Research Note :

Astronomical Acounts in Quṭb al-Dīn al-Shīrāzī's *Commentary on the Canon of Medicine*: Testimonies of the Marāgha Observatory[1]

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Abstract:

Quṭb al-Dīn al-Shīrāzī (d. 1311) is one of the commentators on the *Canon of Medicine* of Ibn Sīnā (Avicenna, d. 1037). His commentary, however, has rarely attracted the attention of scholars, who see him mainly as an astronomer. Although he is often reckoned as one of the astronomers of the Marāgha school, there has been no decisive evidence for his working at the Marāgha observatory. This paper provides an edition and translation of three astronomical accounts in his commentary on the *Canon*, two of which indicate that he was engaged in observation at Marāgha.

In the commentary of *Fann* 2, *Taʿlīm* 2, *Jumla* 1, *Faṣl* 3, of the *Canon of Medicine*, al-Shīrāzī gave detailed astronomical explanations. In these, he mentioned 1°/70 years as the rate of the precession of the equinoxes, which was "found through the new observation carried out at Marāgha," and he said that the value of the obliquity of the ecliptic was 23.5°, which had been "verified through our observation of the declination at Marāgha." These expressions can be taken as an evidence for his connection with the Marāgha observatory.

I. Introduction

Quṭb al-Dīn al-Shīrāzī (634–710/1236–1311) is one of the commentators on the *Canon of Medicine* of Ibn Sīnā (Avicenna, d. 1037).[2] His *Commentary on the Canon of Medicine* (henceforth *Commentary*) got a wide readership even in his lifetime and exhibited his expertise in medicine: he criticized his predecessors and presented his own views.[3] His autobiography written in its preface, which I translated into Japanese in the previous volume of this journal, has been frequently referred to.[4] However, his *Commentary* itself has rarely been studied until recently.[5] This is because, I think, al-Shīrāzī has attracted scholars' attention as an

[1] I am very grateful to Taro MIMURA and Akihiro TAWARA, who kindly shared with me precious sources.
[2] E. Wiedemann, "Ḳuṭb al-Dīn Shīrāzī," *Encyclopaedia of Islam: New Edition*, 12 vols., Leiden: E. J. Brill, 1960–2008, vol. 5, 547f.; Seyyed Hossein Nasr, "Quṭb al-Dīn al-Shīrāzī," *Dictionary of Scientific Biography*, 18 vols., New York: Scribner, 1970–90, vol. 11, 247–253.
[3] I discussed it in "Igaku Tenpan chūshaku-ni okeru igaku kenkyū: Kutoubuddeīn Shīrāzuī-no senjin hihan (Study of Medicine in Commentaries on the *Canon of Medicine*: Quṭb al-Dīn al-Shīrāzī's Criticism of Predecessors)," *Bulletin of the Society for Near Eastern Studies in Japan* 62 (2019), 1–12 (in Japanese).
[4] "Kutoubuddeīn Shīrāzuī jiden: 'Igaku tenpan chūshaku' jobun honyaku (Autobiography of Quṭb al-Dīn al-Shīrāzī: Translation of the Preface to *Commentary on the Canon of Medicine*)," *Isuramu Shisō Kenkyū* 1 (2019), 125–141.
[5] Leigh N. Chipman, "Is Medicine an ʿIlm? A Preliminary Note on Quṭb al-Dīn al-Shīrāzī's *al-Tuḥfa al-Saʿdiyya*

astronomer.[6]

It is widely known that he was a disciple of Naṣīr al-Dīn al-Ṭūsī (d. 1274) and excelled in astronomy.[7] However, there remains an unanswered question: was he engaged in observation at Marāgha?[8] At the Marāgha observatory in the Ilkhanid Iran, an astronomical table, *Zīj-i Īlkhānī* (*Ilkhanid Astronomical Table*), was compiled by al-Ṭūsī with some colleagues around 1270.[9] The introduction to the *Zīj* mentions four astronomers who contributed to the establishment of the observatory[10]: Muʾayyad al-Dīn al-ʿUrḍī (d. 1266), Fakhr al-Dīn al-Khilāṭī (d. 1282), Fakhr al-Dīn al-Marāghī, and Najm al-Dīn al-Kātibī (d. 1276).[11] Ibn al-Fuwaṭī (d. 1323), a librarian at Marāgha, related that these four and al-Ṭūsī were the five philosophers who cooperated in observation at Marāgha.[12] Neither *Zīj-i Īlkhānī* nor Ibn al-Fuwaṭī gave al-Shīrāzī's name. Why was al-Shīrāzī's name missing?

Al-Shīrāzī has been frequently said to be one of the astronomers of "Marāgha school." G. Saliba, for example, stated that Ibn al-Shāṭir (d. 1375) mentioned astronomers of the Marāgha school in the introduction to his *Nihāyat al-sūl fī taṣḥīḥ al-uṣūl* (*The Ultimate Quest regarding the Rectification of Principles*).[13] Certainly we find in the text the names of al-Ṭūsī, al-ʿUrḍī, al-Shīrāzī, and others, but he did not assert that

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(MS Şehid ʿAli Peşa 2047)," in Y. Tzvi Langermann (ed.), *Avicenna and his Legacy: A Golden Age of Science and Philosophy*, Turnhout: Brepols, 2009, 289–300; Taro Mimura, "Quṭb al-Dīn Shīrāzī's Medical Work, *al-Tuḥfa al-Saʿdīya* (Commentary on volume 1 of Ibn Sīnā's *al-Qānūn fī al-Ṭibb*) and its Sources," *Tarikh-e Elm* 10 (2013), 1–13; Akihiro Tawara, "Quṭb al-Dīn Shīrāzī on *Rūḥ*: A Note and Editing of Passages on *Rūḥ* in his *al-Tuḥfah al-Saʿdīyah* (Commentary on Avicenna's *Canon of Medicine*, Book One)," *Reports of the Keio Institute of Cultural and Linguistic Studies* 49 (2018), 192–202. See also note 3.

[6] Cf. Leigh Chipman, "The *ʿAllāma* and the *Ṭabīb*: A Note on Biographies of Two Doctors, Rashīd al-Dīn and Quṭb al-Dīn al-Shīrāzī," in Anna Akasoy, Charles Burnett & Ronit Yoeli-Tlalim (eds.), *Rashīd al-Dīn: Agent and Mediator of Cultural Exchanges in Ilkhanid Iran*, London: The Warburg Institute, 2013, 124f. I refer only to a few studies here: Kaveh Niazi, *Quṭb al-Dīn Shīrāzī and the Configuration of the Heavens: A Comparison of Texts and Models*, Dordrecht: Springer, 2014; Amir-Mohammad Gamini, "Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century," *Arabic Sciences and Philosophy* 27 (2017), 165–203.

