ز: لأول

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الباب ١١: في معرفة الاختلاف بين نهار يوم واحد مفروض في بلدين مفروضين مختلفي العرض.

الباب ١٢: في معرفة أزمان الساعات الزمانيّة في أيّ بلد شئت وأيّ يوم شئت.

/و 4أ/ الباب ١٣: في معرفة ما مضى من النهار من الساعات المستوية /و/ إذا كان الطالع معلوما.

الباب ١٤: في معرفة ما مضى من النهار من الساعات الزمانيّة إذا كان الطالع معلوما.

الباب ١٥: في استخراج الطالع، إذا كان ما مضى من النهار من الساعات المستوية معلوما.

الباب ١٦: في استخراج الطالع، إذا كان ما مضى من النهار من الساعات الزمانيّة معلوما.

الباب ١٧: في معرفة جزء وسط السماء، إذا كان الطالع معلوما.

/و 4ب/ الباب ١٨: في معرفة جزء الغارب /و/ ووتد الأرض، إذا كان الطالع أو جزء وسط السماء معلوما.

الباب ١٩: في معرفة قوس نهار أيّ كوكب شئت من الكواكب المرسومة على الكرة.

الباب ٢٠: في استخراج جزء كلّ واحد من الكواكب التي في الكرة من فلك البروج.

الباب ٢١: في معرفة عرض أيّ كوكب شئت من الكواكب الثابتة المرسومة على الكرة.

الباب ٢٢: في استخراج ميل أيّ كوكب شئت من الكواكب التي على الكرة عن خطّ معدّل النهار.

/و 5أ/ /و/ الباب ٢٣: في استخراج ميل أيّ كوكب شئت من الكواكب المرسومة على الكرة عن سمت رءوس أهل أيّ بلد شئت.

35 ن: السماء] و ز: – **36** ن: جزء[2]...37 السماء] و ز: العشر **42** ن: الثابتة] و ز: –
44 ن: من...45 النهار] و ز: عن معدّل النهار من الكواكب المرسومة، ز: من معدّل النهار الكواكب المرسومة **46** ز ن: الكواكب المرسومة] و: هذه الكواكب ن: على...47 الكرة] و ز: –

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الباب ٢٤: في معرفة أعظم ارتفاع كلّ واحد من الكواكب الثابتة التي على الكرة في أيّ /ن/ بلد شئت. /ن 97أ/

الباب ٢٥: في استخراج سعة مشرق أيّ كوكب شئت من كواكب الكرة في أيّ بلد شئت.

الباب ٢٦: في استخراج البعد بين أيّ كوكبين شئت من كواكب الكرة في أيّ بلد شئت.

/و 5ب/ الباب ٢٧: /و/ في استخراج البعد بين مشارق أيّ كوكبين شئت من كواكب الكرة في أيّ بلد شئت.

/ز 2أ/ الباب ٢٨: /ز/ في معرفة الكواكب التي تطلع من الأفق معًا، والتي تغرب معًا، والتي تتوسّط السماء معًا في كلّ واحد من الأقاليم.

الباب ٢٩: في معرفة جزء طلوع كلّ واحد من الكواكب الثابتة وغروبه وتوسّط سمائه في كلّ واحد من الأقاليم.

الباب ٣٠: في استخراج ميل أيّ جزء شئت من أجزاء دائرة البروج.

/و 6أ/ /و/ الباب ٣١: في معرفة سعة مشرق أيّ جزء شئت من أجزاء دائرة البروج في أيّ بلد شئت.

الباب ٣٢: في استخراج مطالع البروج في الفلك المستقيم.

الباب ٣٣: في استخراج مطالع أيّ برج شئت في أيّ إقليم شئت.

الباب ٣٤: في معرفة الكواكب التي لا تغيب عن أيّ بلد أردت معرفة ذلك فيه من الكواكب المرسومة على الكرة.

/و 6ب/ الباب ٣٥: في معرفة الكواكب التي لا تظهر بتّة /و/ في أيّ بلد شئت من الكواكب المرسومة على الكرة.

الباب ٣٦: في معرفة الكواكب التي تُرى في الليلة الواحدة مرتين بالعشيّ بعد غروب الشمس في المغرب وبالغداة قبل طلوع /ن/ الشمس في المشرق. /ن 97ب/

48 ز ن: الثابتة] و: الثانية **52** أيّ[1]] و: ×2 **56** ن: والتي تغرب] و ز: وتغرب **57** ن: والتي تتوسّط] و ز: وتتوسّط **58** ز ن: الثابتة] و: الثانية **59** ن: واحد...الأقاليم] و ز: إقليم **60** ز: شئت] و ن: شئنا **68** ن: على الكرة] و ز: – **69** ن: الليلة الواحدة] و ز: ليلة واحدة ز ن: بالعشيّ] و: – **70** ن: في[1]...وبالغداة] و ز: مغربا و ن: طلوع... المشرق] و ز: طلوعها مشرقا

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الباب ٣٧: في معرفة الكواكب التي تُرى في الليلة المفروضة الليل كلّه فوق الأرض من الكواكب المرسومة على الكرة في البلد المفروض.

الباب ٣٨: في استخراج الساعة التي يطلع فيها أيّ كوكب شئت من الكواكب المرسومة على الكرة في أيّ ليلة وبلد شئت.

/و 7ا/ الباب ٣٩: في استخراج /و/ الساعة التي يغرب فيها أيّ كوكب شئت من الكواكب المرسومة على الكرة في أيّ ليلة وبلد شئت.

الباب ٤٠: في معرفة ساعة طلوع القمر وأيّ كوكب شئت من الكواكب المتحيّرة أين شئت وأيّ ليلة شئت.

الباب ٤١: في استخراج ساعة غروب القمر وأيّ كوكب فرض لنا من الكواكب المتحيّرة في أيّ بلد وليلة شئت.

الباب ٤٢: في معرفة ارتفاع نصف النهار في أيّ بلد ويوم شئت.

/و 7ب/ /و/ الباب ٤٣: في معرفة أعظم ارتفاع كلّ واحد من الكواكب المرسومة في الكرة في أيّ بلد شئت.

الباب ٤٤: في معرفة الاختلاف بين أعظم ارتفاع الشمس في اليوم الواحد من بلدين مختلفي العرض.

الباب ٤٥: في معرفة الموضع الذي تكون فيه السنة كلّها يوما واحدا، ستة أشهر نهارا لا ليل فيه، وستة أشهر ليلا لا نهار فيه.

/و 8ا/ الباب ٤٦: في معرفة البلد الذي لا يطلع عليه كوكب /و/ بتّة ولا يغرب عنه كوكب بتّة، لكن الكواكب التي هي ظاهرة فيه تكون أبدًا ظاهرة، والكواكب
/ن 98ا/ التي هي خفيّة عنه تكون /ن/ أبدًا خفيّة.

الباب ٤٧: في معرفة الموضع الذي يكون النهار فيه أربعا وعشرين ساعة مستويّة.

الباب ٤٨: في معرفة الموضع الذي يطلع فيه الثور قبل الحمل.

72 ن: من...الكرة] و ز: – **73** ن: الكواكب] و ز: – **74** ن: على الكرة] و ز: – **75** يغرب...76 الكواكب] و: تغرب فيها ذلك الكواكب، ز: تغرب فيها ذلك الكوكب، ن: نغرب فيها أيّ كوكب فرض لنا من الكواكب **76** ن: المرسومة...الكرة] و ز: – **79** ن: وأيّ...الكواكب] و ز: أو غيره من **82** ن: في الكرة] و ز: – **84** ز ن: بين] و: نير **87** ز ن: فيه[2] و: فيها **89** ن: لكن...90 خفيّة[2]] و ز: –

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الباب ٤٩: في معرفة الموضع الذي تجوز فيه الشمس على سمت الرأس.

الباب ٥٠: في معرفة البلدان التي لا يكون لشيء فيها ظلّ أصلا في وقت ما من السنة /و/ وفي أيّ وقت ويوم يكون ذلك. /و 8ب/

الباب ٥١: في معرفة البلدان التي تكون الأظلال فيها في جهة واحدة والتي تكون فيها في الجهتين جميعًا، وفي أيّ وقت تكون الأظلال جنوبيّة وفي أيّ وقت تكون شماليّة.

الباب ٥٢: في معرفة البلدان التي تصير الشمس فيها على سمت الرأس مرة واحدة في السنة، والتي تصير فيها على سمت الرأس مرتين وفي أيّ /و/ وقت يكون ذلك. /و 9أ/

الباب ٥٣: في معرفة أخذ ارتفاع الشمس بالكرة في أيّ وقت شئت.

الباب ٥٤: في معرفة الأوتاد الأربع بالكرة.

الباب ٥٥: في استخراج الأوتاد الباقية.

الباب ٥٦: في استخراج خطّ نصف النهار في أيّ بلد شئت وأيّ وقت.

الباب ٥٧: في معرفة سمت القبلة في أيّ بلد شئت وأيّ وقت شئت.

/و 9ب/ الباب ٥٨: في استخراج موضع /و/ القمر وأيّ كوكب شئت من الكواكب المتحيّرة في الليلة التي يمكنك أن تأخذ فيها أعظم ارتفاعه.

/ن 98ب/ الباب ٥٩: في استخراج عرض القمر أو أيّ كوكب شئت من الكواكب /ن/ المتحيّرة في الليلة التي يمكنك أن تأخذ فيها أتمّ ارتفاعه.

الباب ٦٠: في معرفة خسوف القمر إن كان يقع في الشهر الذي أنت فيه.

الباب ٦١: في معرفة كسوف الشمس إن كان يقع في الشهر الذي أنت فيه.

93 تجوز] و: يجوز، ز: ٮجوز، ن: ٮكون **94** التي] و ز ن: الذي **96** تكون[1]] و ز ن: يكون تكون[2]] و ز: يكون، ن: ٮكون **97** تكون] و ز: يكون، ن: ٮكون ن: وفي[2]] و ز: و **98** تكون] و ز: يكون، ن: ٮكون **99** ز: تصير] و: يصير، ن: ٮصير **100** تصير] و ز: يصير، ن: ٮصير **102** وقت] و: +من أيّ يوم، ز: +وأيّ يوم **104** ب: الأوتاد الباقية] و: باقي المراكز، ز: بيوت باقي المراكز، ن: البيوت الباقية **107** ن: الكواكب] و ز: — **108** ن: الليلة التي] و ز: ليلة **109** ن: الكواكب] و ز: — **110** ن: الليلة...أن] و ز: ليلة **111** ن: كان يقع] و: وقع، ز: — **112** ن: يقع] و ز: وقوعة

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/و 10أ/ الباب ٦٢: في معرفة موضع أيّ /و/ كوكب شئت من الكواكب الثابتة الغير مرسومة على الكرة من أجزاء دائرة البروج.

الباب ٦٣: في استخراج عرض أيّ كوكب أردت من الكواكب الثابتة الغير مرسومة على الكرة.

/ز 2ب/ /ز/ الباب ٦٤: في معرفة بعد أيّ كوكب شئت من الكواكب الغير مرسومة في الكرة عن فلك معدّل النهار.

الباب ٦٥: في معرفة البعد بين أيّ كوكب شئت من الكواكب الغير المرّسومة على الكرة وبين نقطة سمت الرأس، في أيّ بلد شئت.

/و 10ب/ **الباب الأوّل: /و/ في معرفة رسوم الكرة وأسمائها.**

الكرة آلة مؤلفة من نفس الكرة والحلقة الثابتة عليها والكرسي الحامل لها. فأمّا الرسوم التي فيها، فهي: فلك وسط البروج، وفلك معدّل النهار، واثنا عشر فلكا تفصل بين الاثنى عشر برجا، وفلك نصف النهار، وفلك الأفق، وقطبا فلك معدّل النهار، وقطبا
/و 11أ/ فلك وسط البروج، وكواكب منازل القمر، وكواكب آخر نيّرة من الكواكب /و/ الثابتة.

أمّا فلك وسط البروج في الكرة، فهو الدائرة المقسومة بثلاثمائة وستين قسما متساوية الموقّع عليها أسماء البروج الاثنى عشر، وموقّع على كلّ برج منها عدد درجة الثلاثين.

وأمّا فلك معدّل النهار فهو الدائرة المقاطعة لهذه الدائرة على أوّل الحمل وأوّل
/ن 99أ/ الميزان، وهي /ن/ أيضًا مقسومة بثلاثمائة وستين جزءا متساوية موقّع عليها أعداد
/و 11ب/ تبتدئ /و/ من واحد وتنتهي إلى ثلاثمائة وستين.

وأمّا الاثنا عشر فلكا التي تفصل بين الاثنى عشر برجا كلّ واحد منها من الذي يليه، فهي اثنتا عشرة دائرة، يجوز كلّ واحد منها على أوّل برج من البروج الاثنى

113 ن: الكواكب] و ز: – ز ن: الثابتة] و: الثانية **115** ن: الكواكب] و ز: – ز ن: الثابتة] و: الثانية **117** ن: في[2]...118 الكرة] و ز: – **118** ن: فلك] و ز: خطّ **119** ن: الكواكب] و ز: – **120** ن: على الكرة] و ز: – **122** ز ن: الثابتة] و: الثانية **125** ز ن: الثابتة] و: الثانية **129** ن: الدائرة[1]] و ز: دائرة **133** اثنتا عشرة] و ز: اثنى عشر، ن: اثنا عشر

113 الغير...114 مرسومة] الصورة الصحيحة : غير المرسومة

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عشر وعلى نظير ذلك البرج، وتتقاطع كلّها على نقطتين على جنبتي فلك وسط البروج.

وأمّا فلك نصف النهار فهو الحلقة الثابتة على الكرة، والكرة تتحرك في داخلها، /و 12أ/ /و/ وهي أيضًا تتحرك على الكرة، وهي مقسومة أيضًا ثلاثمائة وستين جزءا متساوية.

