Islam and Science

The intellectual career of Nīẓām al-Dīn al-Nīsābūrī

Robert G. Morrison

Culture and Civilization in the Middle East

ISLAM AND SCIENCE
THE INTELLECTUAL CAREER OF NĪẒĀM AL-DĪN AL-NĪSĀBŪRĪ

By examining the work of the eminent 14th-century Iranian Shiite scholar Nīẓām al-Dīn al-Nīsābūrī, this book is the first rigorous attempt to explain the cross-fertilization of scientific and religious thought in Islamic civilization. Nīsābūrī did not consider himself a scientist alone, being commissioned by his patrons to work in a variety of fields. *Islam and Science* examines in detail the relationship between the metaphysics of Nīsābūrī's science, and statements he made in his Qur'an commentary and in other non-scientific writings.

Sources suggest that Nīsābūrī was inspired to begin his scientific career by the inclusion of basic science in a religious (*madrasa*) education. By mid-career, he had found methodological similarities between theoretical astronomy and Islamic jurisprudence. Morrison concludes that while Nīsābūrī believed science could give one a taste of God's knowledge, he realized that the study of science and natural philosophy alone could not lead him to a spiritual union with God. Only *ṣūfī* practice and *ṣūfī* theory could accomplish that.

Morrison's work is remarkable in synthesizing the history of Islamic science with other areas of Islamic studies. It will be of interest to students and scholars of religion and the history of science, as well as readers with a more general interest in Middle Eastern studies.

Robert G. Morrison is Assistant Professor of Religion at Whitman College, USA.

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Whether the subject was God's speech (the *Qur'ān*), God's most perfect religion (Islam), or God's creation (the natural world), Nīsābūrī approached its study with a sense of wonder. I am lucky to have found a figure who could hold my interest so tightly for over a decade. Though my interpretation of Nīsābūrī's career may reflect the fact that I became interested in him by dint of his work on astronomy, the amount of space I have devoted in this book to his religious scholarship demonstrates that I have taken seriously all aspects of his career. The inevitable criticisms of this book will be, I hope, ones regarding interpretations more than knowing omissions. These criticisms are my responsibility and not those of anyone whom I am about to thank.

This book began as my 1998 Columbia University Ph.D. dissertation, but the book's argument is 120 degrees (or 121 degrees) away from the argument of my dissertation. In addition, much of the information in the book is due to research I carried out after graduating. So, I would like to thank the National Endowment for the Humanities for a post-doctoral fellowship in 1998–9 for research in Istanbul and for a summer stipend in 2004 for writing this book. Also in 2004 I received a Graves Award from the Graves Foundation, and I would like to thank that foundation for support that funded a month of study and research in India. Finally, I would like to thank the Iranian Academy of Arts for inviting me to Iran to speak at a conference on Quṭb al-Dīn al-Shīrāzī in 2006 and, thus, enabling visits to manuscript libraries in Tehran and Qom.

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In the late 1970s, my father, the late Alan Morrison, got involved in a research project on Renaissance Florence's dowry fund. That was the beginning of my interest in manuscripts and in the role of science in the study of the pre-modern world. I am so sad he missed even the beginning of this project, not to mention its end. For over a decade, as my interests grew by fits and starts into a career, my mother Peggy, my brother Jeremy, and my sister-in-law Molly Schmitt have been a source of support. My friends Greta Austin, Clark Lombardi, and Stephanie Thomas were there constantly during dark days.

The newest member of my family, my wife Dana Gold, has been the source of the greatest love and understanding as my pursuit of Nīsābūrī led me halfway around the world several times but only once in front of a bus (and then to a hospital).

INTRODUCTION

> Quant aux sciences, aucun siècle ne fait une impression tellement mesquine et misérable que le 14e.[1]

Although the author of this sentence was speaking about Europe, most people feel the same way about the fourteenth century in Islamic civilization. These lachrymose impressions arise from the erroneous belief that the Mongol invasions of the thirteenth century occasioned a wholesale decline in Islamic intellectual life. In the past 50 years, scholars of Islamic science have done much to show that the fourteenth century was in fact a time of creativity remarkable for its quality, if not its quantity. The technical character of this research, however, has so far put off scholars of history, languages, religion, and literature engaged in the study of Islamic civilization. The rigorous study of Islamic science is a comparatively new field, and only in the past 25 years have researchers made real progress in explaining the relationship between Islamic science and other areas of Islamic intellectual life. That recent research has shown that studying advances in science helps one understand the development of the religious thought of the period. This book follows in that path by tracing unifying themes in the intellectual biography of a fourteenth-century scholar, Niẓām al-Dīn al-Nīsābūrī (d. c. 1330), who was equally renowned for his work in both science and religion.

