Kaveh Niazi. *A Princely Pandect on Astronomy: Naṣīr al-Dīn Ṭūsī's Muʿīniyya Epistle and Its Appendix*. Vol. 58. Springer Nature, 2022.

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In contemporary discussions on the history of astronomy—particularly within the domain of Islamic astronomy—the term "non-Ptolemaic planetary models" is often emphasized. This focus serves two key purposes: first, to refute the outdated notion, popularized by certain 19th-century Orientalists, of a supposed decline in scientific inquiry in the Islamic world during the 12th and 13th centuries; and second, to highlight the possible links between these models and Copernican astronomy. However, the investigation of non-Ptolemaic models is only one facet of the broader history of science. This field intersects with a wide array of topics, as scholars of the time sought to build a coherent and systematic science that was integrative of both natural philosophy and mathematical inquiry. Consequently, the works from this period are distinguished by their rigor, argumentative depth, and openness to criticism and scholarly debate.

The 7th century AH (13th century CE) marks a golden age of theoretical astronomy within Islamic civilization. The era's foremost contributors included Naṣīr al-Dīn Ṭūsī, Muʾayyad al-Dīn ʿUrḍī, and Quṭb al-Dīn Shīrāzī. Among the period's most important works, Ṭūsī's *al-Tadhkira* has been critically edited, translated into English, and accompanied by an insightful commentary.[1] ʿUrḍī's *Kitāb al-Hayʾa* has

1 Ragep, Jamil. *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī ʿilm al-hayʾa)*. 2 vols. New York: Springer, 1993.

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DOI dx.doi.org/10.12658/Nazariyat.11.1.D113en

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likewise been edited, with parts of its content analyzed.[2] Of Shīrāzī's three major works—*Nihāyat al-Idrāk fī Dirāyat al-Aflāk* (Arabic), *Ikhtiyārāt Muẓaffarī* (Persian), and *al-Tuḥfa al-Shāhīya* (Arabic)—only the second has been published alongside a commentary.[3] Recent contributions by Iranian scholars have further enriched the field, including critical editions of ʿAbd al-Jabbār Kharaqī's[4] *Muntahā al-Idrāk fī Taqāsīm al-Aflāk* and Ṭūsī's[5] *Risāla Muʿīniyya*.

Dr. Kaveh Niazi has produced an English translation and critical edition of Ṭūsī's *Muʿīniyya* and its companion treatise *Ḥall Ishkālāt*, accompanied by an erudite introduction. This contribution renders one of the most significant Persian astronomical texts of the Islamic era accessible to a global scholarly audience. Of particular interest is the appended treatise, which addresses technical challenges and suggests that the earliest conceptual efforts toward non-Ptolemaic models may have first emerged not in Arabic scientific literature, but in earlier Persian texts, particularly those linked to the Ismaili intellectual tradition. These ideas were subsequently integrated into Arabic-language works.

In the 13th century, Ṭūsī and ʿUrḍī were at the forefront of developing innovative models to resolve the inconsistencies within Ptolemaic astronomy. Prior to their work, Kharaqī had not engaged with these problems in his own comprehensive treatise on *hay'a* (astronomical configuration). Ṭūsī, during his affiliation with the Ismailis, confronted these issues in his *Muʿīniyya*, before advancing further models in later writings. Both *Muʿīniyya* and *Ḥall Ishkālāt* were composed during Ṭūsī's tenure in the service of Nāṣir al-Dīn Muḥtasham in Qūhistān (1232–1245). Following the Mongol invasion and the collapse of the Ismaili fortresses, Ṭūsī rearticulated his findings in Arabic, publishing them in his more widely known *al-Tadhkira*.

A central flaw in Ptolemaic astronomy was the concept of the equant, which introduced non-uniform motion in celestial spheres. This issue had already been addressed critically by Ibn al-Haytham in his *al-Shukūk ʿalā Baṭlamīyūs* ("Doubts on

2 Saliba, George, ed. *The Astronomical Work of Mu'ayyad al-Dīn al-ʿUrḍī: A Thirteenth-Century Reform of Ptolemaic Astronomy. Kitāb al-Hay'a*. Beirut: Center for Arab Unity Studies, 1990.

3 Gamini, Amir M., ed. *Quṭb al-Dīn Shīrāzī's Ikhtiyārāt Muẓaffarī* (*Preferences for Muẓaffar*). Tehran: Iranian Institute for Philosophy, 2024.