[7] F. J. Ragep, "al-Ṭūsī, Naṣīr al-Dīn," *Encyclopaedia of Islam: New Edition*, vol. 10, 746–752; Seyyed Hossein Nasr, "al-Ṭūsī, Naṣīr al-Dīn," *Dictionary of Scientific Biography*, vol. 12, 508–514.

[8] Sayyed ʻAbd Allāh Anwār, "Qoṭb-al-Din Širāzi," *Encyclopædia Iranica*, online edition, 2005, available at http://www.iranicaonline.org/articles/qotb-al-din-sirazi (accessed 15 July 2019).

[9] E. S. Kennedy, "A Survey of Islamic Astronomical Tables," *Transactions of the American Philosophical Society* 46 (1956), 125 (no. 6). For the Marāgha observatory, see Aydın Sayılı, *The Observatory in Islam: And its Place in the General History of the Observatory*, Ankara: Türk Tarih Kurumu Basımevi, 1960, 187–223.

[10] J. A. Boyle, "The Longer Introduction to the 'Zīj-i-Īlkhānī' of Naṣīr-ad-Dīn Ṭūsī," *Journal of Semitic Studies* 8 (1963), 247; Mudarris Raẓavī, *Aḥvāl va-āṡār-i Muḥammad ibn Muḥammad ibn al-Ḥasan al-Ṭūsī*, Tehran: Intishārāt-i Dānishgāh-i Tihrān, 1354 [1975/76], 232; Ragep, "al-Ṭūsī," 747a.

[11] For al-ʿUrḍī, see George Saliba, *The Astronomical Work of Muʾayyad al-Dīn al-ʿUrḍī: A Thirteenth Century Reform of Ptolemaic Astronomy, Kitāb al-hayʾah*, Beirut: Markaz Dirāsāt al-Waḥda al-ʿArabīya, 1990, 27–30. For al-Kātibī, see M. Mohaghegh, "al-Kātibī, Naǧm al-Dīn abu'l-Ḥasan ʿAlī b. ʿUmar," *Encyclopaedia of Islam: New Edition*, vol. 4, 762; Khaled El-Rouayheb, "al-Kātibī al-Qazwīnī," *Encyclopaedia of Islam, THREE*, Leiden: Brill, 2007–, vol. 2019-1, 117–122.

[12] Ibn al-Fuwaṭī, *Majmaʿ al-ādāb fī muʿjam al-alqāb*, ed. Muḥammad al-Kāẓim, Tehran: Vizārat-i Farhang va-Irshād-i Islāmī, 1416 [1995/6], vol. 3, 54–56. This is an abridgment of Ibn al-Fuwaṭī's original text.

[13] George Saliba, "The Astronomical Tradition of Marāgha: A Historical Survey and Prospects for Future Research," *Arabic Sciences and Philosophy* 1 (1991), 67.

al-Shīrāzī had carried out observations there.(14)

I have no doubt that al-Shīrāzī belonged to the Marāgha school, but there is no decisive evidence for it. Did the *Zīj* exclude his name, because al-Ṭūsī was on bad terms with al-Shīrāzī? I doubt it. It seems that their relationship was not so bad, for in his testament al-Ṭūsī advised his son, Aṣīl al-Dīn, to cooperate with al-Shīrāzī to complete the *Zīj*.(15)

There are a lot of astronomical accounts in his *Commentary*, and among them I found indications that al-Shīrāzī worked at the Marāgha observatory. In this paper, I provide an edition and translation of three of these accounts, two of which suggest his connection with the observatory. Although these are testimonies by al-Shīrāzī himself, they will help us to settle the question.

II. Biographical information of al-Shīrāzī

Before these accounts, we will take a look at his biographical information concerning the Marāgha observatory or his career as an astronomer.(16) In the first place, we should note that his autobiography in the preface to his *Commentary* did not mention Marāgha at all. He told us that he had been at work in Muẓaffarī hospital in Shīrāz until he was twenty-four (658/9 [1260/1]) and then headed for "the city of science and *Kaʿba* of wisdom, the high presence of Naṣīr al-Dīn al-Ṭūsī."(17) The city should have been Marāgha, for the construction of the Marāgha observatory began in 657 (1259). He stayed there until sometime between 667 (1268) and 672 (1274).(18)

This agrees with his biography by others. Ibn al-Fuwaṭī told us as follows: having arrived at Marāgha in 658 (1260/1), al-Shīrāzī studied with Muʾayyad al-Dīn al-ʿUrḍī what al-ʿUrḍī composed in astronomy and geometry. He wrote, with his fine and neat hand, books in all that he had been engaged in and had gained, and he studied eagerly day and night.(19) According to Shams al-Dīn al-Dhahabī (d. 1348), when al-Shīrāzī was young, he visited Naṣīr al-Dīn al-Ṭūsī. There he studied with al-Ṭūsī his commentary on *al-Ishārāt wa-l-tanbīhāt* (*Pointers and Reminders*) of Ibn Sīnā, mathematics, and *ʿilm al-hayʾa* (the science of the configuration [of the heavens]), and he distinguished himself in these. Furthermore, al-Dhahabī told us an episode which showed his self-confidence. When al-Shīrāzī and al-Ṭūsī were in company with Hülegü (r.