Nīsābūrī's major religious and scientific texts have proven to be influential and are situated within a tradition of Islam's most outstanding scientists and exegetes. The greatest challenge of writing this book was the discrepancy between modern academia's emphasis on specialization and Nīsābūrī's polymathic range. Rather than present at once every single field that Nīsābūrī studied and the eminent figures in those fields, I have chosen to introduce information only as such information becomes necessary. As a background for the rest of the introduction, I do need to describe briefly the five fields that dominated his career

Nīsābūrī's major work of religious scholarship was a *tafsīr*, a *Qur'ān* commentary. *Qur'ān* commentary was important because the *Qur'ān* is Islam's central text and a primary source for the *Sharī'a*, God's law. Muslims

developed a science, *fiqh* (jurisprudence), that enabled humans to determine what God's law would be on certain questions. Different jurists could come to different conclusions, in some cases, about what the *Sharī'a* was. Islam has recognized a valid range of debate among jurists and among the schools (Ar. *madhāhib*, sing. *madhhab*) of Islamic law. Nīsābūrī's *tafsīr* included many practical and theoretical points of *fiqh* indicating that Nīsābūrī was well versed in this central area of religious scholarship.

In many cases, the pre-eminent sources of the *Sharī'a*, the *Qur'ān* and the Prophet Muḥammad's practice and sayings, spoke clearly as to what the law was and why. In other cases, though, the human intellect had to reason inferentially about what God's reasons were for certain laws. So, Nīsābūrī's command of *fiqh* will be most important for this book because the most central religious science allowed the human intellect to reach legally significant conclusions about God's reasons. After all, the role and power of the human intellect would matter to a scientist.

Nīsābūrī's *tafsīr* was encyclopedic in that it not only discussed the meaning of the text, but also included any information that Nīsābūrī thought would be relevant to understanding the text.[2] He often explained the connection of verses and passages to debates in *kalām*, a speculative discourse about God and Islam's closest equivalent to theology. In order to argue for divine omnipotence, *kalām* attacked the idea that although God created nature, natural processes then behaved wholly independently. So while *kalām* as a whole was in a dialogue with science and philosophy (before eventually appropriating parts of those disciplines), there were also debates among practitioners of *kalām*. One of the relevant *kalām* debates for this book was over whether God was bound by human values such as justice. One group of *kalām* practitioners, the *Mu'tazilī*s, argued in the affirmative; their eventual opponents, the *Ash'arī*s, held that God was not bound by human values and, in fact, could contravene them. Nīsābūrī's most important predecessors in *kalām* and *fiqh* were Abū Ḥāmid al-Ghazālī (d. 1111) and Fakhr al-Dīn al-Rāzī (d. 1210). In the last chapter of the book, we will find that Nīsābūrī also mined Ghazālī and Rāzī's ideas on mysticism.

Astronomy was the science in which Nīsābūrī did his best work. In his era, astronomy studied an earth-centered cosmos composed of the sun and moon and the planets Venus, Mercury, Mars, Jupiter, and Saturn. Beyond Saturn were the fixed stars, the stars that made up the constellations. Astronomers in Nīsābūrī's time conducted observations, tabulated the results so as to compute where the planets were going, and proposed physical models that could move the planets to their observed locations. Because this book presents science within a tradition of religious scholarship, I would like to introduce two points of tension relevant to astronomy's position within such a tradition.

The first point of tension was astronomy's connection to astrology. Tables of planetary positions could be used for astrological predictions and

forecasts. Scholars found astrological predictions objectionable for religious and non-religious reasons. By Nīsābūrī's lifetime, astrology had come to be recognized as a science distinct from astronomy, a development that aided astronomy's integration into a tradition of religious scholarship. But Nīsābūrī did discuss astronomy's application to astrology, and his presentation of astrology took religious criticisms of astrology into account and, nevertheless, managed to find something valuable in that science.