4 Ghalandari, Hanif. *ʿAbd al-Jabbār Kharaqī's Muntahā al-Idrāk fī Taqāsīm al-Aflāk*. Tehran: Mīrāth-i Maktūb, 2021.

5 Savadi, Fatemeh, and Sajjad Nikfahm. *Naṣīr al-Dīn Ṭūsī's Risāla Muʿīnīya, with English Translation*. Tehran: Mīrāth-i Maktūb, 2021–2024.

Ptolemy"), where he argued that the equant contradicts fundamental physical principles. According to Ibn al-Haytham, if the center of the epicycle does not move uniformly with respect to the deferent's center, then the deferent itself must exhibit variable speed to maintain uniformity relative to the equant—violating the assumption of uniform circular motion [for the celestial orbs].[6] Although Ṭūsī and his contemporaries addressed these inconsistencies, they did not explicitly cite Ibn al-Haytham in their major works. Nevertheless, Ṭūsī acknowledged Ibn al-Haytham's insights in a letter to Athīr al-Dīn al-Abharī, which Niazi includes in the appendix, offering both the original and an English translation.

George Saliba, a leading scholar in the field, offers a different interpretation. He contends that the equant's flaw lies not in violating uniform motion per se, but in its physical implausibility: a sphere cannot rotate uniformly around an axis that does not pass through its center. He writes:

They [Maragha astronomers] could not accept the physical impossibility that a sphere moves uniformly mound an axis that did not pass through its center. To them, if such a requirement were introduced, as was indeed done by the Ptolemaic concept of the equant, then the term "sphere" would lose its meaning, for then it would no longer be the physical object we commonly refer to as a sphere.[7]

Although Saliba emphasizes non-sphericity, Sabra identifies non-uniformity as the primary conceptual problem in Ptolemaic models.[8] Saliba, however, reiterates his interpretation in response to Sabra, stating:

The equant problem does not arise from violating the principle of uniform motion as is so often asserted, and here repeated by Sabra although this violation is one of its consequences. Rather it arises from the conceptual notion of having physical spheres that could not possibly move, in place, uniformly, around an axis that did not pass through their centers, a veritable physical absurdity that would be obvious to anyone giving it more than a moment's consideration.[9]

6 Ibn al-Haytham. *al-Shukūk ʿalā Baṭlamīyūs*. Edited by Abdulhamid Sabra. Cairo: Dār al-Kutub al-Miṣrīya, 1971, 27.

7 Saliba, George. *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*. New York: NYU Press, 1995, 23.

8 Sabra, A. I. "Configuring the Universe: Aporetic, Problem Solving, and Kinematic Modeling as Themes of Arabic Astronomy," *Perspectives on Science* 6, no. 3 (1998): 293, 299.

9 Saliba, George. "Arabic versus Greek Astronomy: A Debate over the Foundations of Science," *Perspectives on Science* 8, no. 4 (2000): 331.

Saliba's interpretation appears to rest on a misapprehension: he posits that the entire circumference of deferent sphere revolves uniformly around the equant point, whereas, in the Ptolemaic model, it is solely the center of the epicycle that is maintained by the deferent with uniform motion relative to that point, namely only one point on the deferent exhibits such a motion. Ibn al-Haytham had already clarified that in order for the epicycle center to maintain uniform motion with respect to the equant, the deferent must vary its speed—accelerating and decelerating—depending on its distance from the equant. Sabra pointed this out, though Saliba appears to have rejected the correction. Morrison, for his part, declined to arbitrate.[10] Despite these earlier clarifications[11], Saliba's interpretation resurfaces in Niazi's introduction to his edition (p. 6).

Niazi devotes a significant portion of his introduction to a scholarly biography of Ṭūsī during his time among the Ismailis, drawing on both primary texts and supplementary historical sources. In addition to Ṭūsī's own autobiographical treatise *Risāla-yi Sayr wa Sulūk*, Niazi uses a variety of documents to fill in historical gaps. For example, he traces Ṭūsī's intellectual lineage through his teachers—Farīd al-Dīn Dāmād and Kamāl al-Dīn al-Ḥāsib—using *ijāzāt* (transmission certificates) and other materials to investigate whether Ṭūsī could be considered, via intellectual mediation, a student of Avicenna (Ibn Sīnā) and Fakhr al-Dīn al-Rāzī in the interpretation of *al-Ishārāt wa al-Tanbīhāt*. He also reconstructs Ṭūsī's scholarly connections in the study of Ptolemy's *Almagest*, particularly through his engagements with Kamāl al-Dīn al-Mūṣilī and Athīr al-Dīn al-Abharī, supported by their surviving correspondence. After completing his studies in Khurasan, Ṭūsī traveled to Iraq, where he met Shahāb al-Dīn Muḥtasham in the Ismaili fortress of Girdkūh. Seeking refuge from the violent upheavals of the Mongol invasion, Ṭūsī entered the service of the Ismailis. Shahāb al-Dīn reportedly offered sanctuary to several scholars during this time. In order to establish the chronology of Ṭūsī's major works composed under Nāṣir al-Dīn Muḥtasham's patronage, Niazi consults historical narratives such as Jawzjānī's *Ṭabaqāt-i Nāṣirī*, alongside modern secondary literature.