(14) Erwan Penchèvre, *La nihāya al-sūl fī taṣḥīḥ al-ʾuṣūl d'Ibn al-Šāṭir: Édition, traduction et commentaire*, eprint arXiv:1709.04965, 2017, 42f.
(15) Raẓavī, *Aḥvāl va-āṡār*, 50. However, Raẓavī did not refer to any sources; he simply wrote, "it is well-known (*mashhūr*) ...." See also Niazi, *Quṭb al-Dīn Shīrāzī*, 68; Hadi Jorati, "Science and Society in Medieval Islam: Nasir al-Din Tusi and the Politics of Patronage," Ph.D. diss., Yale University, 2014, 191f.
(16) This section is based on the following studies: Niazi, *Quṭb al-Dīn Shīrāzī*, 61–84; Mujtabā Mīnuvī, "Mullā Quṭb Shīrāzī," in Mujtabā Mīnuvī and Īraj Afshār (eds.), *Yādnāmah-i Īrānī-yi Mīnūrskī: shāmil-i maqālāt-i taḥqīqī marbūṭ bi-muṭāliʿāt-i Īrānī*, Tehran: Intishārāt-i Dānishgāh-i Tihrān, 1348 [1969], 165–205; John Walbridge, *The Science of Mystic Lights: Quṭb al-Dīn Shīrāzī and the Illuminationist Tradition in Islamic Philosophy*, Cambridge, MA: Distributed for the Center for Middle Eastern Studies of Harvard University, 1992, 1–24, 169–171.
(17) MS Berlin, Or. 3039, 4r; MS Ayasofya, 3649, 4v. For these manuscripts, see below.
(18) Walbridge, *The Science of Mystic Lights*, 13.
(19) Ibn al-Fuwaṭī, *Majmaʿ al-ādāb*, vol. 3, 440.

1256–65) and Abaqā (r. 1265–82), Abaqā said to him that since al-Ṭūsī had grown old, he should make effort not to miss al-Ṭūsī's knowledge. He replied that he had been doing so, and he did not need it any more.[20] This episode has been often reproduced in medieval and modern biographies with some modification and read as the reason for the omission of al-Shīrāzī's name from *Zīj-i Īlkhānī*.[21]

As far as I know, other medieval sources contained nothing new about him as an astronomer.[22] Al-Sallāmī used al-Dhahabī and Ibn al-Fuwaṭī as his sources. He wrote that al-Shīrāzī travelled at the age of some twenty towards al-Ṭūsī, studied with him his books in philosophy and *ʿilm al-hayʾa*, and excelled in these.[23] In al-ʿAsqalānī's biography of al-Shīrāzī, we cannot find any piece of information concerning his career as an astronomer.[24] It seems to me that there is no biography of al-Shīrāzī that informed explicitly his connection with the Marāgha observatory.

III. Astronomical accounts in al-Shīrāzī's *Commentary*

In the preface, al-Shīrāzī's *Commentary* was given the title *al-Tuḥfa al-Saʿdīya* (*The Offering for Saʿd*) named after his patron and its dedicatee Saʿd al-Dīn Sāvajī (d. 1311), or *Nuzhat al-ḥukamāʾ wa-rawḍat al-aṭibbāʾ* (*Promenade of Sages and Garden of Physicians*). However, the work is sometimes called *Sharḥ kullīyāt al-Qānūn* (*Commentary on the Universality of the Canon*). This means it covers only the first volume of the *Canon of Medicine*, which is devoted to the *universal* principles of medicine.

The *Canon of Medicine* (*Qānūn fī al-ṭibb*, henceforth *Canon*) of Ibn Sīnā is composed of five volumes. Volume 1 of the *Canon* is divided into four parts (*funūn*), and each part is divided into some lessons (*taʿālīm*) and occasionally into some classes (*jumal*). Part 1 of Volume 1 discusses the definition of medicine and the principles of human body such as elements, temperaments, anatomy, and faculties. Part 2 explores the disorders of human body and includes an explanation of the environment and of signs of diseases. Part 3 is devoted to the preservation of health. Finally, Part 4 deals with the treatment of diseases. Al-Shīrāzī's astronomical accounts below are found in the commentary on Lesson 2 of Part 2.

Commenting on Part 2, Lesson 2, Class 1, Section 3 (*Fann* 2, *Taʿlīm* 2, *Jumla* 1, *Faṣl* 3), on the natures of

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[20] As I could not read al-Dhahabī's *Taʾrīkh*, vol. 54 by myself, this is borrowed from Niazi, *Quṭb al-Dīn Shīrāzī*, 67f.
[21] Mīnuvī, "Mullā Quṭb Shīrāzī," 168f.; Walbridge, *The Science of Mystic Lights*, 13f.
[22] Ibn al-ʿIbrī, *Tārīkh mukhtaṣar al-duwal*, ed. Anṭūn Ṣālḥānī, Beirut: al-Maṭbaʿa al-Kāthūlīkīya, 1958, 287; Khalīl ibn Aybak al-Safadi, *Kitāb al-Wāfī fī al-wafayāt*, eds. Aḥmad al-Arnāʾūṭ and Turkī Muṣṭafā, Beirut: Dār Iḥyāʾ al-Turāth al-ʿArabī, 2000, vol. 25, 200–202; ʿAbd al-Raḥīm al-Isnawī, *Ṭabaqāt al-Shāfiʿīya*, ed. Kamāl Yūsuf al-Ḥūt, Beirut: Dār al-Kutub al-ʿIlmīya, 1987, vol. 2, 32; Tāj al-Dīn al-Subkī, *Ṭabaqāt al-shāfiʿīya al-kubrā*, eds. ʿAbd al-Fattāḥ Muḥammad al-Ḥilw and Maḥmūd Muḥammad Ṭanāḥī, [Cairo]: Maṭbaʿat ʿĪsā al-Bābī al-Ḥalabī, 1964, vol. 10, 386; Ghiyās al-Dīn Khvānd Amīr, *Tārīkh ḥabīb al-siyar*, ed. Jamāl al-Dīn Humāʾī, Tehran: Intishārāt-i Khayyām, 1333 [1954/55], vol. 3, 116f.
[23] Muḥammad ibn Rāfiʿ al-Sallāmī, *Tārīkh ʿulamāʾ Baghdād al-musammā muntakhab al-mukhtār*, ed. ʿAbbās ʿAzzāwī, Beirut: al-Dār al-ʿArabīya li-l-Mawsūʿāt, 2000, 177; Niazi, *Quṭb al-Dīn Shīrāzī*, 71f.
[24] Ibn Ḥajar al-ʿAsqalānī, *al-Durar al-kāmina fī aʿyān al-miʾa al-thāmina*, Beirut: Dār Iḥyāʾ al-Turāth al-ʿArabī, 1349 [1931], vol. 4, 339–341.

seasons (*fī ṭabāʾiʿ al-fuṣūl*), al-Shīrāzī employed his knowledge in astronomy and gave astronomical commentaries. In these, there may be his contribution to the tradition of the study on the *Canon*, but it is not examined here. His predecessors, such as Fakhr al-Dīn al-Rāzī (d. 1210) and Ibn al-Nafīs al-Qurashī (d. 1288), also explained Ibn Sīnā's words on the environment, using astronomical and mathematical terms.(25) Their explanations, however, were not so detailed as al-Shīrāzī's.