وأمّا فلك الأفق فهو حلقة الكرسي التي تنصب عليها الكرة، وهي أيضًا مقسومة بثلاثمائة وستين جزءا متساوية، موقّع عليها أعداد مشارق الشتاء ومشارق الصيف ومغارب الشتاء ومغارب الصيف، والشمال والجنوب.

/و 12ب/ وأمّا قطبا فلك معدّل النهار فهما الثقبان اللذان /و/ فيهما المسماران اللذان بهما تثبت الحلقة على الكرة، وبهما تدور الحلقة على الكرة، والكرة في الحلقة؛ وهما ثابتان موقّع على أحدهما القطب الشماليّ وعلى الآخر القطب الجنوبيّ. وبعدهما عن فلك معدّل النهار من أجزائه كلّها بُعد متساو.

وأمّا قطبا فلك وسط البروج فهما النقطتان اللتان تتقاطع عليهما الاثنتا عشرة دائرة /و 13أ/ الفاصلة البروج وبعدهما /و/ عن فلك وسط البروج من أجزائه كلّها بُعد متساو.

وأمّا منازل القمر، فهي الدارات الصغار المختلفة في العظم الموقّع عليها أسماء الثماني والعشرين منزلة على فلك البروج وعن جنبتيه.

وأمّا الكواكب الثابتة فهي الدارات الصغار المتساوية في العظم الموقّع عليها أسماء الكواكب المرسومة في الأسطرلاب.

/ن 99ب/ /ن/ **الباب الثاني: في نصب الكرة.**

/و 13ب/ وأمّا نصب الكرة، فهو أن تضع الكرسي /و/ بين يديك وتصيّر مشارق الصيف ومشارق الشتاء فيما يليك، وتضع القطب الشماليّ على العرض الموقّع عليه الشمال، والقطب الجنوبيّ على العرض الموقّع عليه الجنوب؛ وتركب الحلقة أيضًا في العرض الذي في العارضة التي في أسفل الكرسي، وترفع القطب الشماليّ عن الأفق من أجزاء حلقة نصف النهار بقدر عرض البلد الذي أنت فيه. فإنك إذا فعلت ذلك كنت

134 ن: على[2]] و ز: عن **136** ن: الثابتة] و ز: الثانية **145** الاثنتا عشرة] ز ن: الاثنى عشر، و: الاثنا عشر **148** الثماني] و ز: الثمان، ن: الثمانية **149** ز ن: الثابتة] و: الثانية **150** ن: المرسومة] و: التي، ز:— **153** ز ن: العرض] و: الغرض **154** ز ن: العرض[1]] و: الغرض ز ن: العرض[2]] و: الغرض

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/و 14أ/ قد نصبت /و/ الكرة حقّ نصبها وصارت رسوم حلقة نصف النهار فيما يليك، وصار ربع الكرة الذي من حلقة نصف النهار إلى حلقة الأفق ظاهرا لك كلّه، وأمكنك أن تعمل بها ما تريد من الأعمال.

الباب الثالث: في معرفة شكل السماء وهيئتها وحركتها.

أمّا شكل السماء، فهو مستدير كاستدارة الكرة، ونصفها أبدًا فوق الأرض ونصفها أبدًا /و 14ب/ تحت الأرض، كما /و/ أن نصف الكرة أبدًا فوق حلقة الكرسي التي تقوم مقام الأفق ونصفها أبدًا تحتها. وأمّا حركة السماء، فهي كحركة الكرة إذا أدرتها من المشرق ذاهبا إلى المغرب، فإنها تدور دورة واحدة وجزءا من ثلاثمائة وستين جزءا من دورة بالتقريب في أربع وعشرين ساعة مستوية. وذلك أنك إذا جعلت جزءًا ما من أجزاء /و 15أ/ دائرة البروج على الأفق الشرقيّ، ثمّ أدرت الكرة إلى أن يصير نصف ذلك /و/ الجزء على الأفق الغربيّ، كان ذلك مثل دوران السماء في اليوم الذي تكون فيه الشمس في ذلك الجزء من طلوع الشمس إلى غروبها. وإذا أدرت الكرة حتّى يغيب ذلك /ز 3أ/ الجزء من الأفق الغربيّ ويبلغ أوّل الجزء الذي يليه من الأفق /ز/ /ن/ الشرقيّ، فإن /ن 100أ/ ذلك مثل دوران السماء في الليلة التي تكون فيها الشمس في ذلك الجزء، فتدور /و 15ب/ الشمس في اليوم والليلة دورة واحدة /و/ وجزءا من ثلاثمائة وستين من تلك الدورة بالتقريب، وهي الدقائق التي سارتها الشمس في فلك البروج في ذلك اليوم، وهذا الدوران على قطبي فلك معدّل النهار، لا على قطبي فلك البروج.

الباب الرابع: في معرفة اختلاف حركة السماء على كلّ واحد من البلدان.

السماء وإن كانت حركتها مستديرة متشابهة من الجهات كلّها، فإنها تختلف على /و 16أ/ المدن لاختلاف /و/ مواضع المدُن من الأرض، وذلك أن الأرض لمّا كانت كريّة وكانت في وسط السماء صارت كلّ نقطة منها تسامت نقطة من السماء، وكلّ فلك من الأفلاك التي في السماء يسامت موضعا منها، فالموضع من الأرض الذي يسامت خطّ معدّل النهار من السماء يسمى خطّ الاستواء، وهو الموضع الذي يكون

157 حلقة] ز و: +فلك **161** ن: شكل السماء] و ز: شكلها **167** تكون] و ز: يكون، ن: بكون **170** ز ن: تكون] و: يكون **175** ن: تختلف] و: مختلف، ز: مختلفة **177** ن: صارت] و ز: صارق

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/و 16ب/ فيه القطبان جميعا في الأفق؛ وكلّما تقدّمت المساكن عن ذلك /و/ الخطّ إلى الشمال، ارتفع القطب الشماليّ عليها وانحطّ عنها القطب الجنوبيّ؛ وبقدر ارتفاع القطب الشماليّ، ينحطّ القطب الجنوبيّ. وأمّا الناحية الجنوبيّة عن خطّ الاستواء، فإن المسكون منها يسير جدًا، والذين يسكنونه حبشان وزنج في جزائر في البحر، وأمم شبيهة بالبهائم، لا بناء لها، ولا صناعة، ولا علم. وأمّا الناحية الشماليّة، فهي /و 17أ/ المعمورة من الأرض التي فيها /و/ مدن الروم، والعرب، والفرس، وسائر الأمم. فكلّما ارتفع القطب الشماليّ عن الأفق، صار دوران الكرة مائلا منحرفا، وذلك الميلان /ن 100ب/ والانحراف يختلف في الزيادة والنقصان /ن/ على قدر اختلاف ميل ذلك البلد عن خطّ الاستواء في الكثرة والقلّة، فإن البلد الذي بُعده عن خطّ الاستواء بعدا كثيرا، يكون انحرف دوران السماء عليه انحرافا كثيرا، والبلد القريب من خطّ الاستواء يكون /و 17ب/ /و/ هذا الانحراف عليه يسيرا.

فإذا أردت أن ترى ذلك في الكرة، فصيِّر القطبين جميعًا في حلقة الأفق وأدِرْ الكرة، فإنك ترى دورانها دورانا مستويا لا ميل فيه ولا انحراف، وعلى مثل ذلك الدوران تدور السماء على خطّ الاستواء. ثمّ ارفع القطب الشماليّ أجزاء ما عن الأفق وأدِرْ الكرة، فإنك ترى دورانها مائلا ميلا ما؛ وكلّما زدت القطب ارتفاعا، ازداد دوران /و 18أ/ /و/ الكرة ميلا، حتّى يصير دورانها كدوران الرحى على موازاة الأفق، وذلك يكون إذا صيّرت أحد القطبين على نقطة سمت الرأس، وهو إذا رفعت القطب الشماليّ عن الأفق بتسعين جزءا. وبهذا العمل يظهر اختلاف دوران السماء على المساكن كاختلاف مواضع المساكن من الأرض.

الباب الخامس: في معرفة علّة استواء الليل والنهار في خطّ الاستواء.

/و 18ب/ إذا أردت /و/ ذلك فضع القطب الشماليّ على الأفق من جهة الشمال، فإن القطب الجنوبيّ لا محالة يصير على الأفق من جهة الجنوب. وضع أيّ جزء شئت من أجزاء

180 ن: القطبان] و ز: النقطتان ن: الأفق] ز و: الأرض ز ن: وكلّما] و: وكلّ ما **181** ز ن: القطب[2]] و: لقطب **186** ز: الشماليّ] ن و: – **188** ن: بعدا كثيرا] و ز: بعد كثير **192** ز ن: دورانا] و: دوران **194** ز ن: وكلّما] و: وكلّ ما **195** ز ن: كدوران الرحى] و: دوران الرخا **197** ز: بتسعين] و: تستعين، ن: تسعون **200** ن: القطب الشماليّ] و ز: قطب الشمال

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دائرة البروج على الأفق الشرقيّ، وانظر أيّ جزء من أجزاء فلك معدّل النهار يصير مع ذلك الجزء على الأفق من جهة المشرق، فتعلّم عليه بمداد. ثمّ أدِرْ الكرة إلى أن يصير ذلك الجزء من أجزاء دائرة البروج على الأفق من جهة المغرب، فإنك
/و/ ستجد أيضًا الجزء الذي علّمت عليه من أجزاء فلك معدّل النهار قد وافى معه (و 19أ)
المغرب. ثمّ عدّ من ذلك الجزء راجعا إلى المشرق من أجزاء /ن/ فلك معدّل النهار، (ن 101أ)
فإنك ستجد بها أبدًا مائة وثمانين، التي هي نصف الثلاثمائة والستين، وهي الأجزاء التي طلعت في ذلك اليوم. وإذا غربتَ ذلك الجزء وأدرتَ الكرة حتّى يدور الجزء
ونصف الكرة التي تحت الأرض ويرجع إلى أفق المشرق، /و/ ثمّ عددت الأجزاء (و 19ب)
التي دارت من الكرة من المشرق إلى المغرب في تلك الليلة، وجدتها أيضًا مائة وثمانين جزءا متساوية لأجزاء مسيرة الفلك في النهار، فيكون مسير الفلك في الليل والنهار مسيرا متساويا أبدًا، وكذلك إن فعلت هذا في جزء آخر من أجزاء فلك البروج، أيّ جزء كان، وجدت ذلك كالذي وصفنا؛ فيظهر لك بهذا العمل أن مسير
الفلك على خطّ /و/ الاستواء في الليل والنهار أبدًا مستو، لا اختلاف فيه ولا تغيير البتّة. (و 20أ)

الباب السادس: في معرفة اختلاف الليل والنهار في كلّ واحد من المساكن.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق كم شئت من الأجزاء، ثمّ أدِرْ
الكرة حتّى يصير أيّ جزء شئت من أجزاء /ز/ فلك البروج على الأفق، وتعلّم من (ز 3ب)
أجزاء دائرة معدّل النهار على الجزء الذي وافى الأفق /و/ مع ذلك الجزء. ثمّ أدِرْ (و 20ب)
الكرة حتّى يصير ذلك الجزء من أجزاء دائرة البروج على أفق المغرب، وانظر الجزء الذي كنت علّمت عليه من أجزاء فلك معدّل النهار أين صار من الأفق الغربيّ، فإنك تجده، إن كان جزء الشمس من البروج الشماليّة، غائبا تحت الأرض، وإن كان جزء الشمس من البروج الجنوبيّة، طالعا فوق الأرض بعدُ لم يغب، فيظهر لك
من ذلك أن جزء معدّل /و/ النهار الذي طلع مع الشمس قد غاب قبل أن تغيب (و 21أ)

203 ن: من...المشرق] و ز: — **204** ز: يصير] و: تصير، ن: — ز: الجزء] و: الجزوء، ن: — **205** ز: علّمت] و: اعلمت، ن: عملت ز ن: أجزاء] و: أجز **210** ز ن: وجدتها] و: وحدتها **221** ز ن: علّمت] و: اعلمت **223** ن: جزء الشمس] و: جزءيها، ز: جزءها طالعا] و: +بعد ن: بعدُ...يغب] ز: لم يغيب بعد

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/ن 101ب/ الشمس، وأن أزمان النهار /ن/ في ذلك اليوم أكثر من أزمان نهار الاستواء الذي هو اثنتا عشرة ساعة، إن كانت الشمس في البروج الشماليّة. وأمّا إن كانت في البروج الجنوبيّة، كان عكس ذلك، أعني انّ جزء الشمس يغرب قبل جزء معدّل النهار /و 21ب/ الذي وافى معه المشرق، فيظهر من ذلك أن النهار في ذلك اليوم أقصر /و/ من نهار الاستواء، وكذلك يظهر في الليل؛ وذلك أن العمل في الليل والنهار عمل واحد. وإن رفعت القطب أكثر من ذلك الارتفاع أو حططته عن ذلك الارتفاع، بعد أن لا يكون على الأفق نفسه، خرج لك اختلاف الليل والنهار بينا أيضًا، إلّا أنّه يختلف في الكثرة والقلّة، وذلك أن كلّما كان القطب أكثر ارتفاعا، كان الاختلاف بين الليل /و 22ا/ والنهار /و/ أكثر.

الباب السابع: في معرفة استواء الليل والنهار عند دخول الشمس أوّل الحمل وأوّل الميزان في جميع المساكن.

إذا أردت ذلك فارفع القطب الشماليّ أيّ ارتفاع شئت، وصيِّر أوّل الحمل على الأفق الشرقيّ، وتعلّم على الجزء الذي على الأفق من أجزاء فلك معدّل النهار. ثمّ أدِرْ الكرة حتّى يصير أوّل الحمل على أفق المغرب؛ فإنك ترى الجزء الذي علمّت /و 22ب/ عليه من أجزاء فلك معدّل النهار /و/ قد وافى معه الأفق الغربيّ، وقد دارت الكرة من أجزاء الاستواء مائة وثمانين جزءا. وكذلك إذا دارت الكرة حتّى يصير جزء الشمس من الأفق الغربيّ إلي الأفق الشرقيّ، وافى معه الجزء، الذي علّمت عليه من أجزاء فلك معدّل النهار، الأفق الشرقيّ، فيتوافيان جميعا على الأفق الغربيّ والأفق الشرقيّ، فيكون زمان النهار مساويا لزمان الليل. وكذلك إن رفعت القطب عن الأفق أكثر من /و 23ا/ ذلك /و/ الرفع أو حططته، وجدت العمل واحدا؛ فيظهر من ذلك أن الليل والنهار /ن 102ا/ /ن/ يتساويان في دخول الشمس أوّل الحمل ودخولها أوّل الميزان في جميع المساكن.