Muʿīniyya was not the first Persian treatise on *hay'a*, and Niazi situates it within a Persian scientific tradition that includes earlier works like Sharaf al-Dīn Masʿūdī's

10 Morrison, Robert. "Quṭb al-Dīn al-Shīrāzī's Hypotheses for Celestial Motions," *Journal for the History of Arabic Science* 13 (2005): 79–80.

11 Gamini, Amir M. "Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century," *Arabic Sciences and Philosophy* 27, no. 2 (2017).

Jahāndānish, Qaṭṭān Marwazī's *Kayhānshinākht*, and Abū Rayḥān Bīrūnī's *al-Tafhīm*—the latter not strictly a *hay'a* treatise, but rich in astronomical content as well as *hay'a*. Throughout both the introduction and the body of the work, Niazi refers to these precursors and demonstrates their influence on the content and structure of *Muʿīniyya*. He is also attentive to the deep impact of Kharaqī's *Muntahā al-Idrāk* on *Muʿīniyya*, and its connections with other works by Ṭūsī, such as *Zubdat al-Idrāk* and *Zubda fī al-Hay'a*. For instance, Niazi examines cases where Ṭūsī uses the terms *ikhtilāf* (variation or discrepancy) and *tafāwut* (non-uniformity or disproportion) interchangeably, analyzing their occurrence across multiple texts (p. 140).

At one point, Ṭūsī argues for the sphericity of the Earth by referencing observations of eclipses and meteors visible in different cities (p. 91). However, as is well-known, solar eclipses do not provide evidence for Earth's sphericity—only lunar eclipses do. This is consistent with Ṭūsī's own omission of solar eclipses and meteors when discussing the Earth's shape in his later work, *al-Tadhkira* (p. 105). Despite Niazi's close comparative work between *Muʿīniyya*, *al-Tadhkira*, *Muntahā*, and other *hay'a* texts, he does not address this discrepancy. Its omission is noteworthy, as it suggests a scientific inaccuracy in *Muʿīniyya* that was later corrected. In fact, one could argue that *al-Tadhkira* functions as a refined, expanded, and Arabic-language version of *Muʿīniyya* and its companion *Ḥall*—a transformation that underscores the importance of these earlier Persian works.

This perspective brings into sharper focus the importance of *Muʿīniyya* and *Ḥall Ishkālāt*. In one of his articles, George Saliba argues that it is "very difficult to isolate the Persian elements in the general scientific production of the medieval Islamic world."[12] He suggests that Persian texts in scientific contexts were either direct translations from Arabic or heavily influenced by Arabic sources.[13] While acknowledging that some *hay'a* texts in Persian exhibit unique characteristics, Saliba positions *Muʿīniyya* as the first Persian work in this domain that was consciously written as a subordinate to Arabic traditions.[14] Yet this view is historically and textually debatable. Works such as *Jahāndānish* and *Kayhānshinākht* predate *Muʿīniyya* and clearly fall within the Persian *hay'a* tradition. Furthermore, Saliba interprets the presentation

12 Saliba, George. "Persian Scientists in the Islamic World: Astronomy from Maragha to Samarqand," in *The Persian Presence in the Islamic World*, 126–146, at 126.

13 Ibid., 127.

14 Ibid., 133.

of the *Ṭūsī couple* model in *Ḥall* as merely a Persian translation of what had already been formulated in Arabic in *Taḥrīr al-Majisṭī*. However, this assumption hinges on the unproven premise that *Taḥrīr* predates *Ḥall*. By presuming the Arabic version came first, Saliba reaches the convenient conclusion that Persian works could not have been innovative.