Al-Shīrāzī's commentary is normally composed of some *baḥth* (argument or inquiry). In section 3, there are three *baḥths*. The first *baḥth* is on the verification of the meaning of "season (*faṣl*)" (MS Berlin, Or. 3039, 413v–417v; MS Ayasofya, 3652, 5r–13r); the second is on the reason of the natures of spring, summer, and winter (417v–423v; 13r–24v); the third is on the reason of the nature of autumn (423v–430v; 24v–38v). Our texts below come from this section, and two of them suggest his working at the Marāgha observatory. Text 1 and Text 2 belong to the first *baḥth*, and Text 3 to the second.(26)

Text 1 is on the third *lemma* of the first *baḥth*. Ibn Sīnā's words "ʿinda al-munajjimīna ([these seasons for the physicians are different from those] for the astronomers)" was given a longer account.(27) First, al-Shīrāzī analyzed the grammatical structure of the *lemma*. Next, elementary terms such as "globe (*kura*)" and "celestial sphere (*falak*)" were defined. He criticized the comment of Ibn al-Quff al-Masīḥī (d. 1286) concerning the motion of the celestial spheres.(28) Then, he outlined all the nine spheres of the heavens, but he excluded the explanation of the spheres except the ninth and the eighth, which were relevant to Ibn Sīnā's text. The ninth sphere, he said, revolves once a day, and thus its motion is called "daily motion (*ḥaraka yawmīya*)." Ibn al-Quff's misconception was criticized again. After he explained the ninth sphere, he moved on to the eighth sphere.

The eighth sphere is the sphere of the fixed stars, and it moves slowest. This motion, called "second motion (*ḥaraka thānīya*)," is the precession of the equinoxes. Al-Shīrāzī mentioned different views about the rate of this motion: (a) 1°/100 years, for the ancients; (b) 1°/66 years, for the moderns; (c) 1°/70 years, for the truth-finders (*muḥaqqiqūn*) of the moderns. Historically, the value (a) was accepted by Ptolemy or his predecessors, and the value (b) was found by the early Muslim astronomers. The value (c) was, said al-Shīrāzī, found through "the new observation *we carried out at Marāgha* (*al-raṣad al-jadīd alladhī ʿamalnā-hu fī Marāgha*)." This value appears in *Zīj-i Īlkhānī*.(29) Niẓām al-Dīn al-Naysābūrī (d. ca. 1330), a disciple of al-Shīrāzī, also said that it was the value which al-Ṭūsī's contemporaries found on the basis of the *new observation*.(30) These

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(25) Fakhr al-Dīn al-Rāzī, *Sharḥ-i mushkilāt-i Kitāb al-Qānūn*, ed. Najafqulī Ḥabībī, Tehran: Kitābkhānah, Mūzah va-Markaz-i Asnād-i Majlis-i Shūrā-yi Islāmī, 1396 [2018], 257–271; Ibn al-Nafīs, *Sharḥ al-Qānūn*, MS London, Wellcome Library, Or. 51, 70r–72r.
(26) For the manuscripts I consulted, see below.
(27) Ibn Sīnā, *Al-Qānūn fī al-ṭibb*, vol. 1, New Delhi: Institute of History of Medicine and Medical Research, 1981, 141, line 22.
(28) S. K. Hamarneh, "Ibn al-Ḳuff," *Encyclopaedia of Islam: New Edition*, vol. 12, 391; Sami K. Hamarneh, "Ibn al-Quff," *Dictionary of Scientific Biography*, vol. 11, 238f.
(29) Kennedy, *A Survey*, 161b; F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī ʿilm al-hayʾa)*, New York: Springer-Verlag, 1993, vol. 2, 396.
(30) Robert G. Morrison, *Islam and Science: The Intellectual Career of Niẓām al-Dīn al-Nīsābūrī*, London:

suggest that al-Shīrāzī cooperated in observation at Marāgha.

He continued to explain the eighth sphere and enumerated its various appellations. Our Text 1 below ends here, but his commentary goes on. In the following commentary, he described the ecliptic and the celestial equator in detail.

Text 2 is on the reason why spring and autumn are shorter than summer and winter, and it has no relation to the testimonies of the Marāgha observatory. However, as it showed his expertise in astronomy too, I provide an edition and translation of this account. He gave two versions of explanation: according to the first, the beginning of spring is similar to winter, and the end of spring is similar to summer, and so on. This makes spring and autumn shorter than the rest.

The second explanation is astronomical. The rate of the motion of the Sun away from the celestial equator, or the equinoctial, varies in accordance with its position on the ecliptic. In the vicinity of the equinoxes, it moves faster away from the celestial equator, while in the vicinity of the solstices, it moves slower. According to al-Shīrāzī, its motion away from the celestial equator around the equinoxes is four times faster than around the solstices. When the Sun is around the solstices, it stays there causing heat or cold. Thus, summer and winter are longer than spring and autumn.

He said that Ibn al-Nafīs did not comprehend the cause of this phenomenon and quoted the explanation word for word. Here ends our Text 2. Subsequently he described the error of Ibn al-Nafīs.

Text 3 explains why summer is hot. It is because the Sun moves on the ecliptic. Where the local latitude is smaller than the obliquity of the ecliptic (23.5°), the Sun passes the zenith of there twice a year. Thus, the summer there becomes longer. Where the local latitude is equal to that obliquity, the Sun passes the zenith once a year. In the south, however, summer is hotter than in the north, for the perigee is in the south. Where the local latitude is larger than that obliquity, the Sun never passes the zenith. In the case of the northern hemisphere, it approaches most the zenith in the beginning of Cancer and goes away from it most in the beginning of Capricorn. The commentary on this lemma and our Text 2 end here.

The immediate cause of the heat of summer is mentioned in the commentary on the next *lemma*: the rays of the Sun produce heat. He gave a geometrical or optical explanation. When the Sun is at the zenith, it is the nearest to the point on the Earth under it, where we are. The nearer the Sun comes to the zenith, the nearer to us it comes and the more intense the rays of the Sun are. This causes the intensity of heat.(31) The Sun comes nearest to the zenith in summer, as already said. Thus, summer is hot.