225 ز ن: الاستواء] و: الاستراء **226** اثنتا عشرة] و ز ن: اثنا عشر **232** ن: كلّما] و ز: كلّ ما **237** ز: وتعلّم] و: يعلم، ن: نعلم **240** ن: دارت] و ز: ادرت ز ن: يصير] و: يسير

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الباب الثامن: في معرفة أطول النهار وأقصره في جميع المساكن.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق كم شئت من الأجزاء، ثمّ أدِرْ الكرة حتّى يصير أوّل السرطان على الأفق الشرقيّ، وتعلّم على الجزء الذي وافق /و 23ب/ /و/ الأفق من أجزاء دائرة معدّل النهار. ثمّ أدِرْ الكرة حتّى يصير جزء أوّل السرطان على الأفق الغربيّ، وتعلّم على الجزء الذي وافى المشرق عند موافاة أوّل السرطان المغرب، وعدّ ما بين العلامتين وأثبته ناحية؛ وافعل مثل ذلك بأوّل الجدي، وتَعرَّف ما يخرج لك من الأجزاء، وتثبته ناحية. افعل مثل ذلك بأيّ جزء شئت من أجزاء فلك /و 24أ/ البروج؛ فإنك تجد أكثر النهار أزمانا نهار أوّل السرطان، /و/ وأقلّها أزمانا نهار أوّل الجدي؛ وتجد أزمان نهار أوّل الحمل وأوّل الميزان متساوية لأزمان ليلهما. وتجد ما كان من أجزاء فلك البروج بين أوّل الحمل وأوّل السرطان أزمان نهارها أكثر من أزمان ليلها، وتجد ما كان من أجزاء فلك البروج من أوّل الجدي إلى أوّل الحمل أزمان /و 24ب/ نهارها أقلّ من أزمان لياليها. وكذلك إن رفعت القطب الشماليّ أكثر /و/ من ذلك الارتفاع، أو حططته عنه، بعد أن لا يكون القطب على الأفق، يظهر لك أن أكثر النهار أزمانا إذا كانت الشمس في أوّل السرطان، وأقلّها أزمانا إذا كانت الشمس في أوّل الجدي؛ فيظهر من هذا أن أطول النهار في جميع المساكن نهار أوّل السرطان، وأقصرها نهار أوّل الجدي.

الباب التاسع: في معرفة الاختلاف بين نهار أيّ يومين شئت من أيّ بلد شئت.

/ن 102ب/ إذا أردت ذلك، فارفع /ن/ القطب الشماليّ عن /و/ الأفق بقدر أجزاء عرض البلد /و 25أ/ الذي تريد معرفة ذلك فيه. وتعرّف موضع الشمس في اليومين اللذين تريد معرفة اختلاف النهار بينهما، وضع أحد الجزئين على الأفق الشرقيّ، وتعلّم على الجزء من أجزاء فلك معدّل النهار الذي وافى معه الأفق. ثمّ أدِرْ الكرة حتّى يصير جزء الشمس على الأفق الغربيّ، وتعلّم على الجزء الذي وافى المشرق من أجزاء فلك معدّل /و 25ب/ النهار، ثمّ عدّ ما بين العلامتين /و/ من الأجزاء، وأثبتها ناحية. ثمّ ضع الجزء الآخر

256 الحمل] و ز ن: السرطان السرطان] و ز ن: الحمل **257** ن: ليلها] و ز:لياليها ن: من2...الحمل] و ز: بين أول الحمل وأول الجدي **258** ن: القطب] و ز: بالقطب **260** ن: الشمس2] و ز: – **263** ز: شئت1] و: شئنا، ن: فرض لنا ز: شئت2] و ن: شئنا **266** بينهما] و ز: +فيه **268** ز: وتعلّم] و: ويعلم، ن: وبعلم

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/ز 4أ/ من أجزاء دائرة البروج /ز/ على الأفق الشرقيّ وتعرّف أزمانه من أجزاء فلك معدّل النهار بمثل ما عرفتها في الجزء الآخر، وأثبتها ناحية تحت الذي أثبت أوّلا، وانقص الأقلّ منها من الأكثر، فما بقي فهو زيادة أحد النهارين على الآخر. فاقسمها على خمسة عشر، فما خرج لك من القسم فهو زيادة نهار أحد اليومين على الآخر من /و 26أ/ ساعة، /و/ أو جزء من ساعة.

الباب العاشر: في معرفة ساعات النهار في أيّ بلد شئت لأيّ يوم شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر عرض البلد الذي تريد معرفة ذلك فيه، ثمّ أدِرْ الكرة حتّى يصير جزء الشمس الذي تريد أن تعرف ساعات نهاره على الأفق الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء فلك معدّل /و 26ب/ النهار. /و/ ثمّ أدِرْ الكرة حتّى يصير جزء الشمس على الأفق الغربيّ، وتعلّم على الجزء الذي وافى معه الأفق الشرقيّ من أجزاء فلك معدّل النهار، وعدّ ما بين العلامتين من الأجزاء، فاقسمها على خمسة عشر، وخذ لكلّ خمسة عشر جزء ساعة مستوية، وما لم يتمّ خمسة عشر فجزء من ساعة مستوية.

/ن 103أ/ **الباب الحادي عشر: في معرفة الاختلاف /ن/ بين نهار يوم واحد مفروض في بلدين مفروضين مختلفي العرض.**

/و 27أ/ إذا أردت ذلك، فتعَرّف /و/ جزء الشمس في ذلك اليوم، فارفع القطب الشماليّ عن الأفق بقدر عرض أحد البلدين المفروضين، وأدِرْ الكرة حتّى يصير جزء الشمس على الأفق من جهة المشرق، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء فلك معدّل النهار. ثمّ أدِرْ الكرة حتّى يصير جزء الشمس على الأفق الغربيّ، وتعلّم على جزء معدّل النهار الذي وافى المشرق مع غروب جزء الشمس، وعدّ ما بين /و 27ب/ /و/ العلامتين من الأجزاء، وأثبِتْها ناحية. ثمّ ارفع القطب الشماليّ أو حطّه حتّى يصير بقدر عرض البلد الآخر، وتعرف أزمان نهار ذلك الجزء كما عرفت أزمان نهار الجزء الأوّل، فما خرج لك من الأجزاء أثبِتْه تحت ما كنت أثبَتَّ أوّلا، وانقص

270 ز: وتعرّف] و: ويعرف، ن: — **271** ن: عرفتها] و: نعرفها، ز: نعرفها **281** ز: جزء] و: —، ن: منه **282** ن: من...مستوية[2]] و: ساعة، ز: — **285** ن: ذلك[1]] و ز: — **291** ن: الجزء] و ز: —

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الأقلّ من الأكثر، فما بقي فهو الاختلاف ما بين نهار ذينك اليومين في ذينك البلدين، وأكثرهما أزمانا هو أطولهما نهارا.

/و/ الباب الثاني عشر: في معرفة أزمان الساعات الزمانيّة في أيّ بلد وأيّ يوم شئت. /و 28أ/

إذا أردت ذلك، فاعرف جزء الشمس في ذلك اليوم، وارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه؛ ثمّ ضع جزء الشمس على الأفق الشرقيّ، وانظر أيّ جزء وافى معه الأفق من أجزاء فلك معدّل النهار. وأدِرْ الكرة
حتّى يصير جزء الشمس على الأفق /و/ الغربيّ، وتعلّم على الجزء الذي وافى معه /و 28ب/
الأفق الشرقيّ، وعدّ ما بين العلامتين من الأجزاء، واقسمها على اثنى عشر، فما خرج من القسم فهو أجزاء الساعات الزمانيّة في ذلك اليوم والبلد.

الباب الثالث عشر: في معرفة ما مضى من النهار من الساعات المستويّة، إذا كان الطالع معلوما.

إذا أردت ذلك فارفع القطب الشماليّ عن الأفق بقدر عرض /و/ البلد الذي تريد /و 29أ/
معرفة ذلك /ن/ فيه. ثمّ ضع جزء الطالع على الأفق، وتعلّم على الجزء الذي وافى /ن 103ب/
معه الأفق من أجزاء فلك معدّل النهار. ثمّ أدِرْ الكرة إلى المشرق حتّى يصير جزء الشمس على الأفق، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء فلك معدّل النهار، وعدّ ما بين العلامتين من الأجزاء، واقسمها على خمسة عشر، فكلّ خمسة
عشر منه ساعة مستوية مضت من النهار، وما لم يتمّ خمسة عشر /و/ فجزء من /و 29ب/
ساعة مضت.

الباب الرابع عشر: في معرفة ما مضى من النهار من الساعات الزمانيّة، إذا كان الطالع معلوما.

إذا أردت ذلك، فاستخرج أزمان ساعات ذلك اليوم كما فعلت فيما تقدّم. ثمّ ضع جزء الطالع على الأفق الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء

297 ز ن: فاعرف] و: فاعر **301** ز ن: واقسمها] و: او اقسمها **308** ز: وتعلّم] و ن: ويعلّم
310 ن: منه...مستوية] و ز: ساعة **314** ن: ذلك[1]...أزمان] و ز: –

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فلك معدّل النهار. ثمّ أدِرْ الكرة راجعا إلى المشرق حتّى يصير جزء الشمس على /و 30ا/ الأفق، وتعلّم على الجزء الذي وافى /و/ معه الأفق من فلك معدّل النهار، وعدّ ما بين العلامتين من الأجزاء، واقسمها على ما خرج لك من أجزاء ساعات ذلك اليوم، فما خرج لك من القسم من ساعة أو جزء من ساعة، فهو ما مضى من نهار ذلك اليوم من الساعات الزمانيّة.

الباب الخامس عشر: في معرفة استخراج الطالع، إذا كان ما مضى من النهار من الساعات المستوية معلوما.

/و 30ب/ إذا أردت ذلك، فضع جزء الشمس /و/ على الأفق، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء فلك معدّل النهار. ثمّ اضرب ما مضى من النهار من الساعات المستوية وكسورها في خمسة عشر، واطلع جزء الشمس، وعدّ من الجزء الذي علّمت عليه نازلا إلى ما يلي المشرق في أجزاء فلك معدّل النهار حتّى يستوي /ن 104ا/ /ن/ في أجزاء الساعات التي خرجت من ضربها في خمسة عشر، وتعلّم على /و 31ا/ الموضع الذي انتهى إليه العدد /و/ واطلع الجزء الذي انتهى إليه العدد حتّى يصير على الأفق، وانظر أيّ جزء وافى معه الأفق من أجزاء فلك البروج، فذلك الجزء هو الطالع في ذلك الوقت.

الباب السادس عشر: في استخراج الطالع، إذا كان ما مضى من النهار من الساعات الزمانيّة معلوما.

إذا أردت ذلك، فاستخرج أزمان الساعات لذلك الجزء على ما علمت فيما تقدّم. /و 31ب/ ثمّ ضع جزء الشمس على الأفق /و/ الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء فلك معدّل النهار، واضرب ما مضى من النهار من الساعات الزمانيّة وكسورها في أزمان ساعات ذلك اليوم، فما خرج من الضرب فعدّ مثله من الجزء الذي علّمت عليه نازلا في جهة المشرق، فحيث انتهى العدد تعلّم عليه علامة.

319 ن: من[3]] و ز: – **321** ن: من النهار] و ز: – **326** ز ن: علّمت] و: اعلمت ن: يستوي] و ز: يستو **335** ن: الساعات الزمانيّة] و ز: ساعة **337** ز ن: علّمت] و: اعلمت

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وأَدِرْ الكرة حتّى تصير تلك العلامة على أفق المشرق، وانظر أيّ جزء وافى أفق المشرق من أجزاء /و/ دائرة البروج، فذلك الجزء هو الطالع في ذلك الوقت. /و 32ا/

الباب السابع عشر: في معرفة جزء وسط السماء، /ز/ إذا كان الطالع معلوما. /ز 4ب/

إذا أردت ذلك، فضع جزء الطالع على الأفق، وانظر أيّ جزء وافى معه حلقة خطّ نصف النهار من أجزاء فلك البروج، فذلك الجزء هو جزء وسط السماء في ذلك الوقت وذلك البلد.

الباب /و/ الثامن عشر: في معرفة جزء الغارب ووتد الأرض، إذا كان الطالع أو جزء وسط السماء معلوما. /و 32ب/

إذا أردت ذلك، فضع جزء الطالع أو جزء وسط السماء، أيما أحببتَ، من دائرة فلك البروج في موضعه، وانظر أيّ جزء وافى أفق المغرب من فلك البروج، فهو الغارب؛ والجزء الذي يوافي /ن/ خطّ نصف النهار تحت الأرض من دائرة /و/ فلك البروج، فهو وتد الأرض في ذلك الوقت. /ن 104ب/ /و 33ا/

الباب التاسع عشر: في معرفة قوس نهار أيّ كوكب شئت من الكواكب المرسومة على الكرة.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق من أجزاء حلقة نصف النهار بقدر عرض البلد الذي تريد معرفة ذلك فيه. ثمّ أَدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة قوس نهاره على الأفق الشرقيّ، وانظر أيّ جزء /و/ يوافي معه الأفق من أجزاء الاستواء، وهي أجزاء فلك معدّل النهار، فتعلّم عليه. ثمّ أدِرْ الكرة حتّى يصير ذلك الكوكب على أفق المغرب، وانظر أيّ جزء وافى أفق المشرق من أجزاء الاستواء عند مصير الكوكب على أفق المغرب، فتعلّم عليه. وتعدّ ما بين العلامتين من الأجزاء، /و 33ب/

344 ن: الطالع] و ز: +معلوما **345** ن: معلوما] و ز: – **349** في...الوقت] ن: في ذلك، و ز: – **350** ن: الكواكب...351 على] و ز: كواكب **352** فارفع] و: ×2
354 ن: معرفة] و ز: معرفته ز ن: يوافي] و: توافي **355** ز ن: أجزاء] و: أجز

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فما خرج لك فهو قوس نهار ذلك الكوكب في ذلك البلد، وما بقي إلى تمام ثلاثمائة وستين فهو قوس ليلته.