Saliba extends this argument to Shīrāzī's *Ikhtiyārāt Muẓaffarī*, a comprehensive and professional *hay'a* text in Persian. He views it as a simple Persian rendering of *al-Tuḥfa al-Shāhīya*, despite the fact that *Ikhtiyārāt* was completed at least four years earlier. While it is true that parts of *Ikhtiyārāt* draw from *Nihāyat al-Idrāk*, the text also contains original content, including a map of Europe and novel models for Mercury—features that are absent in *Nihāyat* and appear only later in *al-Tuḥfa*.[15] Saliba's reading suggests that the Persian-language domain in Islamic astronomy was essentially derivative and unnecessary. However, the contents of *Muʿīniyya*, *Ḥall*, and especially *Ikhtiyārāt* show that these texts were not mere paraphrases but professional contributions in their own right, directed at a technically informed audience.

In his introduction, Niazi also examines the historical context in which *Muʿīniyya* was composed and dedicated. He discusses why the treatise was addressed not to Nāṣir al-Dīn Muḥtasham himself but to his son Muʿīn al-Dīn, designated as "the prince of Iran." After Ṭūsī fled the Ismaili fortresses and entered the service of the Mongols, he revised the introduction of the text, changing its title from *Muʿīniyya* (معينية) to *Mughniyya* (مغنية) and removing the honorifics praising the Ismaili court. In the edition by Savadi and Nikfahm, the original Ismaili and revised Mongol-era introductions are presented separately. In contrast, Niazi chooses to critically annotate and present the changes and omissions without distinguishing them as discrete textual layers. While this integrated approach offers a smooth reading experience, it may risk blurring the political and intellectual shifts reflected in the textual transformation.

Niazi presents the four chapters of *Muʿīniyya* individually, outlining the key features and conceptual focus of each. He concludes his introduction by citing a well-known passage from Ibn Khaldūn on the destruction of science and civilization in Islamic territories following the Mongol invasions. While Ibn Khaldūn presents a narrative of decline, Niazi uses this reference to emphasize that the Ismaili strongholds had in fact nurtured the intellectual conditions necessary for the composition

15 See Gamini, "Introduction" in *Quṭb al-Dīn Shīrāzī's Ikhtiyārāt Muẓaffarī*, 78–57.

of pioneering works such as *Muʿīniyya*. This is a compelling point, though it invites a necessary caveat: contrary to Ibn Khaldūn's claim, the Mongol invasions did not mark the end of scientific activity. On the contrary, Ṭūsī and his contemporaries not only survived this period but thrived within it—thanks in part to the support of the Maragha observatory established under Hulagu Khan. Ṭūsī's *al-Tadhkira*, for instance, was composed after the Mongol conquest and went on to inspire a tradition of commentaries and reinterpretations. The resilience and productivity of Ṭūsī and his successors serve as a powerful counterexample to the Orientalist myth of scientific collapse.

Niazi based his edition on six primary manuscripts from libraries around the world, supplemented by twelve additional copies where necessary. While the re-editing of classical scientific texts might appear superfluous to some, this volume exemplifies the value of such efforts. Just as multiple editions of literary works like *Tārīkh-i Bayhaqī* have proven indispensable for historians, new editions of scientific texts open up interpretive possibilities beyond the decisions of a single editor. Furthermore, the bilingual format of this edition enhances its value significantly.

That said, the Persian typography and page design leave room for improvement. While the overall layout is elegant and the cover design is visually appealing, the Persian text is printed in a small, visually uninviting font at the bottom of each page, leaving half of the bilingual spread effectively blank. More critically, the Persian pages lack diagrams—an unfortunate omission, as all the figures appear only in the English section.

The illustrations themselves are generally accurate and aesthetically well-executed. The use of varied line weights (thin and thick circles) helps convey the geometry of celestial models clearly. Nonetheless, there is one technical issue: in some diagrams (p. 172; see also Savadi & Nikfahm, p. 78), the Moon and planetary bodies are depicted along the epicycle's circumference. Yet Ṭūsī explicitly states that the Moon is "set in the epicycle like a gemstone in a ring, so that the convex of the Moon is tangent to the convex of the epicycle at a common point" (p. 149). This implies internal tangency, not circumferential placement. If this feature was misrepresented in all available manuscripts, the editor should have clarified that in a footnote. That said, the diagram of Ṭūsī's non-Ptolemaic model for the Moon is impressively accurate. Unlike in Savadi & Nikfahm's edition (p. 225), Niazi ensures that the epicycle's orbit is drawn concentrically with the deferent and that the inclined orb's thickness is depicted correctly (p. 440).