The second point of tension was astronomy's connection to *falsafa*, the philosophy of the Hellenistic tradition (e.g. the tradition of Aristotle and Plato). Many religious scholars were suspicious of *falsafa*'s pre-Islamic origins, and *kalām* reflected those suspicions. Because Islamic astronomy drew on Hellenistic astronomy, the physical models of theoretical astronomy originally had a strong connection to *falsafa*. *Falsafa*, for example, held that nature, though created by God, functioned with independence. *Kalām*, of course, disagreed. Against the background of debates in *kalām* and *fiqh* about the independence of nature and the role of the human intellect, Nīsābūrī re-assessed the foundations of theoretical astronomy. The most relevant astronomers, astronomers who also assessed the foundations of theoretical astronomy, for his career were the savant Naṣīr al-Dīn al-Ṭūsī (d. 1274) and Quṭb al-Dīn al-Shīrāzī (d. 1311). Both Ṭūsī and Shīrāzī were well known religious scholars, too, and I will refer to their religious work. Subsequent chapters of this book will introduce a few other areas in which Nīsābūrī wrote, but *tafsīr*, *kalām*, *fiqh*, astronomy, and astrology are the most important ones for following his career. Similarly, while many other political figures and scholars will appear throughout the book, Rāzī, Ghazālī, Ṭūsī, and Shīrāzī wielded the greatest influence on Nīsābūrī.

Nīsābūrī is a figure who is more interesting from a multi-disciplinary perspective than he is when situated within the purview of a particular area of Islamic studies. This book takes a diachronic approach not just because Nīsābūrī's views in different areas of scholarship developed throughout his career, but because the conditions of fourteenth-century Mongol Iran shaped his career. Consider Nīsābūrī's intellectual forefather, Ṭūsī. Ragep's model study of Ṭūsī's astronomy accurately identified Hellenism, "a commitment to rational discourse in all matters," as a distinct strand in Ṭūsī's thought.[3] With Nīsābūrī, the influence of Hellenism is detectable, particularly in his science and in his esoteric interpretations of the *Qur'ān*; a distinct strand of Hellenism is much less visible. This is not to say that Ṭūsī and Nīsābūrī did not have much in common; rather, the 60 years between them mattered.

We know very little about Nīsābūrī's early life. The bio-bibliographical sources about Nīsābūrī contain information derived from his writings and say little about the events of his life. What these sources do say generally could be deduced from his writings. To provide an introduction for the diachronic study of his writings, Chapter 1 of this book reconstructs the earliest stages of Nīsābūrī's education, both in Arabic and

in the memorization of the *Qur'ān*, and in basic arithmetic and astronomy. Information in his *Qur'ān* commentary and his earliest scientific texts is the foundation for this chapter's conclusions. The cosmopolitan outlook communicated by his *Qur'ān* commentary in particular and by the breadth of his output in general may have had its roots in the intellectually diverse environment of Nishapur. Nīsābūrī's family had its roots in Qom, a Shiite city, but in Nishapur he had access to Sunni teachers.

Chapter 2 examines the beginnings of Nīsābūrī's serious engagement with science, starting around 1300. By this point in his career, Nīsābūrī had begun to read the texts of his most influential teachers, Naṣīr al-Dīn al-Ṭūsī and Quṭb al-Dīn al-Shīrāzī. Chapter 2 investigates the religious motivations for studying science, in particular for Nīsābūrī's interest in observational astronomy. Chapter 2 provides, in addition, material on observational astronomy from Nīsābūrī's earliest scientific text and the religious implications of his work on observational astronomy.

Chapter 3 starts at the time of Nīsābūrī's move, in 1304–5, from Khorasan to Tabriz, where Shīrāzī was living at the time. From Nīsābūrī's *Qur'ān* commentary and other sources, we know that Nīsābūrī had begun to be interested by this time in questions of *kalām* that impinged on science's role in a tradition of religious scholarship. Also by the middle of that decade, Nīsābūrī would have come into contact with his most important patrons. These facts raise several questions that the chapter explores. Who supported Nīsābūrī's work in Tabriz? Is there any correlation between his teachers and patrons, some of whom were Sunni, and Nīsābūrī's positions on religious debates? Are we able, at this stage of Nīsābūrī's career, to harmonize the positions he took in religious debates with the reasons he has given for the study of science? On all levels, his religious scholarship indicated a strong intellectual commitment to God's omnipotence.