Text 3 also contains a testimony of his cooperation in observation at Marāgha. The value of the obliquity of the ecliptic, 23.5°, is said to agree with "what has been verified through our observation of the declination at Marāgha (*mā taḥaqqaqa bi-raṣadi-nā al-mayla fī Marāgha*)." The value of this obliquity accepted by

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Routledge, 2007, 167. A near-contemporary astronomer of al-Shīrāzī, Muḥyī al-Dīn al-Maghribī (d. 1283), who conducted observation at Marāgha, used the value 1°/66 years (George Saliba, "Solar Observations at the Maraghah Observatory before 1275: A New Set of Parameters," *Journal for the History of Astronomy* 16 [1985], 113–122).

(31) MS Berlin, Or. 3039, 421r, ll. 4–7; MS Ayasofya, 3652, 20r, ll. 5–11.

Ptolemy was roughly 23.85°. Al-Ṭūsī wrote in his *Tadhkira* that it was less than 24°, more than 23.55°, but he was said to have found it to be 23.5°. The fact that the value adopted in *Zīj-i Īlkhānī* was 23.5° confirms these words of al-Shīrāzī.[32]

These are al-Shīrāzī's own testimonies. Although we can trust him, it does not necessarily mean that he participated in observation at Marāgha. It is possible that he only had access to the data accumulated through the new observation. Furthermore, there are a lot of circumstantial evidences besides them. He studied astronomy with Naṣīr al-Dīn al-Ṭūsī when the latter resided at Marāgha. His proposal led to the revision of al-Ṭūsī's *al-Tadhkira fī ʿilm al-hayʾa* (*Memoir on Astronomy*) before al-Ṭūsī left Marāgha.[33] His name was mentioned in al-Ṭūsī's testament.

Without the testimonies I provide here, it is agreed that he had a connection with the Marāgha observatory. We may not need another evidence, but these testimonies will be of some significance for research in the future.

IV. Edition and translation of the accounts

Following is an edition and translation of the accounts (vocalization and punctuation are mine). For ease of consultation, I add folio numbers of MS Berlin, Staatsbibliothek zu Berlin, Or. 3039.[34] The edition here is, however, not the transcription of this MS; this edition is made by collating a few MSS, including MS Istanbul, Ayasofya, 3652, with the Berlin MS.[35] Where the text of this edition diverges from the text of the Berlin MS, I note in the apparatus (as "ب"). Underline indicates the *lemma* of *Canon*.

Text 1: the explanation of the celestial spheres (MS Berlin, Or. 3039, 413v, l. 24–414r, l. 22)

عند المنجمين[36]

... والأفلاك الكلية تسعة: سبعة للسيارات السبع، والثامن للكواكب الثابتة، والتاسع هو الفلك الأعظم ولا كوكب عليه ولهذا سمي بـ«الأطلس». ولكل من الأفلاك التسعة حركة خاصة على منطقة وقطبين. ولسنا[37] نحتاج ههنا إلى بيانهما في أفلاك السيارات لأنها بمعزل عن نظرنا ههنا بل في التاسع والثامن.

أما التاسع فيتحرك من المشرق إلى المغرب على قطبين: أحدهما وهو الذي في جهة بنات النعش قريب من كوكب جدي يسمى «القطب الشمالي للعالم»، وثانيهما وهو الذي في الجهة الأخرى يسمى «القطب الجنوبي للعالم»؛ وعلى منطقة تسمى «معدل النهار»، و«فلكه» تجوزًا. وإنما سميت به لتعادل 414rب

(32) Ragep, *al-Ṭūsī's Memoir*, vol. 1, 119f.; vol. 2, 394; Morrison, *Islam and Science*, 164f.
(33) Ragep, *al-Ṭūsī's Memoir*, vol. 1, 72f.
(34) http://resolver.staatsbibliothek-berlin.de/SBB0001577000000000 (accessed 15 July 2019).
(35) For the Istanbul manuscript, see Mimura, "Quṭb al-Dīn Shīrāzī's Medical Work," 3–5.
(36) Ibn Sīnā, *Al-Qānūn*, vol. 1, 141, line 22.
(37) ولسنا] وليسنا ب

الملوين أبدًا عند من يسكن تحتها وفي جميع البقاع سوى النقطتين المسامتتين[38] لقطبها عند وصول الشمس إليها ساعة طلوعها ليكون ليله كنهاره أو غروبها ليكون نهاره كليله. إذ لو وصلت إليه في غيرهما كما في نصف النهار مثلًا امتنع تساويهما لكون قوس إليها وحينئذٍ من قطعتي مدارين: أحدهما شمالي والآخر جنوبي. وإذن يستحيل أن يوجد ليل متقدم[39] على التحويل أو متأخر عنه ويساوي[40] ذلك النهار. وسميت هذه الحركة بـ«الحركة اليومية» لتتميمها الدورة في قريب من يوم بليلته.

... وأما الثامن وهو فلك الكواكب الثابتة فيتحرك حركة بطيئة. وجدها القدماء تقطع جزءً في مائة سنة وتتم الدور في ستة وثلثين ألف سنة؛ والمحدثون في ستة وستين سنة وتتم في ثلثة وعشرين ألف سنة؛ وقوم من محققيهم في سبعين سنة وتتم في خمس وعشرين ألف سنة ومائتي سنة، وهذا هو المعمول عليه في زماننا هذا لكونه موافقًا لما وجدناه بالرصد الجديد الذي عملناه في مراغة.[41] ومنطقة الثامن دائرة عظيمة متساوية البعد عن قطبيه وسميت هذه الحركة بـ«البطيئة». إذ لا أبطأ منها. وقد يطلق عليها «الغريبة» و«الثانية» أيضًا. وهذه الحركة ليست على منطقة الثامن وقطبيه بل على منطقةٍ منطقةُ الثامن في سطحها وهي المسماة بـ«منطقة الحركة الثانية». قال بطلميوس في *المجسطي* «ههنا لأن الحركة إنما تكون على قطبي دائرة تحفظ الكواكب أبعادها منها والكواكب الثابتة تحفظ أبعادها من هذه المنطقة على ما دل[42] عليه الأرصاد». وبـ«الدائرة الشمسية» لارتسامها بحركة الشمس حقيقة لأنها[43] دائرة حادثة في سطح الفلك الأعلى من توهم سطح الدائرة التي ترسمها الشمس بحركتها الخاصة قاطعًا للعالم. وبـ«دائرة البروج» لقسمتها أولًا عليها. وبـ«منطقة البروج» و«فلك أوساط البروج» لمرورها بوسطها وبـ«فلك البروج» تجوزًا. ولو كانت البروج مرسومة على الثامن لا على التاسع لَما أمكن انتقال الثوابت من برج إلى برج اللهم إلا على وجه أشرنا إليه في *التحفة*.