/و 34أ/ **الباب /و/ العشرون: في استخراج جزء كلّ واحد من الكواكب التي في الكرة من فلك البروج.**

إذا أردت ذلك، فأدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة جزئه من فلك البروج مع وجه حلقة خطّ نصف النهار الذي يلي المشرق، وانظر أيّ جزء وافى معه تحت وجه حلقة نصف النهار من أجزاء فلك البروج، فذلك الجزء من ذلك البرج هو جزء ذلك الكوكب، وهو له في الأقاليم كلّها، وليس يتغيّر /و/ بتغيّر العروض. /و 34ب/

الباب الحادي والعشرون: في معرفة عرض أيّ كوكب شئت، من الكواكب الثابتة المرسومة على الكرة.

إذا أردت ذلك، فأدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة عرضه مع وجه حلقة خطّ نصف النهار، وانظر الجزء من دائرة البروج الذي وافى معه تحت وجه هذه الحلقة، فعدّ ما بين الكوكب وجزء فلك البروج من أجزاء الحلقة، فما خرج فهو عرض ذلك /و/ الكوكب في الجهة /ن/ التي هو فيها عن خطّ وسط البروج. فإن كان أقرب إلى القطب الجنوبيّ، فإنّ عرضه جنوبيّ؛ وإن كان أقرب إلى القطب الشماليّ، كان عرضه شماليًا؛ وذلك العرض ثابت أبدًا، غير متغيّر في الأقاليم كلّها. /و 35أ/ /ن 105أ/

الباب الثاني والعشرون: في استخراج ميل أيّ كوكب شئت من الكواكب التي في الكرة عن خطّ معدّل النهار.

/و 35ب/ إذا أردت ذلك، فأدِرْ الكرة حتّى /و/ يصير الكوكب مع وجه حلقة نصف النهار، ثمّ انظر أيّ جزء من أجزاء فلك معدّل النهار يوافي معه خطّ نصف النهار، فتعلّم عليه. وعدّ ما بين ذلك الجزء وبين الكوكب من أجزاء حلقة نصف النهار، فما خرج لك فهو ميل ذلك الكوكب عن خطّ معدّل النهار في الجهة التي الكوكب فيها؛ فإن كان

358 ن: تمام...359 ثلاثمائة] و: تم المائة، ز: ثنمة المائة **362** ن: جزئه] و ز: جزء
365 ن: هو] و ز: – **366** ز ن: والعشرون] و: والعشرين ز ن: عرض] و: –
374 ز ن: والعشرون] و: والعشرين ن: الكواكب...في2] و ز: كواكب

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/و 36أ/ الكوكب أقرب إلى القطب الشماليّ، كان ميله شماليًا؛ وإن كان أقرب /و/ إلى القطب الجنوبيّ، كان ميله جنوبيًا. وهذا الميل أيضًا ثابت، غير متغيّر في المواضع كلّها.

الباب الثالث والعشرون: في استخراج ميل أيّ كوكب شئت من الكواكب المرسومة على الكرة عن سمت رءوس أهل أيّ بلد شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر عرض البلد الذي تريد معرفة /و 36ب/ ذلك فيه. ثمّ عدّ من أجزاء حلقة خطّ نصف /و/ النهار من الموضع الذي لاقى الأفق منها إلى فوق تسعين جزءا، فحيث انتهى العدد فعلِّم هناك علامة، فتلك العلامة هي سمت رءوس أهل ذلك البلد. ثمّ أدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة ميله عن سمت الرأس على خطّ نصف النهار، وعدّ ما بينه وبين العلامة التي كنت علّمت عليها من أجزاء حلقة نصف النهار، فما خرج فهو ميله عن سمت /و 37أ/ رأس أهل ذلك /و/ البلد في الجهة التي الميل فيها؛ فإن كان مائلا إلى ناحية /ن 105ب/ القطب الشماليّ، /ن/ فإنّ ميله شماليّ؛ وإن كان مائلا إلى ناحية القطب الجنوبيّ، كان ميله جنوبيًا. وهذا الميل يتغيّر على قدر اختلاف المساكن، ولذلك احتجت أن يُرفع له القطب على قدر عرض البلد الذي تريد معرفة ذلك فيه.

/و 37ب/ **الباب الرابع والعشرون: في معرفة أعظم ارتفاع كلّ واحد من الكواكب /و/ الثابتة التي على الكرة في أيّ بلد شئت.**

إذا أردت ذلك، فاستخرج ميل الكوكب الذي تريد معرفة أعظم ارتفاعه عن سمت الرأس، كما علمت في الباب الذي قبل هذا، وانقصه من تسعين، فما بقي فهو أتمّ ارتفاعا ذلك الكوكب. وإن أردت بوجه آخر، فارفع القطب الشماليّ بقدر عرض ذلك

380 ن: الكوكب] و ز: — **384** ن: المرسومة...الكرة] و ز: المذكورة **387** ن: تسعين] و ز: سبعين ز ن: فحيث] و: بحيث ز ن: فعلِّم] و: فاعلم **390** ز ن: علّمت] و: اعلمت **392** ن: مائلا] و ز: ميله **393** ل: ولذلك] و ز ن: كذلك ن: احتجت أن] و ز: احتجتان **394** ل: يُرفع] و: يرفع له، ز: برفع له، ن: برفع **398** ل: في...هذا] و ز: في الباب الذي قبله، ن: فيما تقدم **399** ن: وإن...بوجه] و: وتوجه، ز: وبوجه ن: فارفع] و ز: وارفع

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البلد وأدِرْ الكرة حتّى يصير الكوكب على خطّ نصف النهار، وعدّ ما بين الأفق /و 38ا/ والجزء الذي /و/ وقع عليه الكوكب من أجزاء خطّ نصف النهار، فما خرج لك فهو أعظم ارتفاع ذلك الكوكب؛ وهذا الارتفاع أيضًا يختلف على قدر اختلاف الأقاليم.

الباب الخامس والعشرون: في استخراج سعة مشرق أيّ كوكب شئت من الكواكب التي على الكرة في أيّ بلد شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض ذلك البلد. ثمّ /و 38ب/ أدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة /و/ سعة مشرقه على الأفق ⟨الشرقي⟩، وتعلّم على الجزء الذي وقع عليه من أجزاء الأفق. ثمّ أدِرْ الكرة حتّى يصير أوّل الحمل أو أوّل الميزان على الأفق ⟨الشرقي⟩، وتعلّم على الجزء الذي وقع عليه من أجزاء الأفق. ثمّ عدّ ما بين العلامتين من الأجزاء، فما خرج لك فهو سعة مشرق /ز 5ا/ ذلك الكوكب في الجهة التي تلك الأجزاء فيها عن مطالع رأس الحمل /ز/ والميزان؛ فإنّها، إن كانت في الشمال، كان مشرقه شماليًا، وإن كانت في الجنوب، كان /و 39ا/ مشرقه جنوبيًا. وهذا /و/ أيضًا يختلف على قدر اختلاف الأقاليم.

/ن 106ا/ **الباب /ن/ السادس والعشرون: في استخراج البعد بين أيّ كوكبين شئت من الكواكب التي على الكرة.**

إذا أردت ذلك، فأدِرْ الكرة حتّى يصير أحد الكوكبين اللذين تريد معرفة البعد بينهما على خطّ نصف النهار، وتعلّم على الجزء الذي يقع عليه من أجزاء حلقة خطّ /و 39ب/ نصف النهار. ثمّ أدِرْ الكرة حتّى يصير الكوكب الآخر على خطّ نصف /و/ النهار أيضًا، وتعلّم على الجزء الذي وقع تحته من أجزاء خطّ نصف النهار، وعدّ ما بين العلامتين من الأجزاء، فما خرج لك فهو البعد بين الكوكبين في الجهة التي الأجزاء فيها. وهذا البعد ثابت أبدًا غير مختلف في شيء من المساكن، وكذلك يمكنك أن تعرفه في أيّ ارتفاع شئت، من ارتفاعات القطب الشماليّ.

406 ن: الذي] و ز: التي ن: معرفة] و ز: – **410** ا: الكوكب] و ز ن: الجزء
412 ز ن: وهذا] و: وهذه **414** ن: الكواكب...على] و ز: كواكب

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/و 40أ/ **الباب السابع والعشرون: في استخراج البعد بين مشارق /و/ أيّ كوكبين شئت من الكواكب التي على الكرة في أيّ بلد شئت.**

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه، وأدِرْ الكرة حتّى يصير أحد الكوكبين اللذين تريد معرفة البعد بين مشرقيهما على الأفق ⟨الشرقيّ⟩، وتعلّم على الجزء الذي وقع عليه من أجزاء فلك الأفق. ثمّ أدِرْ الكرة حتّى يصير الكوكب الآخر أيضًا على الأفق، وتعلّم على الجزء
/و 40ب/ الذي وقع /و/ عليه من أجزاء الأفق، وعدّ ما بين العلامتين من الأجزاء، فما خرج العدد فهو البعد ما بين مشرقي ذينك الكوكبين. وهذا البعد يختلف باختلاف المساكن.

الباب الثامن والعشرون: في معرفة الكواكب التي تطلع من الأفق معًا، والتي تغرب معًا، والتي تتوسّط السماء معًا في كلّ واحد من الأقاليم.

/ن 106ب/ اعلم أن الكواكب التي تطلع معًا لا تتوسّط السماء معًا، ولا تغرب /ن/ معًا، ولا
/و 41أ/ الكواكب /و/ التي تتوسّط السماء معًا تغرب معًا وتطلع معًا، ولا الكواكب التي تغرب معًا تتوسّط السماء معًا وتطلع معًا، إلّا في خطّ الاستواء فقط. فإن في خطّ الاستواء الكواكب التي تطلع معًا تغرب معًا وتتوسّط السماء معًا ويكون دورانها كلّه معًا.

فإذا أردت أن تعرف ذلك بالكرة، فضع القطب الشماليّ في الأفق وأدِرْ الكرة، فإنك ترى الكواكب التي تصير على الأفق الشرقيّ معًا، تصير أيضًا على خطّ
/و 41ب/ /و/ وسط السماء معًا، وتصير على الأفق الغربيّ معًا. ثمّ ارفع القطب الشماليّ عن الأفق كم شئت من الأجزاء، وأدِرْ الكرة حتّى يصير الكوكبان على حلقة الأفق. ثمّ أدِرْ الكرة حتّى يصير أحد الكوكبين على حلقة خطّ نصف النهار، فإنك ترى الكوكب الآخر إمّا أن يكون قد جازها أو قد قصر عنها، وكذلك يظهر لك إذا أدرت الكرة حتّى يصير أحد الكوكبين على أفق المغرب.

423 ن: الكواكب...على] و ز: كواكب **425** ز: اللذين] و: الذين، ن: الذي
435 ن: السماء] و ز: – **436** ا: معًا[1]] و ز ن: – **437** ن: القطب] و ز: –
440 ج: الكوكبان] و ز: الكوكبين، ن: – **441** ز ن: ترى] و: يرى

440 الكوكبان... 441 يصير] ا، ب، ل، ن:–؛ انظر مناقشة الفصل Q28 في التعليقات على الفصل P14.

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/و 42أ/ /و/ فإذا أردت أن تعرف الكواكب التي تطلع معًا، والتي تغرب معًا، والتي تتوسّط السماء معًا، فارفع القطب الشماليّ بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه، ثمّ أدِرْ الكرة وتفقَّدْ حلقة الأفق وحلقة نصف النهار، وانظر ما يوافي عليها من الكواكب معًا، فما وافى أفق المشرق معًا فطلوعه معًا؛ وما وافى خطّ نصف النهار معًا فتوسُّطه السماء معًا؛ وما وافى /و 42ب/ /و/ أفق المغرب معًا فغروبه معًا. وذلك أيضًا يختلف على قدر اختلاف الأقاليم.

الباب التاسع والعشرون: في معرفة جزء طلوع كلّ واحد من الكواكب الثابتة، وغروبه، وتوسّطه السماء في كلّ واحد من الأقاليم.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه. ثمّ أدِرْ الكرة حتّى يصير الكوكب الذي تريد /ن 107أ/ /ن/ أن تعرف /و 43أ/ /و/ درجة طلوعه على الأفق الشرقيّ، وانظر أيّ جزء من أجزاء دائرة البروج وافى معه الأفق، فذلك الجزء هو جزء طلوعه في ذلك البلد. ثمّ أدِرْ الكرة حتّى يصير ذلك الكوكب على الأفق الغربيّ، وانظر أيّ جزء وافى معه الأفق الغربيّ من أجزاء فلك البروج، فذلك الجزء هو جزء غروبه. وأدِرْ الكرة أيضًا حتّى يصير ذلك الكوكب على خطّ نصف النهار، وانظر الجزء الذي /و 43ب/ /و/ توسّط معه السماء من دائرة فلك البروج، فذلك الجزء هو جزء توسّطه السماء، وهو جزؤه الحقيقيّ من فلك البروج. واعلم أن جزء الطلوع والغروب يختلف لاختلاف المساكن؛ وأمّا أجزاء توسّط السماء فإنّها ثابتة في كلّ الأقاليم، غير مختلف في شيء منها.

الباب الثلاثون: في استخراج ميل أيّ جزء شئنا من أجزاء دائرة البروج.