God's omnipotence was an important foundation of Nīsābūrī's next text, also completed in the first decade of the fourteenth century, in 1308–9. This text included a section on the applications of a knowledge of planetary positions to astrological predictions. Nīsābūrī understood astrology to be founded upon the premise that God's power infused the cosmos, a premise that would seem to enhance God's omnipotence, just as making astrological predictions would seem to detract from it. Chapter 4 explains how Nīsābūrī accepted the theoretical premisses of astrology while questioning the way it was applied. The second half of Chapter 4 uses statements Nīsābūrī made in his religious scholarship, along with statements he made with regard to astrology, to determine just how the human intellect could understand the actions of an omnipotent God.

Clearly, the first decade of the fourteenth century was a productive period for Nīsābūrī. It was, in addition, when he completed his most important text on theoretical astronomy. In that text, Nīsābūrī, like other astronomers of the period, aimed to discern a greater degree of consistency between

available observations and the physical theories that developed to account for these observations. In addition, he was most attentive to the issue of whether those physical theories could function in the real world. Chapter 5 uses material from Nīsābūrī's work on theoretical astronomy to demonstrate that he perceived a resemblance between scientific theories and processes of reasoning in *fiqh*. The parallels he drew between the role of the human intellect in science and in *fiqh* enabled Nīsābūrī to make statements about the cosmos that were more than simply plausible descriptions of the cosmos. He understood astronomy's theoretical models to be realistic representations of nature. The chapter arrives at a conclusion about how humans could make realistic statements about such a distant part of God's creation, all the while acknowledging religious critiques of the Hellenistic natural philosophy upon which earlier Islamic astronomers had relied for a foundation for theoretical astronomy.

After the beginning of the second decade of the fourteenth century, the only major text that Nīsābūrī was certainly still writing was his *Qur'ān* commentary. Chapter 6 uses the *Qur'ān* commentary as a locus to examine how Nīsābūrī's commitment to God's omnipotence and his interest in astronomy came together. While Chapter 4 and Chapter 5 will show that science was a way for Nīsābūrī to appreciate the magnitude and order of God's creation, those commitments raise significant issues from Islamic intellectual history. For example, would not humans' abilities to develop confident scientific explanations undercut God's free choice? What value would scientific explanations have if God could invalidate human understanding by performing miracles at any time? Conversely, if scientific explanations were not correct in any absolute sense, then what confidence could humans have that their study of science enabled them to grasp accurately God's glory? Finally, could the study of astrology yield actionable knowledge about how God operated? Chapter 6 investigates Nīsābūrī's positions on those issues and shows that he defended the epistemological power of science in a *Qur'ān* commentary. After all, Nīsābūrī's work on theoretical astronomy found that theoretical astronomy could arrive at meaningful conclusions about reality. Chapter 6 explains how Nīsābūrī brought that work in science to bear on his interpretations of the *Qur'ān*.

Much of the book focuses on the theme of study as a way to better appreciate the magnitude of God's work and to understand aspects of God's control over creation. Only in certain portions of Nīsābūrī's *Qur'ān* commentary that attempted to uncover the *Qur'ān*'s esoteric meaning does one find explicit discussion of the impact of all this knowledge on one's personal relationship with God. Chapter 7 is devoted to the overriding theme of those portions of Nīsābūrī's *Qur'ān* commentary and asks the following questions: How might one attain proximity to God? In general this could occur through one's being suffused with divine light or by one's soul separating itself from the body. Were there things humans could do to

acquire God's light and/or to facilitate the soul's separation, or were these things more dependent on God's grace? To what extent was God's light a metaphorical concept? What types of *ṣūfī* (mystic) practices were important to Nīsābūrī? Most important, how did this mystical separation of the soul from the body derive from Hellenistic motivations for the study of philosophy? In the esoteric portions of Nīsābūrī's *Qur'ān* commentary, which date from the latter part of his career, we see how the power of God's light as a way for God to exert control (an idea drawn from the *Qur'ān*) has become intertwined with the soul's salvation through separation from the body (an idea whose complex history involves Hellenistic philosophy.) The Islamic and Hellenistic intellectual traditions that Ṭūsī worked so hard to harmonize are the main components of Nīsābūrī's ideas about how to attain proximity to God.