وهاتان الحركتان أعني الأولى والثانية شاملتان لما دونهما من الكواكب والأجرام العلوية. ولكرة[44] الأثير عند بعض لما يشاهد من حركة ذوات الأذناب على موازاة المعدل.

[these seasons for the physicians are different from those] for the astronomers

... [I omit the elementary explanation of the *lemma* and of geometrical and astronomical terms.]

There are nine spheres in all: seven of them are those of the seven planets; the eighth is that of the fixed stars; the ninth is the largest sphere, which has no star on it and is thus called “the Atlas (*Aṭlas*).” All the nine spheres have a proper motion on an equator (*minṭaqa*) and two poles (*quṭbay*). We need not to explain here both [equator and poles] of the spheres of the planets, for they are irrelevant to

(38) المسامتتين] المسامتين ب
(39) متقدم] مقدم ب
(40) ويساوي] وليساوي ب
(41) في مراغة] بمراغة ب
(42) دل] دلت ب
(43) لأنها] النهار ب
(44) ولكرة] ولكثرة ب

our examination here; [we should explain only] the ninth and the eighth.

The ninth [sphere] moves from the east to the west on two poles: one of them, which is on the side of Ursa (*banāt al-naʿsh*) near to the North Star (*kawkab al-jady*), is called "the north pole of the world (*quṭb shamālī li-l-ʿālam*)"; the second, which is on the other side, is called "the southern pole of the world (*quṭb janūbī li-l-ʿālam*)." And [it moves] on an equator which is called "the equinoctial (*muʿaddil al-nahār*)" and "its sphere (*falak-hu*)" by metaphor. It is called so because day and night (*mawalān*) are always equated for those who dwell under it. And [for dwellers] in all spots except two points [on the Earth] facing its pole, when the Sun crosses it at its rise, night is equal [of length] to day; [when the Sun crosses it] at its set, day is equal [of length] to night. If the Sun crossed it at other [times] than these, at noon for example, it would be impossible that [day and night] be equated, for an arc toward the Sun would then be formed of two segments of two curves: one of them is northern, the other is southern. It is impossible, therefore, that nights preceding or following 'the time when the Milky Way appears in the middle of the sky' (*taḥwīl*) should be equal [of length] to days of that [time]. This motion is called "the daily motion (*ḥaraka yawmīya*)" for its completion of a revolution in approximately a whole day and night.

... [I omit a few lines criticizing the commentary of Ibn al-Quff al-Masīḥī.]

As for the eighth [sphere], which is the sphere of the fixed stars, it moves slowly. The ancients found out that it traversed 1° in 100 years and made a revolution (*dawr*) in 36,000 years. The moderns [found out that it traversed 1°] in 66 years and made [a revolution] in 23,000 years. Some truth finders (*muḥaqqiqūn*) of [the moderns found out that it traversed 1°] in 70 years and [made a revolution] in 25,200 years. This is [the parameter] upon which we base calculation in our days, because it agrees what we found through the new observation carried out at Marāgha. The equator of the eighth [sphere] is a bi

g circle equidistant from the two [celestial] poles. This motion is named "the slowest [motion] (*baṭīʾa*)," for there is no motion slower than this. Sometimes it is also called "the strange (*gharība*)" or "the second (*thāniya*)." This motion is not on the equator of the eighth [sphere] with its poles, but on the equator called "the equator of the second motion," on whose plane is the equator of the eighth [sphere]. Ptolemy said in the *Almagest*: [the second motion is] there, because the motion is on the two poles of a circle from which the celestial bodies keep a distance. The fixed stars keep a distance from this equator. This conforms to what is attested to by observations.(45) And [the equator of the eighth sphere is called] "the solar circle (*al-dāʾira al-shamsīya*)," for it is really described by the motion of the Sun. [This is] because it is a circle appearing in the surface of the uppermost sphere, on the supposition of the plane of the circle which the Sun describes through its proper motion traversing the world. And [it is called] "the circle of the zodiac (*dāʾirat al-burūj*)," for it is divided

(45) Cf. *Syntaxis Mathematica*, vol. 2, ed. J. L. Heiberg, Lipsiae: B. G. Teubneri, 1903, VII.ii, p. 12, ll. 7–10 (G. J. Toomer, *Ptolemy's Almagest*, London: Duckworth, 1984, 327).

first by [the signs of the zodiac]. And [it is called] "the equator of the zodiac (*minṭaqat al-burūj*)" and "the sphere of the midpoints of the zodiac (*falak awsāṭ al-burūj*)," for it passes the midpoints of them. And [it is called] "the sphere of the zodiac *(falak al-burūj)*" by metaphor. If the zodiac were described on the eighth [sphere], not on the ninth, the fixed [stars] could not shift from a sign [of the zodiac] to another, except in a manner which we pointed out in *al-Tuḥfa* [*al-Shāhīya*].

These two motions, i.e. the first and the second, encompass the stars and the celestial bodies which are under them. Some [think] the globe of ether (*athīr*) is also [encompassed by these motions], for the motion of comets (*dhawāt al-adhnāb*) parallel to the equinoctial is observed.

Text 2: why spring and autumn are shorter than summer and winter (MS Berlin, Or. 3039, 416v, l. 22–417r, l. 17)

هو جميع الزمان البارد. فيكون زمان الربيع والخريف كل[46] واحد منهما عند الأطباء أقصر من كل واحد من الصيف والشتاء[47]

لأن أول الربيع شبيه بالشتاء وآخره شبيه بالصيف، وكذا أول الخريف شبيه بالصيف وآخره شبيه بالشتاء. والكائن على طبيعة الاعتدال أوساطها على ما دل عليه الاستقراء، والأوساط وهي الربيع والخريف أقل من الأطراف وهي الصيف والشتاء.