/و 44أ/ إذا أردت ذلك، فأدِرْ الكرة حتّى يصير /و/ الجزء الذي تريد معرفة ميله مع حافّة حلقة خطّ نصف النهار، وعلّم على الجزء الذي وقع عليه منها، وتعلّم أيضًا على

446 ن: وانظر] و ز: فتنظر **453** ن: أن] و ز: – **456** جزء] و ز: +فلك البروج الغربي
457 ن: أيضًا] و ز: – **459** ن: هو] و ز: – ز: الحقيقيّ] و ن: الحقي
460 ن: المساكن] و ز: – **461** ن: في] و ز: – **464** ن: وعلّم...الجزء] و ز: –

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الجزء الذي وقع على جزء فلك معدّل النهار، وعدّ ما بين العلامتين من أجزاء خطّ نصف النهار، فما خرج لك فهو ميل ذلك الجزء.

واعلم أن أوّل الحمل وأوّل الميزان لا تجد لهما ميلا بتّة، لأنهما يقاطعان فلك معدّل النهار، ويقع عليهما جميعًا جزء واحد من أجزاء فلك نصف النهار. وأمّا أوّل /و 44ب/ الجدي وأوّل /و/ السرطان، فإنّك تجد ميلهما ثلاثة وعشرين جزءا وثلاثا وثلاثين دقيقة، وسائر الأجزاء تجد ميلها داخلا في هذه الثلاثة والعشرين جزءا والثلاث والثلاثين دقيقة؛ وهذا الميل هو على حالة واحدة في الأقاليم كلّها، ولذلك يمكنك /ن 107ب/ أن تعرفه إذا رفعت القطب /ن/ الشماليّ على الأفق أو لم ترفعه.

الباب الحادي والثلاثون: في معرفة سعة مشرق أيّ جزء أحببتَ من أجزاء /و 45أ/ /و/ دائرة البروج في أيّ بلد شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة سعة مشرق ذلك الجزء فيه. ثمّ أدِرْ الكرة حتّى يصير ذلك الجزء على الأفق الشرقيّ، وانظر على أيّ جزء طلع من أجزاء دائرة الأفق فتعلّم عليه، وتعدّ ما بين تلك العلامة وجزء طلوع أوّل الحمل، فما اجتمع لك من أجزاء فهو سعة مشرق ذلك /و 45ب/ الجزء في الجهة التي ذلك /و/ الجزء فيها عن معدّل /ز/ النهار. فإن كان ذلك الجزء /ز 5ب/ من البروج الشماليّة، كانت أجزاء سعة مشرقه شماليّة؛ وإن كان من البروج الجنوبيّة، كانت أجزاء سعة مشرقه جنوبيّة. وسعة المشارق تختلف لاختلاف المدن، ولذلك احتجت أن ترفع القطب الشماليّ بقدر عرض البلد الذي تريد معرفة ذلك فيه.

/و 46أ/ الباب الثاني والثلاثون: في استخراج مطالع البروج في /و/ الفلك المستقيم.

إذا أردت ذلك، فضع القطب الشماليّ على الأفق، وأدِرْ الكرة حتّى يصير أوّل الحمل على الأفق من جهة المشرق، وانظر أيّ جزء من أجزاء فلك معدّل النهار وافى معه أفق المشرق، فتعلّم عليه. ثمّ أدِرْ الكرة حتّى يصير أوّل الثور على الأفق الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق من أجزاء دائرة معدّل النهار. وعدّ ما

465 ن: من...466 النهار] و ز: – **466** لك] و: +من أجزاء، ز: +من الأجزاء
471 والثلاثين] و ز: وثلثين، ن: والثلثون **472** ترفعه] و ز: يرفعه، ن: برفعه
475 ن: الشماليّ] و ز: – **478** ن: أوّل] و ز: – **481** ز ن: مشرقه] و: مشرقية

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/و 46ب/ بين العلامتين من الأجزاء، /و/ فما خرج فهو أجزاء مطالع الحمل في الفلك المستقيم. وكذلك فافعل بالثور والجوزاء، وباقي البروج، لتستخرج مطالعها في الفلك المستقيم. واعلم أن مطالع الفلك المستقيم هي مثل أجزاء مجاز البروج على خطّ نصف النهار في أيّ بلد شئت. فإن أردت أن تعرفها بخطّ نصف النهار، فارفع /ن 108ا/ القطب الشماليّ أيّ رفع شئت، ثمّ أدِرْ الكرة حتّى يصير أوّل البرج /ن/ الذي تريد /و 47ا/ معرفة مطالعه /و/ تحت وجه حلقة نصف النهار، وتعلّم على الجزء الذي وافى معه خطّ نصف النهار من أجزاء فلك معدّل النهار، ثمّ أدِرْ الكرة إلى ما يلي المغرب حتّى يجوز البرج كلّه خطّ نصف النهار، ويصير أوّل البرج الذي يليه على خطّ نصف النهار، وتعلّم على الجزء الذي وافى خطّ نصف النهار مع أوّل البرج الذي يلي ذلك البرج، وعدّ ما بين العلامتين من الأجزاء، فما خرج لك فهو أجزاء مطالع /و 47ب/ الفلك المستقيم. وإن امتحنت /و/ العملين جميعا، أصبتهما متفقين، لا اختلاف فيهما بتّة.

الباب الثالث والثلاثون: في استخراج مطالع أيّ برج شئت في أيّ إقليم شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بمقدار أجزاء عرض البلد الذي تريد معرفة ذلك فيه، وأدِرْ الكرة حتّى يصير أوّل جزء من البرج الذي تريد أن تستخرج مطالعه على الأفق الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق الشرقيّ /و 48ا/ من أجزاء فلك /و/ معدّل النهار. ثمّ أدِرْ الكرة إلى ما يلي المغرب حتّى يطلع ذلك البرج كلّه، ويصير أوّل البرج الذي يليه على الأفق الشرقيّ، وتعلّم على الجزء الذي وافى معه الأفق الشرقيّ من أجزاء فلك معدّل النهار، وعدّ ما بين العلامتين من الأجزاء، فما خرج لك فهو أجزاء مطالع ذلك البرج في ذلك الإقليم.

489 ل: في الفلك] و ز: بالفلك، ن: – **490** مجاز] و ن: مجار، ز: مجاري ن: على] و ز: عن **494** ن: إلى] و ز: – **505** ن: وتعلّم...506 الشرقيّ] و ز: –

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الباب الرابع والثلاثون: في معرفة الكواكب التي لا تغيب عن أيّ بلد أردت من الكواكب المرسومة على الكرة.

/و 48ب/ إذا أردت ذلك، فارفع القطب الشماليّ /و/ عن الأفق بقدر أجزاء عرض البلد الذي /ن 108ب/ تريد معرفة ذلك فيه. ثمّ أدِرْ الكرة /ن/ دورة واحدة، فما كان من الكواكب ممرّه تحت خطّ نصف النهار بين القطب الشماليّ والأفق، فإنّه لا يغيب البتّة عن ذلك البلد، ويدور دائرة تامّة فوق الأرض. وما كان ممرّه تحت خطّ نصف النهار بين القطب الشماليّ وفلك معدّل النهار فإنّه يطلع ويغرب، ويغيب ويظهر؛ فما كان منها /و 49أ/ أقرب /و/ إلى القطب الشماليّ كان زمانه فوق الأرض أكثر، وما كان منها أقرب إلي القطب الجنوبيّ فإنّ زمانه تحت الأرض أكثر.

الباب الخامس والثلاثون: في معرفة الكواكب التي لا تظهر بتّة في أيّ بلد شئت من كواكب الكرة.

إذا أردت ذلك، فضع القطب الجنوبيّ على الأفق الجنوبيّ، وعدّ منه في أجزاء حلقة /و 49ب/ نصف النهار بقدر عرض البلد الذي تريد معرفة ذلك فيه، وتعلّم /و/ على حيث انتهى العدد بمداد أو بشمع. ثمّ أدِرْ الكرة دورة واحدة، فما كان ممرّه من الكواكب على خطّ نصف النهار، بين القطب الجنوبيّ وبين العلامة التي علّمت، لا يظهر في ذلك البلد أصلا. وما كان ممرّه من الكواكب بين تلك العلامة ودائرة معدّل النهار ذاهبا إلى القطب الآخر، فهو يظهر في ذلك البلد. وهذا أيضًا مختلف على قدر /و 50أ/ اختلاف البلدان، لِأنّ البلدان /و/ التي عروضها قليلة جدًا، تكون الكواكب التي لا ترى فيها قليلة جدًا؛ والبلدان التي عروضها كثيرة، تكون الكواكب التي لا ترى فيها كثيرة.

509 ن: الكواكب...على] و ز: كواكب **512** فإنّه] و ز ن: فإنّها **513** ويدور دائرة] و ز: وتدور دوائر، ن: وتدور دائرة **520** ز: وتعلّم] و: ويعلّم، ن: وبعلّم **522** ز ن: علّمت] و: اعلمت **525** ز: تكون] و ن: يكون **526** ز: تكون] و: يكون، ن: بكون

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الباب السادس والثلاثون: في معرفة الكواكب التي تُرى في الليلة الواحدة مرتين، بالعشيّ بعد غروب الشمس في المغرب، وبالغداة قبل طلوع الشمس في المشرق.

/و 50ب/ /ن 109ا/ **هذا يتهيّأ في الكواكب القريبة من القطب الشماليّ، إذا /و/ كانت الشمس في البروج /ن/ الجنوبيّة.**

فإذا أردت أن تَرى ذلك في الكرة، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد أن تَرى ذلك فيه. ثمّ أدِرْ الكرة حتّى يصير جزء الشمس من البروج الجنوبيّة على الأفق الغربيّ، وانظر أيّ الكواكب تغرب منه من الكواكب التي فوق الأرض؛ فإنّ تلك الكواكب في تلك الليلة تكون ظاهرة في المغرب بعد غروب /و 51ا/ /و/ الشمس. ثمّ أدِرْ الكرة حتّى يغيب جزء الشمس وتغيب تلك الكواكب ويصير جزء الشمس على الأفق الشرقيّ، فإنك تَرى تلك الكواكب قد طلعت من الأفق قبل طلوع الشمس. فتكون قد غابت بعد مغيب الشمس وطلعت قبل طلوع الشمس، ورُئيَت في الليلة الواحدة مرتين: بالعشيّ بعد غروب الشمس، وبالغداة قبل طلوع الشمس، كما سبق ذكره.

/ز 6ا/ /و 51ب/ /ز/ **الباب السابع والثلاثون: في معرفة الكواكب التي تُرى في /و/ الليلة المفروضة جميع الليل فوق الأرض من الكواكب المرسومة على الكرة في البلد المفروض.**

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه، وتعرّف الجزء الذي الشمس فيه من أجزاء دائرة البروج في الليلة التي تريد معرفة ذلك فيها أيضًا. ثمّ أدِرْ الكرة حتّى يصير الجزء الذي فيه الشمس من /و 52ا/ أجزاء دائرة البروج على الأفق الغربيّ، /و/ وانظر أيّ كوكب يكون على الأفق الشرقيّ من الكواكب المرسومة على الكرة، وأدِرْ الكرة إلى أن يصير في أفق المشرق جزء الشمس، فما كان من تلك الكواكب ظاهرا في الغرب وقريبا من الأفق، فتلك الكواكب في تلك الليلة لا تغيب عن ذلك البلد، بل تكون ظاهرة فوق أفق الليل كلّه.

530 ا: يتهيّأ] و: نتها ز: سهما، ن: بين **535** ز: تكون] و ن: يكون **539** ن: بالعشيّ...540 الشمس] و ز: — **547** ب: وأدِرْ...548 الغرب] و ز ن: — **548** وقريبا] و ز: أو قريبا منه، ن: أو قريب

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الباب الثامن والثلاثون: في استخراج الساعة التي يطلع فيها أيّ كوكب شئت من الكواكب المرسومة على الكرة في أيّ ليلة، وأيّ بلد شئت.

/و 52ب/ إذا /و/ أردت ذلك، /ن/ فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد
/ن 109ب/ الذي تريد معرفة ذلك فيه، وتعرّف الجزء الذي الشمس فيه في تلك الليلة. ثمّ أدِرْ
الكرة حتّى يصير ذلك الجزء على الأفق الغربيّ، وتعلّم على الجزء الذي وافى معه
الأفق الشرقيّ من أجزاء دائرة معدّل النهار. ثمّ أدِرْ الكرة حتّى يصير الكوكب الذي
/و 53أ/ تريد معرفة ساعة طلوعه على الأفق /و/ الشرقيّ، وتعلّم على الجزء الذي وافى معه
الأفق من أجزاء دائرة معدّل النهار. ثمّ عدّ ما بين العلامتين من الأجزاء، واقسمها
على خمسة عشر، فما خرج لك من القسمة فهو الساعة من الليل التي يطلع فيها
ذلك الكوكب، وهذه الساعات مستوية. فإن أردت معرفة ذلك بالساعات الزمانيّة،
فاقسم الأجزاء التي خرجت لك من فضل ما بين العلامتين على أجزاء ساعات تلك
/و 53ب/ الليلة، فما خرج /و/ من القسمة فهو الساعة التي يطلع فيها ذلك الكوكب في تلك
الليلة في ذلك البلد بالساعات الزمانيّة.