The most important conclusions I will draw in Chapter 7 about Nīsābūrī's career have their immediate locus in mystical and theological ideas. Nevertheless, one cannot understand Nīsābūrī's argument for those conclusions without following his entire career chronologically.

This book's central argument about how humans understood a potentially inscrutable and certainly all-powerful God addresses the role of science in a tradition of religious scholarship. This book is also the first chronological account of Nīsābūrī's career and the first in-depth analysis of his scientific work. Three appendices provide additional information on the chronology of his writings and the technical aspects of his science. Appendix A is an essay explaining how I determined the chronological order of Nīsābūrī's major works. Appendix B is a more detailed presentation of the material in Chapter 2 on observational astronomy. Appendix C is a more detailed presentation of the material in Chapter 5 on theoretical astronomy. Originally, I had hoped to integrate the contents of these appendices into the main text, but found that too many chapters were trying to do too much and thereby distracting the reader from the book's central argument. Appendices B and C contain especially technical material and I did not want to make comprehension of technical astronomy a requirement for following the book's broader argument.

We move now into Chapter 1, an account of the history of Nishapur, Nīsābūrī's home town, in the thirteenth century and a reconstruction of Nīsābūrī's early education. Chapter 1 presents the context and beginnings of a career that integrated *tafsīr*, *kalām*, *fiqh*, astronomy, and astrology.

1

RECONSTRUCTING NĪSĀBŪRĪ'S EARLY EDUCATION

Nishapur during Nīsābūrī's early years

In Nishapur, probably around 1270, al-Ḥasan ibn Muḥammad ibn al-Ḥusayn Niẓām al-Dīn al-Aʿraj al-Nīsābūrī was born to a Shiite family that came originally from Qom, in what is now Iran.[1] Nishapur[2] was the principle town of the province of Khorasan (in present-day Iran) and it enjoyed an illustrious history during the early centuries of Islam through the eleventh century that has attracted the attention of modern scholars.[3] The Seljuqs made Nishapur their first capital, and it benefitted from irrigated agriculture and trade.[4] With an earthquake in 1145, plunder by the Ghuzz in 1154–5, and then another earthquake in 1209, the city's fortunes went into a decline. The Mongols' 1221 invasion sealed Nishapur's fate; it never regained its earlier prominence.[5] Among subsequent tragedies, Nishapur was devastated by an earthquake in either 1268 or 1270, and then by another in 1280, in which 10,000 reportedly died.[6] If it was not the dominant city that it once had been, it nevertheless remained a center of culture. It continued as a site of mints for Mongol currency from 660 AH (1261–2) until 703 AH (1303–4).[7] In the fourteenth century, Ibn Baṭṭūṭa would praise its numerous schools and report that the city was called "Little Damascus" due to its gardens, water, fruits, and beauty.[8]

The Mongol invasions shocked the Islamic world at the time. Exaggerated death tolls in the histories written at the time reflect the momentousness of the Mongol conquests.[9] As the Mongols were non-Muslims, the rapidity and ease of the conquests challenged Islamic conceptions of history.[10] Chingiz Khān (Gengis Khan), enthroned in 1206, attacked Transoxiania in 1219, and by 1221 controlled all of Khorasan, including Nishapur. After conquering much of Central Asia, Chingiz Khān returned to Mongolia and died in 1227. Chingiz Khān's son Toluy was in charge of subduing Khorasan. Chingiz Khān's grandson Hülegü, the father of the Ilkhanid successor dynasty to Chingiz Khān, conquered Baghdad in 1258.[11] Nishapur became a provincial capital, ruled by Ilkhanid governors. Military defeats at the hands of the Mamlukes meant that the Mongols would not expand to the west after 1260.[12]