A further merit of the edition is the consistent alignment of Persian and English texts on facing pages, with matched paragraphing—an invaluable feature for scholars working across both languages. An exception occurs on page 133, where the translation appears in three paragraphs while the Persian counterpart is condensed into two. Spelling and typographical errors are rare but worth noting. For example, the constellation "Banāt al-Naʿsh al-Ṣughrā" is rendered as "Naʿsh-i Ṣughrā [Little Bier]" (p. 124), instead of the more accurate "Little Bier's Daughters." Similarly, the lunar mansion *Sharaṭayn* (شرطین) is mistranslated as "Sharatān" (p. 136). Paragraph alignment is mostly consistent, but a sentence on page 75—continued from the previous page—has lost its original verb, likely in an effort to syntactically conform to the preceding sentence.

These minor editorial inconsistencies, however, do not significantly detract from the overall quality of the work. Perhaps the most serious editorial lapse occurs in the emendation of the phrase "و به طول تقویم خواهند." Niazi notes in a footnote that although all manuscripts read "خواهند" (they want), this may be a scribal error. He replaces it with "و به طول تقویم خوانند" (pp. 114–115), drawing on a parallel from *al-Tadhkira*, where Ṭūsī writes "وقد يُسمى الطول تقويم." However, "خواهند" also means "to intend" or "to signify"—a usage attested in classical prose. For instance, Bayhaqī writes: "حکما تن مردم را تشبیه کرده‌اند به خانه‌ای که اندر آن خانه مردی و خوکی و شیری باشد و به مرد خرد خواهند," meaning "the sages likened the human being to a house… and by 'man' they meant intellect." Thus, the original phrasing could have been retained with appropriate annotation rather than silently corrected.

The English translation is overall fluent and displays a solid command of both mathematical and astronomical terminology. Only a few minor slips emerge when comparing the Persian and English texts. For example, "انسان عین الکرم" is translated as "humanity as the essence of generosity," whereas here "انسان عین" refers not to essence but to the "pupil" of the eye—i.e., the metaphor of man as the central point of generosity. In another instance, the word "جز" (= but) is missing from the Persian sentence on page 59, but the English version correctly includes "but"—without which the sentence's meaning is reversed. Similarly, on page 121, the Persian text mistakenly states "عروض این کواکب متغیر می‌شود" (latitudes of these stars change), when the correct reading should be "نمی‌شود" (do not change); the English version reflects the correct meaning. In contrast, one commendable editorial decision appears on page 141, where Niazi identifies the phrase "مرکز خارج مرکز تدویر" as erroneous and suggests omitting "تدویر"—a word absent from all manuscripts used by Savadi & Nikfahm.

Regarding terminology, Niazi mostly adheres to Jamil Ragep's translation of Ṭūsī's *al-Tadhkira*, ensuring consistency with existing scholarship. However, in the case of *ḥarakat khāṣṣa*, he diverges from Ragep's "proper motion," using instead "epicyclic motion" and "characteristic motion" (p. 152), without offering clarification. Likewise, the term "اعتبار" *iʿtibār*, central to the epistemology of Ibn al-Haytham, is translated variously as "example" (p. 92) and "relying" (p. 98). In a discussion of Venus's transit, Ṭūsī cites Ibn Sīnā: "اعتبار قران در آفتاب متعذر بود." Here, "iʿtibār" clearly denotes observation or testing, rather than trust or reliance. Ṭūsī's point is that the transit could not be observed, not that it lacked epistemic trustworthiness. Ragep, in his commentary on *al-Tadhkira*, rightly equates *tajriba* and *iʿtibār* with "observation and testing" (p. 383). Hence, Niazi's translation might have been better rendered as "observing the conjunction with the Sun is impossible," preserving the scientific nuance of the statement. Nonetheless, these isolated issues do not compromise the translation's overall quality. On the contrary, the English rendering is exemplary, allowing scholars to engage directly with Ṭūsī's Persian prose in a form that is both accessible and precise.

The joint edition and translation of *Muʿīniyya* and *Ḥall* represent a milestone in the study of Islamic astronomy. This volume is the first to present a Persian *hay'a* treatise in its original language alongside an English translation. Given the longstanding scholarly debates surrounding the originality and significance of Persian-language scientific production in the Islamic world, this edition offers a timely and indispensable resource. It invites renewed engagement with the Persian astronomical tradition, encourages comparative study, and enriches our understanding of the intellectual diversity of Islamic science. One hopes that Niazi will continue this important editorial and translational work, helping to bring more Persian scientific texts to the attention of the global scholarly community.

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