الباب التاسع والثلاثون: في استخراج الساعة التي يغرب فيها أيّ كوكب فُرض لنا من الكواكب المرسومة على الكرة في أيّ ليلة شئنا وأيّ بلد شئنا.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض ذلك البلد،
/و 54أ/ وتعرّف جزء الشمس في تلك الليلة، وأدِرْ الكرة حتّى يصير ذلك /و/ الجزء على أفق
المغرب، فلا محالة أن الكوكب الذي تريد معرفة ساعة غروبه يكون ظاهرا في الكرة
على الأفق، فتعلّم على الجزء الذي وقع على الأفق الشرقيّ من أجزاء فلك معدّل
النهار، لما وضعت جزء الشمس على الأفق الغربيّ. ثمّ أدِرْ الكرة حتّى يصير
الكوكب على الأفق الغربيّ، وتعلّم على الجزء الذي وافى معه الأفق الشرقيّ من أجزاء
/ن 110أ/ دائرة معدّل /ن/ النهار. ثمّ عدّ ما بين العلامتين من الأجزاء واقسمها على خمسة
/و 54ب/ عشر، /و/ فما خرج لك من القسمة فهو عدد الساعات التي غرب فيها ذلك

556 زن: الكوكب] و: الكواكب **560** ن: مستوية] و: بالساعات المستوية، ز: بالسات المستوية **561** ن: من...العلامتين] و ز: – **562** زن: فهو الساعة] و: فهي الساعات ن: يطلع] و ز: – زن: الكوكب] و: الكواكب **564** زن: التي] و: الذي **565** ن: أيّ...شئنا[2]] و ز: ذلك الكوكب المذكور طلوعه **573** ن: القسمة] و ز: القسم

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الكوكب في تلك الليلة عن ذلك البلد، وهي ساعات مقام ذلك الكوكب فوق الأرض في تلك الليلة بالساعات المستوية. فإن أردت ذلك بالساعات الزمانيّة، فاقسم ما خرج لك من أجزاء فلك معدّل النهار على أزمان ساعات تلك الليلة، فما خرج لك /و 55أ/ فهي ساعات زمانيّة لوقت غروب ذلك الكوكب عن ذلك البلد ومقدار /و/ ساعات مقامه عليه.

الباب الأربعون: في معرفة ساعة طلوع القمر أو أيّ كوكب شئت من الكواكب المتحيّرة في أيّ ليلة وأيّ بلد شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه. ثمّ تعرّف جزء القمر أو الكوكب الذي تريد معرفة ساعة طلوعه من /و 55ب/ أجزاء دائرة البروج، وعرضه، وجهة عرضه. وأدِرْ الكرة حتّى يصير ذلك /و/ الجزء من أجزاء دائرة البروج تحت خطّ نصف النهار. ثمّ عدّ من أجزاء حلقة نصف النهار من موضع ذلك الجزء بقدر عرض القمر أو الكوكب المتحيّر في جهة عرضه، وتعلّم على الكرة في الموضع الذي يلاصق منها ذلك الجزء، فتلك العلامة هي موضع القمر أو الكوكب المتحيّر في تلك الليلة. ثمّ أدِرْ الكرة حتّى يصير الجزء الذي فيه الشمس /و 56أ/ على الأفق الغربيّ، وتعلّم على الجزء الذي وافق معه /و/ الأفق الشرقيّ من أجزاء فلك معدّل النهار. ثمّ أدِرْ الكرة حتّى تطلع العلامة التي علّمت لموضع الكوكب، وتعلّم على الموضع الذي وافى معه الأفق الشرقيّ من أجزاء دائرة فلك معدّل النهار، /ن 110ب/ وعدّ ما بين العلامتين من الأجزاء، فما خرج /ن/ لك فاقسمه على خمسة عشر، إن كنت تريد معرفة ساعة طلوعه بالساعات المستوية، أو على أجزاء ساعات تلك الليلة، إن كنت تريد معرفة ساعات طلوعه بالساعات الزمانيّة، فما خرج لك من القسمة فهو /و 56ب/ الساعة التي يطلع فيها القمر أو الكوكب المتحيّر في تلك الليلة /و/ في ذلك البلد.

579 ن: الكواكب] و ز: – **580** ن: أيّ] و ز: أية **592** ن: المستوية...593 بالساعات] و ز: – **593** ا: إن] ن: اليوم، و ز: – ن: لك...القسمة] و ز: القسم **594** ز: يطلع] و: تطلع، ن: نطلع

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الباب الحادي والأربعون: في استخراج ساعة غروب القمر وأيّ كوكب فرض لنا من الكواكب المتحيّرة في أيّ ليلة وأيّ بلد شئنا.

/ز 6ب/ إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء /ز/ عرض البلد الذي تريد معرفة ذلك فيه، فلا محالة أن القمر أو الكوكب المتحيّر يكون ظاهرا فوق /و 57ا/ الأرض. فتعرّف جزءه من فلك البروج، وعرضه، وجهة عرضه بتقويم /و/ أو بزيج. وأدِرْ الكرة حتّى يصير جزؤه تحت خطّ نصف النهار، وعدّ من أجزاء حلقة نصف النهار بقدر عرض الكوكب أو القمر في جهة عرضه، وتعلّم على الكرة في الموضع الذي انتهى العدد إليه علامة بمداد، فتلك العلامة هي موضع القمر أو الكوكب المتحيّر من الكرة. ثمّ أدِرْ الكرة حتّى يصير جزء الشمس على أفق المغرب، وتعلّم /و 57ب/ على الجزء الذي وافى معه أفق المشرق من /و/ أجزاء فلك معدّل النهار، وأدِرْ الكرة حتّى تصير تلك العلامة التي علّمت على أفق المغرب، وتعلمّ على الجزء الذي وافى معها أفق المشرق من أجزاء معدّل النهار، وعدّ ما بين العلامتين من الأجزاء وأقسمها على خمسة عشر، فما خرج لك فهو ساعات مستوية لغروب القمر أو الكوكب المتحيّر ومقامه فوق الأرض. وإن أردت ذلك بالساعات الزمانيّة، فاقسم الأجزاء التي /و 58ا/ خرجت لك على /و/ أجزاء ساعات تلك الليلة، فما خرج من القسمة فهو ساعات /ن 111ا/ /ن/ زمانيّة لمقام ذلك الكوكب فوق الأرض، ووقت غروبه.

الباب الثاني والأربعون: في معرفة ارتفاع نصف النهار في أيّ بلد ويوم شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد /و 58ب/ معرفة ذلك فيه، وتعلّم على الجزء الذي تكون فيه الشمس /و/ في ذلك اليوم من أجزاء فلك البروج. وأدِرْ الكرة حتّى يصير الجزء الذي علّمت عليه تحت حلقة نصف النهار، وانظر إلى أيّ ناحية هو أقرب من الأفق، إلى الشمال أو إلى الجنوب، فالناحية التي هو إليها أقرب عدّ منها ما بينه وبين الأفق من الأجزاء، فتلك أجزاء

595 ن: وأيّ...596 شئنا] و ز: أو أحد المتحيرة حسب ما ذكر في طلوعه **598** ن: أو الكوكب] و ز: والكوكب **601** ن: أو القمر] و ز: — **602** ا: بمداد] و: بهاد، ز: النهار، ن: — **603** ثمّ] و: ×2 **604** ن: أفق] و ز: — **605** ز ن: علّمت] و: اعلمت **609** ن: القسمة] و ز: القسم **613** ا تكون] و ز: يكون، ن: نكون **614** ن: تحت حلقة] و ز: بحلقة **615** ن: أيّ] و ز: —

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ارتفاع نصف النهار، اليوم الذي تكون فيه الشمس في ذلك الجزء في ذلك البلد. /و 59ا/ وهذا الباب أيضًا يختلف باختلاف المساكن، ولذلك /و/ احتجت أن ترفع القطب فيه بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه.

الباب الثالث والأربعون: في معرفة أعظم ارتفاع كلّ واحد من الكواكب المرسومة في الكرة في أيّ بلد شئت.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه. ثمّ أدِرْ الكرة حتّى يصير الكوكب الذي تريد معرفة أعظم ارتفاعه /و 59ب/ تحت /و/ حلقة خطّ نصف النهار، وانظر إلى أيّ جهة هو أميل، فعدّ الأجزاء في تلك الجهة من أجزاء حلقة نصف النهار التي بين الجزء الذي وقع علي الكوكب وبين الأفق، فما خرج فهو أجزاء الارتفاع لذلك الكوكب في ذلك البلد. وهذا الارتفاع يختلف في البلدان، ولذلك احتجت أن ترفع القطب فيه بقدر أجزاء عرض البلد الذي تريد معرفة ذلك فيه.

/ن 111ب/ /و 60ا/ **الباب الرابع والأربعون: /ن/ في معرفة الاختلاف /و/ بين أعظم ارتفاع الشمس في اليوم الواحد بين بلدين مختلفي العرض.**

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر أجزاء عرض أحد البلدين الذين تريد معرفة ذلك فيهما، وأدِرْ الكرة حتّى يصير جزء الشمس في فلك البروج تحت حلقة نصف النهار، وتعرّف أعظم ارتفاع الشمس في ذلك اليوم. ثمّ ارفع القطب الشماليّ أو حُطّه بقدر أجزاء عرض البلد الآخر، وأدِرْ الكرة حتّى يصير /و 60ب/ /و/ ذلك الجزء تحت حلقة خطّ نصف النهار، وتعرّف أيضًا أعظم ارتفاعه، فما وجدت من الاختلاف بين العددين، فهو الاختلاف بين أعظم ارتفاع الشمس في ذينك البلدين.

617 ز ن: النهار] و: نهار   ا: تكون] و ز: يكون، ن: نكون   **620** ن: الكواكب...621 في[1] و: كواكب، ز: كوكب   **622** ن: البلد...623 فيه] و ز: ذلك البلد   **624** ن: خطّ] و ز: –   **629** ن: ارتفاع] و ز: اختلاف   **630** ن: بين] و ز: من   **632** ن: فلك] و ز: ذلك، ا: ذلك اليوم في تلك   **635** حلقة خطّ] و ز: خطّ، ن: حلقة

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الباب الخامس والأربعون: في معرفة الموضع الذي يكون فيه السنة كلّها يوما واحدا: ستة أشهر كلّها نهارا لا ليل فيها، وستة أشهر كلّها ليلا لا نهار فيها.

/و 61أ/ إذا أردت ذلك، فارفع القطب الشماليّ /و/ عن الأفق تسعين جزءا، فإنه يكون عند ذلك القطب في سمت الرأس، ويكون فلك معدّل النهار محاذيا للأفق، وتدور السماء هناك كدوران الرحى، وتكون الستة البروج الشماليّة التي من أوّل الحمل إلى أوّل الميزان فوق الأرض أبدًا، والستة البروج الجنوبيّة التي من أوّل الميزان إلى أوّل الحمل تحت الأفق أبدًا. فتكون الشمس، إذا كانت في الستة البروج الشماليّة، /و 61ب/ طالعة أبدًا؛ وإذا كانت في البروج الجنوبيّة غائبة أبدًا، فيكون /و/ ستة أشهر نهارا لا ليل فيه، وستة أشهر ليلا، لا نهار فيه، وتكون السنة كلّها يوما واحدا، نصفها نهارا كلّه، ونصفها ليلا كلّه، في عرض تسعين جزءا.

/ن 112أ/ **الباب السادس والأربعون: /ن/ في معرفة البلد الذي لا يطلع عليه كوكب بتّة، ولا يغرب عنه كوكب بتّة، بل الكواكب التي هي ظاهرة فيه تكون أبدًا ظاهرة، والكواكب الخفيّة عنه تكون أبدًا خفيّة.**

/و 62أ/ إذا أردت ذلك، فارفع القطب الشماليّ /و/ عن الأفق تسعين جزءا؛ وأدِرْ الكرة، فإنك تَرى الكواكب التي فوق الأرض كلّها تدور دورا رحويّا فوق الأرض، ولا تغيب /ز 7أ/ بتّة، وتَرى الكواكب التي تحت الأفق تدور /ز/ أيضًا دورا رحويّا تحت الأرض، ولا تطلع بتّة، وذلك أيضًا في عرض تسعين جزءا.

638 ن: الموضع الذي] و ز: المواضع التي **639** ن: واحدا] و ز: واحد ن: كلّها[2] و ز: – ز: ليلا] و ن: ليل **641** محاذيا] و: محاذًا، ز: محاذ، ن: – ز: وتدور] و: ويدور، ن: – **642** السماءِ] و ن: + محاذًا ز: وتكون] و ن: ويكون **643** ن: أوّل[2] و ز: – **644** ن: أبدًا] و ز: – ز: فتكون] و: فيكون، ن: – الشماليّة] ن: + يكون ن: الشماليّة... 645 البروج] و ز: – **646** ز: وتكون] و ن: ويكون ز ن: نهارا] و: نهار **647** ز ن: ليلا] و: ليل **649** ز: تكون] و: يكون، ن: نكون **650** تكون] و ز: يكون، ن: نكون **652** ز ن: الكواكب] و: الكوكب تدور...رحويّا] و: تدور دورا رحويا، ز: تدورو دورانا قويا، ن: تدور دورانا رجاويا

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الباب السابع والأربعون: في معرفة الموضع الذي يكون النهار فيه أربعا وعشرين ساعة مستوية.

/و 62ب/ إذا أردت ذلك، فارفع /و/ القطب الشماليّ عن الأفق بقدر ستة وستين جزءا. ثمّ أدِرْ
الكرة وتفقّدْ أوّل جزء من السرطان، فإنك تجده لا يغيب بتّة. فإذا صارت الشمس
فيه، صار زمان النهار والليل كلّه نهارا، فيصير النهار أربعا وعشرين ساعة مستوية في
ذلك اليوم في ذلك العرض. وإذا صارت الشمس في أوّل الجدي، لم تطلع بتّة،
فتصير ليلة دخول الشمس أوّل الجدي أربعا وعشرين ساعة مستوية، ولا يكون لها
/و 63أ/ نهارا /و/ أصلا، ويزيد النهار وينقص في سائر السنة، من ساعة إلى أربع وعشرين
ساعة، وذلك في عرض ستة وستين جزءا.

الباب الثامن والأربعون: في معرفة الموضع الذي يطلع فيه الثور قبل الحمل.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق بقدر ثمانية وسبعين جزءا، وأدِرْ
الكرة، فإنك تَرى الثور يتقدّم الحمل في دوران الكرة، وتَرى الحمل قد غاب
/و 63ب/ /و/ والثور /ن/ لم يغِب، وتَرى الحمل يطلع تاليا للثور، وذلك أنّ الثور لا يغيب في
/ن 112ب/ هذا العرض والحمل يغيب؛ فيظهر ذلك لهذا السبب.