أو لأنك قد علمت في أوائل الكتاب في فصل المزاج أن الميل من الاعتدال إلى الانقلاب وإن كان إلى التزايد لكن تفاضله على التناقص لما برهن عليه ثاودسيوس[48] في كتابه *في الأُكَر*. ولهذا فإن فضل ميل الثور وهو عشرون على ميل الحمل وهو إثنى عشر تقريبًا أكثر من فضل ميل الجوزاء وهو ثلثة وعشرون ونصف على ميل الثور لأن الأول ثمانية والثاني ثلثة ونصف. فقد ظهر أن الشمس إذا قطعت الحمل وهو ثلثون جزء بعدت عن المعدل إثنى عشر جزء، وإذا قطعت الثور وهو ثلثون أيضًا بعدت عنه ثمانية أجزاء لأن إثنى عشر هو[49] ميل الحمل، وإذا قطعت الجوزاء بعدت عنه ثلثة وعشرين[50] ونصفًا لأن العشرين هو ميل مجموع الحمل والثور. وهكذا في كل درجة. 417rب

ولهذا فإن ميل أول درجة من الحمل خمس وعشرون دقيقة تقريبًا، وميل درجة من أول السرطان دقيقة وكسر. وعلى هذا فبمقدار درجة تقطعها الشمس من حوالي الاعتدالين تبعد أو تقرب من المعدل خمسًا وعشرين دقيقة، وبمقدار درجة تقطعها من حوالي الانقلابين تبعد أو تقرب من المعدل دقيقة. وهذا هو المراد من قولهم «إن الشمس إذا كانت حوالي الاعتدالين كانت حركتها في الميل أسرع[51]، وأبطأ ما يكون عند قربها من الانقلابين». فالشمس حوالي الاعتدالين كالمجتاز بسرعة، وحوالي

(46) كل] بل ب
(47) Ibn Sīnā, *Al-Qānūn*, vol. 1, 141, l. 30–142, l. 1.
(48) ثاودسيوس] ثاووسيوس ب
(49) هو] - ب
(50) ثلثة وعشرين] ثلثون ب
(51) أسرع] بسرع ب

الانقلابين كالواقف بلا حركة.

ولأن[52] كون الشمس قريب الاعتدالين هو المقتضي للاعتدال وتمر بسرعة وكونها قريب الانقلابين هو المقتضي للحر والبرد ولا تمر بسرعة بل تلبث زمانًا، يكون زمان الاعتدال أقصر من كل واحد من زماني الحر والبرد على ما دل عليه الاستقراء. وهذا كلام محقق.

وإنما أعدت بعض ما ذكرت لأن بيان سرعة حركة الميل وبطئها وتصورها على ما ينبغي مما يحتاج إلى فضل تكرار وتنبيه. إذ لا يتصوره على ما ينبغي إلا بعض الحكماء الجامعين بين التعمق في البرهان والتدقق في الحسبان، فضلًا عن الأطباء الخالين عن النظر فيهما فضلًا عن التعمق والتدقق.

ولدقة هذا البحث لم يعرفه القرشي على ما دل عليه قوله وهو «إن الاستقراء دل على أن زمان الاعتدال أقصر من كل واحد من زماني[53] الحر والبرد. ولميته أن الشمس حين تصل إلى الموضع الذي يقتضي حصولها فيه الاعتدال تفارقه لأنها دائمة الحركة. وأما إذا حصلت في الموضع الذي يقتضي حصولها فيه الحر والبرد لم يلزم أن تفارقه إلى ما يوجب مقابل ذلك بل قد تنتقل عنه إلى ما يوجب أقوى منه من بابه. إذ الحر والبرد كل واحد منهما له سعة ظاهرة والاعتدال ليس سعة عرضة كسعة عرض الحر والبرد[54].»[55] هذا كلامه بألفاظه، وفيه نظر من وجوه ....

[Winter] is the whole of cold time. Then, both spring and autumn for the physicians is shorter than both summer and winter

This is because the beginning of spring is similar to winter, and its end is similar to summer. Likewise, the beginning of autumn is similar to summer, and its end is similar to winter. That which occurs in accordance with the nature of equilibrium is its middles, as induction proves. The middles, which are spring and autumn, are fewer than the ends, which are summer and winter.

Or, as you learned in the first parts of the book, the chapter on the temperament, that even if the declination (*mayl*) from the equinox (*iʿtidāl*) to the solstice (*inqilāb*) increases, its increment is decreasing on the basis of what Theodosius (d. ca. 100 BC) demonstrated in his book *on the Sphere* (*fī al-Ukar*).[56] Because of this, the excess of the declination (*mayl*) of Taurus (*thawr*), 20°, over the declination of Aries (*ḥamal*), roughly 12°, is more than the excess of the declination of Gemini (*jawzāʾ*), 23.5°, over the declination of Taurus: the former excess is 8° and the latter is 3.5°. It happens, therefore, that when the Sun traverses Aries, which is 30° [in the celestial longitude], it

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[52] ولأن] لأن ب

[53] زماني] زمان ب

[54] كل واحد منهما له ... والبرد] - ب

[55] Ibn al-Nafīs, *Sharḥ al-Qānūn*, MS Wellcome, Or. 51, 70v, ll. 5–7; but some words are missing in Ibn al-Nafīs' manuscript.

[56] For the Arabic version of this book, see Fuat Sezgin, *Geschichte des arabischen Schrifttums, Band V: Mathematik bis ca. 430 H.*, Leiden: E. J. Brill, 1974, 154f. (no. 1).

goes away from the equinoctial by 12°. When it traverses Taurus, which is also 30°, it goes away by 8°, for 12° is the declination of Aries. When it traverses Gemini, it goes away by 23.5°, for 20° is the declination of the entirety of Aries and Taurus. And so on in each degree [in the celestial longitude].

Because of this, the declination of the first degree of Aries [= the spring equinox] is roughly 25′, and the declination of the degree of the beginning of Cancer [= the summer solstice] is 1′ and a fraction. In accordance with this, around the two equinoxes (*iʿtidāl*) the Sun goes away from, or approaches, the equinoctial by 25′ per a degree which it traverses, while around the two solstices (*inqilāb*) it goes away from, or approaches, the equinoctial by 1′ per a degree which it traverses. This is the meaning of the saying, "when the Sun is around the two equinoxes, its motion in declination is faster, but its [moving] slowest is when it is in the two solstices," that is, when the Sun is around the two equinoxes, it is almost running, while when it is around the two solstices, it is almost standing still without motion.

Furthermore, being near to the two equinoxes of the Sun causes the equilibrium for it passes fast, whereas being near to the two solstices of the Sun causes heat and cold for it does not passes fast but stays for a time. This makes the time of the equilibrium shorter than both times of heat and cold, as induction proves. This is a verified argument.

I repeated some of what I said, because the explanation of the rapidity and slowness of the motion of declination and the proper conception (*taṣawwur*) of it belong to what we must repeat and remind [you] of enough. Since only some philosophers who are [capable of] both a profound demonstration and a precise calculation conceive it properly; not to speak of physicians careless in these, let alone profundity and precision.