When Hülegü died in 1265, he was succeeded by his son Abaqa (r. 1265–82). Abaqa was succeeded by Tegüder Aḥmad (1281–4), Arghūn (1284–91), Geikhatu (d. 1295), and Ghāzān (1295–1304). During the early part of Nīsābūrī's lifetime, the viceroy of Khorasan was Arghūn (d. 1291), who, due to his interest in science, made the acquaintance of Nīsābūrī's teacher Quṭb al-Dīn al-Shīrāzī.[13] Due in part to the shared Mamluke foe, the Ilkhanids enjoyed relations with the popes,[14] and Ghāzān's son Öljaytü (1304–16) was baptized before converting to Islam.[15] Indeed, before Ghāzān converted to Islam, Buddhism was the only other religion besides Christianity that had any success against the background of the Ilkhanids' Shamanism.[16] The Mongols' less than wholehearted embrace of Islam did not sit well in Islamic sources.[17]

Of all the actions that the Ilkhanid Mongols took, the one that was most important for facilitating the intimate connection between science and religion characteristic of Nīsābūrī's career occurred, most likely, before his birth. It was the construction of the observatory at Marāgha (near Tabriz) in Azerbaijan soon after Hülegü's conquest of Baghdad.[18] Hülegü, who patronized scientists, granted his advisor, the scientist, theologian, jurist, and philosopher Naṣīr al-Dīn al-Ṭūsī (d. 1274), the post of minister. Ṭūsī became the director of the observatory and staffed it with scientists from as far away as China. In a notable step, Ṭūsī used income from a religious endowment, a *waqf*, for the observatory.[19] Ṭūsī's financial maneuver reflected an acceptance of science as an area of study fit for a religious scholar and Ṭūsī became a figure of immense importance in Nīsābūrī's intellectual development. Ṭūsī was Nīsābūrī's intellectual grandfather, the teacher of Quṭb al-Dīn al-Shīrāzī (d. 1311), Nīsābūrī's best-known teacher. The observatory endured after Ṭūsī's death and Ghāzān had hoped to build an even better one near Tabriz.[20] Marāgha facilitated the scientific work of these scholars who were also adept in religious matters.

As the story of Nīsābūrī's intellectual development unfolds, he will take a place within a then-emerging tradition of religious scholarship that nevertheless accepted knowledge, such as science and philosophy, that had its origins in earlier, non-Islamic civilizations. Linking this tradition of religious scholarship to any one sect or intellectual tradition of Islam would be inappropriate. Öljaytü's own religious vacillations ensured that a variety of religious ideas circulated at the Ilkhanid court.[21] Nīsābūrī's own work contained references to the various currents present in that intellectual ferment.

Different areas of scholarship: Islamic sciences and philosophical sciences

Inasmuch as in this book I try to identify themes common to different areas of Nīsābūrī's scholarship, I obviously assume a distinction between religious

studies on one hand and science and philosophy on the other. More specifically, I assume that one should distinguish the traditional, Islamic sciences and their ancillaries, from the philosophical sciences that had origins in earlier civilizations. This division was neither rigid nor immutable; I introduce it in order to bridge it later in the book. The Islamic sciences were disciplines such as *Qur'ān*, *Sunna*, and Islamic jurisprudence (*fiqh*), that focused on and built upon Islam's revelations.[22] Sciences propaedeutic or ancillary to the Islamic sciences, such as Arabic grammar and lexicography, which Ibn Khaldūn (d. 1407) termed the Arabic sciences, assisted the scholar in absorbing the Islamic sciences. The philosophical sciences (e.g. astronomy, philosophy) originated in the pre-Islamic civilizations of ancient and Hellenistic Greece, India, and Persia. Greek, Sanskrit, and Pahlavi texts were first translated into Arabic during the Umayyad Caliphate and in great quantities during the Abbasid Caliphate.[23] The standing of the Islamic sciences and their ancillaries, due to their centrality in religious scholarship, was more secure than that of the philosophical sciences, and the first step of Nīsābūrī's career was the study of Arabic and the *Qur'ān*. But those first steps in the Islamic sciences would be essential for his later achievements in all areas of learning.