الباب التاسع والأربعون: في معرفة الموضع الذي تجوز فيه الشمس على سمت الرءوس.

إذا أردت ذلك، فارفع القطب الشماليّ عن الأفق أيّ رفع شئت بعد أن يكون أقلّ
/و 64أ/ من أربعة وعشرين جزءا، وعدّ من الأفق على خطّ نصف النهار /و/ تسعين جزءا،
وتعلّم على الجزء الذي انتهى إليه عددك، فتلك العلامة هي سمت الرأس في ذلك

659 ز ن: والليل] و: وليل **661** ن: أوّل الجدي] و: الجدي، ز: للجد **662** ن: نهارا] و ز: نهار **663** ل: وستين] و ز: وسبعين، ن: وستون **667** ز ن: يغِب] و: يغنب **673** ن: هي] و ز: –

662 ويزيد...663 جزءا] ج: ويزيد الليل والنهار في ذلك، على قدر حلول الشمس في البروج الجنوبيّة والشماليّة في ذلك العرض؛ انظر الحاشية السفلية 46 في التعليقات على الفصل P24. من ساعة] يوجد في 12 من 18 مخطوطة

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البلد. ثمّ أدِرْ الكرة، فإنك تَرى جزءا ما من أجزاء دائرة البروج يجوز تحت تلك النقطة، فتكون الشمس إذا صارت في ذلك الجزء تجوز على سمت رءوس أهل ذلك البلد؛ وهذه البلدان هي التي عرضها من جزء إلى أربعة وعشرين جزءا.

/و 64ب/ **الباب الخمسون: في معرفة البلدان التي لا يكون لشيء /و/ فيها ظلّ في وقت ما من السنة، وفي أي وقت ويوم يكون ذلك.**

اعلم أن الشمس، إذا صارت على سمت الرأس في بلد من البلدان، فإنّ ذلك البلد في وقت مسامتة الشمس الرأس فيه لا يكون لشيء فيه ظلّ بتّة؛ ومسامتة الشمس الرأس فيه لا يكون إلّا على خطّ نصف النهار. فإذا أردت أن تعرف البلد الذي لا /و 65أ/ يكون لشيء فيه ظلّ أصلا، فارفع القطب /و/ الشماليّ عن الأفق أيّ رفع شئت بعد أن يكون أقلّ من أربعة وعشرين جزءا. ثمّ أدِرْ الكرة، وعدّ من الأفق على خطّ نصف النهار تسعين جزءا، وتعلّم حيث انتهى العدد علامة. ثمّ أدِرْ الكرة حتّى يقع تحت تلك العلامة جزء من أجزاء دائرة البروج. في اليوم الذي يكون فيه الشمس في ذلك الجزء لا يكون في نصف نهاره لشيء من الأجرام ظلّ بتّة.

/و 65ب/ **الباب الحادي والخمسون: /و/ في معرفة البلدان التي تكون الأظلال فيها في جهة واحدة، والتي تكون الأظلال فيها في الجهتين جميعا، وفي أيّ وقت تكون** /ن 113أ/ **الأظلال جنوبيّة وفي أيّ وقت تكون /ن/ شماليّة.**

اعلم أن كلّ بلد يكون عرضه أقلّ من أربعة وعشرين جزءا، فإنّ الأظلال تكون فيه في الجهتين جميعا، أعني في الشمال والجنوب؛ والبلدان التي يرتفع القطب الشماليّ عن الأفق أكثر من أربعة وعشرين جزءا تكون أظلالها شماليّة كلّها، والبلدان /و 66أ/ التي يرتفع القطب ⟨الجنوبيّ⟩ عليها أكثر من أربعة وعشرين /و/ جزءا تكون أظلالها

674 ما...أجزاء] و ز: ما من آخر، ن: من أجزاء ز: يجوز] و: تجوز، ن: ىجوز ن: تلك] و ز: فلك **681** لا يكون[1]] و: ×2 ا: تعرف] و ز: ترفع، ن: – **685** ن: تلك] و ز: – ز: في اليوم] و ن: فاليوم **688** تكون[2]] و ز: يكون، ن: – **689** تكون] و: يكون، ز ن: ىكون **691** ن: والبلدان...692 كلّها] و ز: – **692** وعشرين] ن: وعشرون و ز: والبلدان...694 كلّها] ن: – **693** يرتفع] و: برفع، ز: ترفع أكثر] و ز: أقلّ

691 والبلدان...694 كلّها] انظر التعليقات على الفصل P27.

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جنوبيّة كلّها. وذلك أن الشمس، إذا كانت على سمت الرأس، لم يكن لشيء ظلّ
بتّة؛ وإذا كانت في الشمال عن سمت الرأس، كان الظلّ جنوبيّا؛ وإذا كانت في
الجنوب عن سمت الرأس، كان الظلّ شماليّا. فإذا أردت معرفة ذلك بالكرة، فارفع
القطب الشماليّ عن الأفق أيّ رفع شئت، بعد أن يكون أقلّ من أربعة وعشرين
/و 66ب/ جزءا، واستخرج نقطة /و/ سمت الرأس، وأدِرْ الكرة، فإنك تَرى بعض أجزاء دائرة
البروج تجوز في الجنوب عن نقطة سمت الرأس، وبعضها في الشمال. فالأجزاء التي
تكون فيها الشمس في الجنوب عن سمت الرأس، يكون الظلّ فيها شماليّا، والأجزاء
التي تكون فيها الشمس في الشمال عن سمت الرأس، يكون الظلّ فيها جنوبيّا.

الباب الثاني والخمسون: في معرفة البلدان التي تصير الشمس فيها على سمت
/و 67ا/ **الرأس مرة واحدة في /و/ السنة، والتي تصير فيها على سمت الرأس مرتين، وفي**
أيّ وقت يكون ذلك من السنة.

اعلم أن كلّ بلد الذي عرضه أربعة وعشرون جزءا تصير الشمس فيه على سمت
الرأس مرة واحدة، وهو في دخولها أوّل السرطان، إن كان عرض البلد شماليّا؛ وإن
كان عرض البلد جنوبيّا، كان ذلك في دخولها أوّل الجدي. وأمّا البلدان التي عرضها
/و 67ب/ أقلّ من أربعة وعشرين جزءا، فإن ذلك يكون فيها مرتين، مرة /و/ في جزء ما، ومرة
في نظيره في الميل من أجزاء دائرة البروج. فإذا أردت أن تَرى ذلك في الكرة، فارفع
/ن 113ب/ القطب الشماليّ عن الأفق بقدر عرض البلد /ن/ الذي تريد، بعد أن يكون أقلّ من
أربعة وعشرين، واستخرج نقطة سمت الرأس على حلقة نصف النهار، وأدِرْ الكرة
/ز 7ب/ /ز/ دورة واحدة، فإنك ستجد جزئين من أجزاء دائرة البروج يمرّان تحت نقطة سمت

697 ن: أقلّ من] و ز: العرض   **699** ن: فالأجزاء] و: والاخر، ز: والأجزاء   **700** ب: فيها[1]
ن: فيه، و ز: –   ن: والأجزاء] و ز: والاخر   **701** ن: عن...الرأس] و ز: –   **704** ا: من
السنة] و ز ن: –   **705** ن: اعلم...بلد] و ز: البلد   ن: وعشرون] و ز: وعشرين
706 ن: عرض البلد] و ز: العرض   **707** ن: عرض البلد] و ز: –   **710** ن: عرض البلد]
و ز: العرض   ز ن: أقلّ] و: اول   **711** ا: نصف النهار] و ز ن: الكرة   **712** ز: واحدة]
و ن: –   ن: يمرّان] و: ىحران (يخران؟)، ز: –، ب: يجوزان

708 مرة...709 البروج] ن:–؛ انظر الحاشية السفلية 58 في التعليقات على الفصل P26.

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/و 68أ/ الرأس: جزءا ونظيره في الميل. فأمّا /و/ إذا جاز على سمت الرأس أوّل السرطان أو أوّل الجدي، فإنه إنما يجوز ذلك الجزء وحده لا غير.

الباب الثالث والخمسون: في أخذ ارتفاع الشمس بالكرة في أيّ وقت شئت.

إذا أردت ذلك، فاتّخذ ربع دائرة من صُفْر مساوية لربع حلقة نصف النهار، واقسمها على تسعين جزءا متساوية، واكتب عليها الأعداد على ما تراها مكتوبة في حلقة /و 68ب/ نصف النهار. وعلق شاقو/و/لا على الثقبتين اللتين في الكرسي، وانصب الكرة على أرض مستوية تكون الشمس ظاهرة عليها نصبا مستويا معدلا بالشاقول. وأدِرْ الكرة حتّى يصير جزء الشمس فوق الأفق، والصق على جزء الشمس من فلك البروج مقياسا أيّ قدر شئت، ومن أيّ جسم شئت، إلصاقا وثيقا بشمع أو غيره. وأدِرْ الكرة، وارفع القطب الشماليّ عن الأفق بقدر عرض البلد الذي أنت فيه، وأدِرْ الكرة تارة /و 69أ/ والكرسي تارة حتّى يظلل المقياس /و/ نفسه، ولا يقع له ظلّ على الكرة بتّة. ثمّ أثبت وضع الكرة على هيئتها واقلع المقياس، وعلّم على جزء الشمس، وضع ربع الحلقة، الذي كنت اتخذته، على الكرة وضعا صحيحا يقع أحد طرفيه، وهو الذي ابتدأ منه العدد، على الأفق، ويمرّ بجزء الشمس، وينتهي إلى نقطة سمت الرأس، وانظر أيّ جزء وقع من أجزاء الربع على جزء الشمس؛ وأيّ عدد موقَّع عليه، فذلك /و 69ب/ العدد هو أجزاء الارتفاع في ذلك /و/ الوقت وفي ذلك البلد.

الباب الرابع والخمسون: في معرفة الأوتاد الأربعة بالكرة.

إذا أردت ذلك، فاستخرج الارتفاع على ما ذكرت في الباب الذي قبل هذا. ثمّ انظر /ن 114أ/ ما وقع على أفق المشرق من /ن/ أجزاء دائرة البروج فهو الطالع، وما وقع تحت حلقة نصف النهار من أجزاء دائرة البروج فهو وسط السماء، وما وقع تحت أفق المغرب

713 ف: في الميل] و ز: والميل، ن: – **716** ن: مساوية] و ز: متساوية ا: لربع] و ز: أربع، ن: لنصف **717** ف: على تسعين] و ز: على سبعين، ن: بتسعين **718** ب: الثقبتين اللتين] و: اللسين، ز: اللبنين، ن: ثقبتين **719** ب: نصبا] و: نصيًا، ز: مضيًا، ن: نصبا (في غير مكانه) **721** ن: أو غيره] و ز: – **724** ن: واقلع] و ز: واقع ز ن: وعلّم] و: واعلّم **725** ا: صحيحا] و ز ن: – **726** إلى] و:×2 **731** ن: فهو...732 البروج] و ز: – ب: حلقة] ن: خطّ، و ز: – **732** ن: المغرب] و ز: المغارب

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فهو الغارب، وما وقع تحت حلقة نصف النهار من أجزاء دائرة البروج تحت الأرض فهو وتد الأرض.

/و 70أ/ **الباب /و/ الخامس والخمسون: في استخراج الأوتاد الباقية.**

إذا أردت ذلك، فاستخرج الطالع واعرفه، واعرف أجزاء الساعات الزمانيّة في ذلك اليوم. ورُدّ الطالع إلى أسفل بقدر أجزاء ساعتين من الساعات الزمانيّة من أجزاء فلك معدّل النهار، وانظر الجزء الذي وقع تحت حلقة نصف النهار من أجزاء دائرة البروج، فهو التاسع. ثمّ رُدّ الجزء الذي على أفق المشرق بقدر أجزاء ساعتين أخريين، وانظر /و 70ب/ للجزء /و/ الذي وقع تحت حلقة نصف النهار، فهو الثامن. ورُدّ الطالع إلى أفق المشرق وحطّ جزء الغارب إلى أسفل بقدر أجزاء ساعتين من الساعات الزمانيّة من أجزاء فلك معدّل النهار، وانظر إلى الجزء الذي وقع تحت حلقة نصف النهار من أجزاء دائرة البروج، فهو الحادي عشر. ثمّ حطّ الجزء الذي على أفق المغرب أيضًا بقدر أجزاء ساعتين زمانيتين أخريين، وانظر ما وقع تحت خطّ نصف النهار، فهو /و 71أ/ الثاني عشر. فيخرج لك باقي البيوت، لأن الطالع نظير /و/ السابع، والثاني نظير الثامن، والثالث نظير التاسع، والرابع نظير العاشر، والخامس نظير الحادي عشر، والسادس نظير الثاني عشر.

الباب السادس والخمسون: في استخراج خطّ نصف النهار في أيّ بلد شئت وأيّ وقت أردت.

إذا أردت ذلك، فخذ ارتفاع الشمس على ما سبق، واعرف الطالع. فإذا فعلت ذلك، /ن 114ب/ فقد وضعت الكرة /ن/ وضع الفلك، وصار كلّ ما فيها من الرسوم /و/ مسامتا لنظيره /و 71ب/

733 ن: حلقة] و ز: خطّ **735** ا ب ل: الأوتاد الباقية] و ز: باقي المراكز، ن: البيوت الباقية **737** ن: من[1]...الزمانيّة] و ز: زمانية **740** ن: حلقة] و ز: خطّ **741** ن: وحطّ] و ز: وخطّ ن: من[1]...الزمانيّة] و ز: زمانية ا: من[2]...742 النهار[1]] و ز ن: — **742** ن: حلقة] و ز: خطّ ا: من...743 البروج] و ز ن: — **743** ن: ثمّ حطّ] و ز: وخطّ **744** ا: زمانيتين أخريين] و ز: أخريين زمانية، ن: — فهو] ن: +البيت **750** ب: ارتفاع الشمس] و ز ن: الارتفاع **751** ن: كلّ ما] و ز: كلما

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مما في السماء. فإذا خططت في الأرض خطّا على استقامة قطر حلقة نصف النهار، كان ذلك خطّ نصف النهار في الأرض في ذلك الموضع.