For the subtlety of this inquiry, [Ibn al-Nafīs] al-Qurashī did not know it in spite of what his words proved. [He said:] Induction proves that the time of the equilibrium is shorter than both times of heat and cold. The reason (*limayya*) of this is that when the Sun reaches the place where its arrival causes the equilibrium, it leaves it [soon], for it is always moving. On the other hand, when it comes to the place where its arrival causes heat or cold, it does not necessarily leave it, so that the contrary to that [effect] follows, but it sometimes moves from it, so that the more intense of the same kind follows. This is because both heat and cold have an apparent range and the equilibrium has not a wide range as the range of width of heat and cold. This is his argument just as he told. To this, there are objections from some viewpoints....

Text 3: why summer is a hot season (MS Berlin, Or. 3039, 418r, ll. 7–25).

لقرب الشمس من سمت الرؤوس[57]

[57] Ibn Sīnā, *Al-Qānūn*, vol. 1, 142, line 6.

وذلك لما علمت أن الشمس تتحرك في سطح دائرة البروج التي نصفها شمالي عن المعدل ونصفها جنوبي عنه. فإذا كانت الشمس في البروج الشمالية فعرض[58] البلد وهو قوس من دائرة نصف النهار بين[59] سمت الرأس ومعدل النهار أو بين قطب معدل النهار والأفق لتساويهما أبدًا، إذ[60] بمقدار ما يميل المعدل عن سمت رؤوس الشماليين إلى الجنوب يرتفع القطب الشمالي عن الأفق وينحط الجنوبي، إما أن يكون أقل من الميل الكلي الذي هو غاية البعد بين منطقتي المعدل والبروج وهي ثلثة وعشرون جزء ونصف على ما تحقق برصدنا الميل في مراغة، أو متساويًا[61] له أو أكثر منه.

فإن كان الأول فالشمس تمر في السنة مرتين بسمت رؤوسهم في نقطتين ميلهما أي بعدهما عن معدل النهار في جهة القطب الظاهر كعرض البلد وحينئذٍ أي عند مرورها بالسمت ينتفي ظل الزوال، ولا تتساوى فصول السنة ثمة لكون صيفهم أطول لوصول الشمس إلى السمت مرتين. وبسبب بعدها عن السمت وعلى قدره يكون في وسطه فتور للحر وإن أمكن أن تعارضه زيادة مكثها فوق الأرض. ولا يتشابه أن زادت على أربعة لاختلاف غايتي بعدها عن السمت في الجهتين بخلاف خط الاستواء ولكونها ذات غايتي قرب[62] بخلاف ما يساوي عرضه الميل أو زاد عليه.

وإن كان الثاني مرت الشمس في السنة مرة بسمتهم وحينئذٍ ينتفي ظل الزوال. وتكون فصول السنة أربعة لا غير. وهذه الخواص وغيرها عامة للمساكن الشمالية والجنوبية لكن الصيف والشتاء لهما على التبادل. وكذا الفصلان الآخران على ما سبق. وما عرضه مساوٍ لغاية الميل في الجنوب أحر مما عرضه في الشمال كذلك لأنها أبعد عن الأرض في الشمال وأقرب منها في الجنوب لأن الأوج في الشمال والحضيض في الجنوب.

وإن كان الثالث فالشمس لا تنتهي إلى السمت هناك. بل تقرب منه في رأس السرطان ويكون البعد بينهما بقدر فضل عرض البلد على الميل، وتبعد عنه في رأس الجدي ويكون البعد بينهما بقدر عرض البلد والميل الكلي.

<u>because of the nearness of the Sun to the zenith</u>

This is because, as you know, the Sun moves on the plane of the circle of the zodiac, whose half [passes] the north of the equinoctial and the other the south of it. Local latitude (*ʿarḍ al-balad*) is the arc of the meridian (*niṣf al-nahār*) between the zenith (*samt al-raʾs*) and the equinoctial or between the pole of the equinoctial and the horizon (*ufq*), for [the angle of these two arcs] are always the same: in proportion to the declination of the equinoctial from the zenith of the northern [inhabitants] to the south, the northern pole declines from the horizon and the southern pole descends. When the

(58) فعرض] بعرض ب
(59) بين] من ب
(60) إذ] أو ب
(61) متساويا] متساوية ب
(62) قرب] القرب ب

Sun is in the northern zodiac, [the local latitude] is (a) smaller than the obliquity of the ecliptic (*mayl kullī*)—the maximum distance between the equinoctial and the zodiac: it is 23.5° according to what has been verified through our observation of the declination at Marāgha—, is (b) equal to it, or is (c) larger than it.(63)

In the first case, the Sun passes their zenith twice a year at two points whose declination, i.e. the distance from the equinoctial in the side of the visible pole, is equal to the local latitude. Then, i.e. at its passing, the shadow disappears. Seasons of year are not equal to each other there, for their summer is longer because of the arrival of the Sun at the zenith twice [a year]. And for the reason of its distance from the zenith, and in proportion to this, heat is moderated in the middle of [their summer], even if its stay over the Earth exerts counteraction to it. There is no ambiguity about whether [the number of seasons] is more than four. [It could be wrongly imagined] because of the difference of its maximum distances from the zenith in the two sides unlike the [terrestrial] equator (*khaṭṭ al-istiwāʾ*), and because of its coming to the maximum nearness [twice a year] unlike the place whose latitude is equal to the declination or larger than this.

In the second case, the Sun passes their zenith once a year, when the shadow disappears. [The number of] seasons of year is four, nothing else. These and other properties are common to the northern and the southern inhabitants. Summer and winter, however, are opposite [for them]. Likewise, the other two seasons are [opposite], as [explained] above. [The place] whose latitude is equal to the maximum declination in the south is hotter than that in the north. This is because [the Sun] is farther from the Earth in the north and nearer to it in the south, for the apogee (*awj*) is in the north and the perigee (*ḥaḍīḍ*) in the south.

In the third case, the Sun does not reach the zenith there. Still, the Sun approaches it at the beginning of Cancer (*saraṭān*) [= the summer solstice], where the distance between them is the same as the excess of the local latitude over the declination, and the Sun goes away from it at the beginning of Capricorn (*jady*) [= the winter solstice], where the distance between them is the same as the local latitude.

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(63) For the sake of clarity, I changed the order of the translations in this paragraph.