Reconstructing Nīsābūrī's early education to 1300

Nīsābūrī provided only a few sentences in his magisterial *Qur'ān* commentary (*Gharā'ib al-Qur'ān wa-raghā'ib al-furqān* [GQ hereafter]) regarding the place of the memorization of the *Qur'ān* in his early education. The bio-bibliographical sources say nothing on this topic. The rest of this chapter thus depends on what we can deduce and infer from the contents of his work. In order to reconstruct Nīsābūrī's early education, we need to define when it could have occurred. Nīsābūrī's earliest work with a certain date of completion is his commentary on Ṭūsī's recension of the Arabic translations of Ptolemy's (fl. ca. 125–50) *Almagest*,[24] entitled *Sharḥ Taḥrīr al-Majisṭī* (*The Commentary on the Recension of the Almagest*).[25] This text is very helpful for reconstructing Nīsābūrī's early education.[26] Astronomers had translated the *Almagest* into Arabic by the beginning of the ninth century, and it proved to be the most influential Greek text for Islamic astronomers. Two different Arabic translations survive, and there is evidence for two others.[27] *Sharḥ Taḥrīr al-Majisṭī* was a commentary on Ṭūsī's recension (*Taḥrīr*) of the *Almagest* translations of Ḥajjāj and Ishāq-Thābit.[28] Nīsābūrī completed his *Sharḥ Taḥrīr al-Majisṭī* in 1305. Fortunately, all of the MSS that I examined, including the Tunis autograph MS, provide colophons for the end of each chapter. Because Nīsābūrī completed the first chapter on the second of *Jumādā al-ākhar* of 703 AH (January 11, 1304), I define the period of Nīsābūrī's early education to cover the period from his birth to 1300, by which point he must have begun to study the *Almagest*. Therefore, the

contents of the earliest chapters of *Sharḥ Taḥrīr al-Majisṭī* reveal much about what Nīsābūrī would have had to have learned before beginning to study the *Almagest* in any serious depth.

Early education in the Islamic sciences

Nīsābūrī hailed from what is now Iran; there is no evidence that he was a native speaker of Arabic. In order to compose a commentary on the recension of the Arabic translations of the *Almagest*, he would have had to learn Arabic. Translations from Arabic into Persian did eventually occur,[29] but the most important texts in all of the philosophical sciences, both in general and for Nīsābūrī's own education, were in Arabic. Proficiency in Arabic was also fundamental for anyone interested, as Nīsābūrī was, in religious texts.[30] Arabic instruction commenced with Arabic script and with the memorization of the *Qur'ān*, a prerequisite for further educational advancement. Nīsābūrī noted, at the beginning of GQ, that he had been studying the *Qur'ān* since his youth (*min ibbān al-ṣabā*), and had memorized it early on. He pursued, he added, knowledge of the meanings of the text.[31] Further proficiency in Arabic would be necessary not only to pursue the traditional subjects of law, *tafsīr* (exegesis of the *Qur'ān*), and *kalām* (speculation into the nature of God), but also to study the philosophical sciences.

Nīsābūrī mastered two texts on Arabic language well enough to compose commentaries on them. The first, and the one which led to Nīsābūrī's well-known commentary (*Sharḥ al-Shāfiya*), was *al-Shāfiya* of Ibn al-Ḥājib (d. 1249). This was a text on morphology. He most likely composed this text sometime after 1307–8.[32] The second text on Arabic that Nīsābūrī mastered was *Miftāḥ al-'ulūm* (*The Key of the Sciences*) of al-Sakkākī (d. 1229), whose title itself advertised the importance of Arabic rhetoric to other fields of knowledge.[33] His commentary on this text he likely composed after 1304, and, in fact, after 1311, because Shīrāzī did not complete his own commentary on *Miftāḥ al-'ulūm* until 1301.[34] Within those texts, Nīsābūrī evinced familiarity with *al-Kitāb* (*The Book*) of Sībawayhi (d. ca. 796), an early text on Arabic grammar which owed its existence, in part, to the need for non-Arab bureaucrats to learn Arabic.[35]

GQ contains clues not only for why Nīsābūrī began to study Arabic, but also for why he began to study the philosophical sciences. GQ incorporates a great deal of material adopted from *Shāfi'ī* jurisprudence and *Ash'arī kalām*, traditions typically associated with Sunni Islam. By the eleventh century, the *Shāfi'ī madhhab* (school) with its adoption of some *ṣūfī* practices, had become a strong presence in Nishapur.[36] In this book, I will argue that trends in the development of *Ash'arī kalām* led Nīsābūrī to the study of science.[37]