الباب السابع والخمسون: في معرفة سمت القبلة في أيّ بلد ووقت شئت.

إذا أردت ذلك، فاستخرج خطّ نصف النهار على ما عرفت ⟨من⟩ قبل. واعرف
/و 72أ/ الاختلاف بين المدينة التي أنت فيها وبين مكة في الطول، /و/ وانظر في أيّ جهة
هو، فعدّ من خطّ نصف النهار في تلك الجهة بقدر تلك الأجزاء من حلقة الأفق،
وعلّم على الموضع الذي انتهى إليه العدد. وأخرِجْ في الأرض خطّا من مركز حلقة
الكرسي السفلانية مسامتا لتلك العلامة، فذلك الخطّ هو خطّ القبلة في ذلك البلد.

الباب الثامن والخمسون: في استخراج موضع القمر وأيّ كوكب شئت من
/و 72ب/ **الكواكب المتحيّرة في الليلة التي يمكنك أن تأخذ فيها /و/ أعظم ارتفاعه.**

إذا أردت ذلك، فارصد القمر أو الكوكب المتحيّر الذي تريد، حتّى تعرف أعظم
ارتفاعه بالأسطرلاب، أو بربع دائرة، أو بغيرهما. ثمّ تعرّف ارتفاع بعض الكواكب
المرسومة على الكرة، وتعلّم على عدد ارتفاعه في أجزاء حلقة الربع، وضع طرف
الربع الموقّع عليه "تسعين" على نقطة سمت الرأس، وطرفة الموقّع عليه "واحد" على
/و 73أ/ حلقة الأفق. وأدِرْ الكرة والربع، بعد أن يكون طرفه /و/ على نقطة سمت الرأس،
حتّى يقع الكوكب الذي أخذت ارتفاعه تحت العلامة التي علّمت على الربع. ثمّ
انظر أيّ جزء وقع تحت حلقة نصف النهار من أجزاء دائرة البروج، فذلك الجزء هو
/ن 115أ/ الذي فيه القمر أو الكوكب /ن/ المتحيّر الذي أخذت ارتفاعه في ذلك الوقت.

757 ن: من[2]] و ز: – **758** ز ن: وعلّم] و: واعلم **759** ن: السفلانية] و ز: السفلي
762 ن: الكوكب] و ز: الكواكب **763** ن: بربع] و ز: يرفع **765** ن: واحد] و ز: واحدا
766 ز ن: والربع] و: والرابع **768** ن: حلقة] و ز: خطّ **769** ن: أو] و ز: و

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الباب التاسع والخمسون: في استخراج عرض القمر أو أيّ كوكب شئت من
/و 73ب/ **الكواكب المتحيّرة في الليلة التي /و/ يمكنك أن تأخذ فيها أتمّ ارتفاعه.**

إذا أردت ذلك، فاعرف الجزء الذي هو فيه من أجزاء دائرة البروج، كما علمت في
/ز 8ا/ الباب الذي قبل هذا، وتعلّم عليه. واعرف أعظم ارتفاعه /ز/ وجهته، وعدّ من أجزاء
حلقة خطّ نصف النهار في جهة ارتفاعه بقدر أجزاء ارتفاعه، وتعلّم حيث انتهى
العدد. ثمّ أدِرْ الكرة حتّى يصير الجزء الذي علّمت عليه من أجزاء دائرة البروج، وهو
/و 74ا/ جزء القمر أو الكوكب المتحيّر، تحت خطّ نصف /و/ النهار، وانظر تحت أيّ جزء
يقع من أجزاء خطّ نصف النهار؛ فإن وقع تحت الجزء الذي كنت علّمت عليه،
فاعلم أن القمر أو الكوكب المتحيّر لا عرض له البتّة، وأن مسيره على وسط فلك
البروج. وإن وقع ناحية عنه، فانظر في أيّ جهة وقع، وعدّ الأجزاء التي بين الجزء
الذي وقع تحته وبين العلامة التي كنت علّمت، فتلك الأجزاء هي عرض القمر أو
/و 74ب/ الكوكب المتحيّر في تلك الليلة /و/ في الجهة التي وقعت الأجزاء فيها عن خطّ فلك
البروج.

الباب الستون: في معرفة خسوف القمر، إن كان يقع في الشهر الذي أنت فيه.

إذا أردت ذلك، فاعرف عرض القمر في ليلة الثالث عشر كما عرفت في الباب الذي
قبل هذا. فإن كان لا عرض له بتّة، وأتمّ ارتفاعه في تلك الليلة يقع على جزء من
أجزاء فلك البروج، فاعلم أنه ينخسف في ذلك الشهر؛ وإن كان له عرض أكثر
/و 75ا/ /و/ من جزء واحد وأربع دقائق، فاعلم أنه لا ينخسف في ذلك الشهر، فإن كان
عرضه أقلّ من جزء وأربع دقائق، فإنه ينخسف لا محالة.

771 ن: الكواكب] و ز: – **780** ز ن: علّمت] و: اعلمت **784** ن: الثالث عشر] و: ثلثة عشرة، ز: ثلثة عشر

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/ن 115ب/ **الباب /ن/ الحادي والستون: في معرفة كسوف الشمس إن كان يقع في الشهر الذي أنت فيه.**

إذا أردت ذلك، فاعرف عرض القمر، كما وصفنا فيما تقدّم، في يوم سبعة وعشرين من الشهر. فإن وقع أعظم ارتفاعه على جزء من دائرة البروج، فإن الشمس تنكسف /و 75ب/ لا محالة. وإن لم يقع /و/ على جزئه وكان له عرض، فاعرف جهة العرض، وانظر جنوبيّ هو أم شماليّ؛ فإن كان جهة عرضه شماليّة وكان عرضه أقلّ من جزء واحد وسبع وثلاثين دقيقة، فاعلم أن الشمس تنكسف لا محالة في ذلك الشهر. وإن كان عرضه أكثر من جزء واحد وسبع وثلاثين دقيقة، فاعلم أنها لا تنكسف في ذلك الشهر. وإن كان عرضه جنوبيّا وكان أقلّ من سبع وأربعين دقيقة، فإنّ الشمس /و 76أ/ تنكسف، لا محالة. وإن كان /و/ عرض القمر أكثر من سبع وأربعين دقيقة في الجنوب، فإنّ الشمس لا تنكسف في ذلك الشهر.

الباب الثاني والستون: في معرفة موضع أيّ كوكب شئت من الكواكب الثابتة التي ليست مرسومة في الكرة من أجزاء دائرة البروج.

إذا أردت ذلك، فارصد الكوكب الذي تريد معرفة جزئه من أجزاء دائرة البروج حتّى يصير في أتمّ ارتفاعه، وتعرّف ارتفاع بعض الكواكب المرسومة على الكرة في ذلك /و 76ب/ الوقت. وأدِرْ الكرة حتّى يصير /و/ الكوكب على جزء ارتفاعه من أجزاء الربع، كما علمت فيما تقدّم، وانظر أيّ جزء يقع من أجزاء دائرة البروج تحت حلقة خطّ نصف النهار، فذلك الجزء من أجزاء دائرة البروج هو جزء ذلك الكوكب الثابت الذي أخذت أتمّ ارتفاعه.

789 ا: الشهر...790 فيه] و ز: ذلك الشهر، ن: الشهر الذي نحن فيه كسوف **791** ز: تقدّم] و: نقدم، ن: نقدم ا: يوم...792 الشهر] و ز: سبعة وعشرين، ن: اليوم التاسع والعشرون
796 في] و: ×2 **800** ن: التي...801 مرسومة] و ز: الغير المرسومة

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الباب الثالث والستون: في استخراج عرض أيّ كوكب شئت من الكواكب الثابتة التي ليست مرسومة على الكرة.

/و 77آ/ إذا أردت ذلك، فاعرف أتمّ ارتفاعه وجهته، /و/ وتعلّم على درجته من أجزاء حلقة نصف النهار في تلك الجهة، وتعرّف جزءه من أجزاء دائرة البروج، كما فعلت في الباب الذي قبل هذا، وأدِرْ الكرة حتّى يصير جزؤه على خطّ نصف النهار. فإن وقع /ن 116آ/ جزؤه من تحت حلقة خطّ نصف النهار /ن/ على جزء أعظم ارتفاعه الذي كنت علّمت عليه، فإنّ ذلك الكوكب لا عرض له، وإنّه على دائرة خطّ وسط البروج؛ وإن /و 77ب/ وقع ناحية عنه، /و/ فانظر في أيّ ناحية وقع، وعدّ ما بين العلامة التي كنت علّمت عليها وبين جزئه من أجزاء خطّ نصف النهار، فما خرج لك فهو عرض ذلك الكوكب في تلك الجهة.

الباب الرابع والستون: في معرفة بعد أيّ كوكب شئت من الكواكب الثابتة التي ليست مرسومة في الكرة عن فلك معدّل النهار.

إذا أردت ذلك، فاعرف أتمّ ارتفاعه في جهته، وعدّ مثله من أجزاء حلقة نصف النهار /و 78آ/ في /و/ تلك الجهة، وتعلّم حيث انتهى عددك. ثمّ اعرف جزء ذلك الكوكب، كما علمتَ فيما قبل، وأدِرْ الكرة حتّى يصير جزؤه من أجزاء فلك البروج تحت حلقة خطّ نصف النهار، وعدّ ما بين العلامة التي علّمت وخطّ معدّل النهار من أجزاء حلقة نصف النهار، فما خرج فهو أجزاء بعد ذلك الكوكب عن خطّ معدّل النهار.

809 ن: التي...مرسومة] و: الغير مرسومة، ز: الغير المرسومة **810** درجته] و ز: + مثله **814** ز ن: علّمت] و: اعلمت **815** ز ن: علّمت] و: اعلمت **816** ب: عليها وبين] و ز ن: — ن: جزئه...أجزاء] و ز: وجزئه من الأجزاء في **818** ن: التي...819 مرسومة] و: الغير مرسومة، ز: الغير المرسومة **819** عن] و ز: + خطّئ **823** ا: العلامة] و ز ن: العلامتين

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/و 78ب/ **الباب الخامس والستون: في معرفة البعد بين أيّ كوكب شئت /و/ من الكواكب التي ليست مرسومة على الكرة وبين نقطة سمت الرأس في أيّ بلد شئت.**

إذا أردت ذلك، فعلّم على نقطة سمت الرأس، واعرف أتمّ ارتفاع الكوكب الذي تريد معرفة ميله عن سمت الرأس. وعدّ من أجزاء حلقة نصف النهار مثل أعظم ارتفاعه، وعلّم حيث انتهى عددك من أجزاء حلقة نصف النهار. وعدّ ما بين العلامتين من الأجزاء، فما خرج لك فهو أجزاء ميل ذلك الكوكب عن سمت الرأس في ذلك البلد.

آخر كتاب العمل بالكرة لقسطا بن لوقا

/و 79أ/ /و/ أتى على آخره سي أيلبك البغداديّ بن كدكك المعموي والله أعلم.

825 ز ن: والستون] و: والخمسون **826** ن: التي ليست] و ز: الغير **827** ز ن: فعلّم] و: فاعلم **829** ز ن: وعلّم] و: واعلم **832** و: آخر...833 أعلم] ن: نحر وبألله التوفيق **833** و: أتى...أعلم] ز: لابي السقر بن بليل البغدادي والله أعلم

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J: Cairo, Dār al-kutub, K ʿarabī 3844,8
D: Cairo, Dār al-kutub, Mīqāt M ʿarabī 101
H: Cairo, Dār al-kutub, Riyāḍiyāt Taymūr ʿarabī 106,11
U: Cairo, Dār al-kutub, Mīqāt Ṭalʿat ʿarabī 202,2
Z: Cairo, Dār al-kutub, Mīqāt M ʿarabī 106,2
Ḥ: Riyadh, University Library, 1007, Falak 520 RB
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This only includes manuscripts that were not used in this study. For a full list of manuscripts studied, see the bibliography on pp. 219–20; for descriptions of the manuscripts of the anonymous *Risāla Dhāt al-kursī*, see pp. 20–35; for descriptions of the manuscripts of Qusṭā ibn Lūqā's *Treatise on the Use of the Celestial Globe with Stand*, see pp. 16–18.

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This book deals with the *Risāla Dhāt al-kursī*, a 33-chapter Arabic treatise on the celestial globe with stand. The treatise is attributed to Ptolemy in some manuscripts, to the Ottoman scholar Akhawayn in others, but is anonymous in most. The book begins with a survey of references to Ptolemaic works in Greek and Arabic sources, presenting various works attributed to Ptolemy either preserved in the original Greek or in translation, or considered lost, including both authentic works and *pseudepigrapha*. Next follows a critical edition of the treatise *Dhāt al-kursī*, based on eight of the twenty-three manuscripts studied. The edition is accompanied by an English translation and an extensive mathematical commentary on each chapter, enriched with explanatory figures. The comparison between this treatise and the *Treatise on the Celestial Globe* by Qusṭā ibn Lūqā (d. ca 912 AD), presented in parallel with the commentary, shows that the former is based on the latter; thus the treatise *Dhāt al-kursī* should be considered a Ptolemaic *pseudepigraphon*. A transcription of the Arabic text of the treatise by Qusṭā ibn Lūqā based on three of the eighteen examined manuscripts is included, so that the reader may compare the two texts. Furthermore, in order to examine Akhawayn's association with the treatise, a bibliographical and historical investigation is conducted, which examines the full range of works attributed to Akhawayn. However, the truth about the authorship was probably lost, as the result of various rivalries in the late fifteenth century.

Flora Vafea is a historian of science and mathematician, and received her PhD from the University Paris 7-Diderot in 2006. Her research is concerned with ancient and Islamic astronomy, in particular astronomical instruments, with several publications and conference presentations in those fields. She is a research associate of the Ptolemaeus Arabus et Latinus project and currently teaches at al-Azhar University in Cairo and at Cairo University.

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