If this is true, questions about Nīsābūrī's religious allegiances arise. Nīsābūrī's family had roots in Qom, a town well known for being almost

wholly Shiite before Nīsābūrī's time, and references to Nīsābūrī sometimes include the additional component *al-Qummī*.[38] The Shiite bio-bibliographical literature latched onto his family's history as prime evidence for his Shiite allegiances, his *tashayyuʿ*. Chapter 3 will explore the nuances of his *tashayyuʿ* in greater depth. But whatever the extent of his *tashayyuʿ*, Nīsābūrī would rarely take partisan Shiite positions. A recent study of an eleventh-century Sunni *tafsīr* from Nishapur has shown that Sunnis, too, could coopt Shiite arguments supporting Shiite political positions, and hence there is some risk in attaching too much significance to categories of Sunni and Shiite in the course of our analysis of Nīsābūrī's career.[39] But because the prime source for GQ was the work of Fakhr al-Dīn al-Rāzī (d. 1210), a *Shāfiʿī* who took *Ashʿarī* positions, we should look to the history of *Ashʿarī kalām* for an explanation, in addition to intellectual interest, of why Nīsābūrī would have had to study science.[40]

The Islamic science of *kalām*[41]

The incorporation of science into a tradition of Islamic religious scholarship, which began by the end of the twelfth century, is a hallmark of Nīsābūrī's career. Although Nīsābūrī's considerable achievements as a scientist must have been due in part to personal interest—and were certainly due to changes in the discipline of astronomy—science and natural philosophy were generally coming within the purview of *kalām*, a science that was Islam's closest analogue to speculative theology.[42] *Kalām* originated in the eighth century in inter-communal discussions and in questions over free will and predestination.[43] Whatever *kalām*'s beginnings, it eventually shed any resemblance it may have had with apologetics.[44] Description of *kalām* as apologetics pays no attention to the significant portions of *kalām* texts that had nothing to do with "theological" issues.[45] In fact, by the ninth century, certain *mutakallimūn* (practitioners of *kalām*) had created a competing atomist theory of matter that vied with the physics of the philosophers in the Hellenistic tradition, the *falāsifa*.[46] Ibn Khaldūn (d. 1407) would note that *falsafa* and *kalām* had become inextricable.[47]

At the time Nīsābūrī wrote, Ibn Sīnā (d. 1037) was the best-known exponent of *falsafa*, thanks to Ghazālī's *Maqāṣid al-falāsifa* (*The Intentions of the Philosophers*). We will see that every statement about the natural world that Nīsābūrī attributes to the *falāsifa* can be found in Ibn Sīnā's *Kitāb al-Shifāʾ* (*The Healing*). Regarding the matter of the terrestrial realm, the *falāsifa* argued that nature was composed of four elements which were earth, air, fire, and water. Elements could not be further differentiated. Each element had its own particular characteristics. Fire was fire because it was hot and dry; water was water because it was cold and damp.[48] Moreover, according to the *falāsifa*, God created certain inherent tendencies in each element. For example, fire tended to rise up and away from the center of the

universe. When flames rose up, they did so naturally because they were flames. Or, when a clump of soil fell down, it did so because soil was composed of earth which tended towards the center of the universe. Although the first cause of the earth's downward motion was God, the secondary cause was the tendency of earth to fall.

Concerns about the implications of *falsafa* for a religious worldview led the *mutakallimūn* to expand the territory of *kalām*. The *mutakallimūn* proposed an alternative conception of terrestrial matter because the presence of an element as a secondary cause could infringe upon God's omnipotence. They argued that nature was composed of uniform atoms that did not exist without the accidents that God conferred upon them at every instant.[49] By the twelfth century, because *kalām* could successfully refute the metaphysical claims of *falsafa*, the *mutakallimūn* no longer needed to adhere to the termino-logy of atomism, but could begin to coopt the terminology, argumentation, and subject matter of *falsafa*.

By the twelfth century, *kalām* had become a systematic investigation into the nature of God and into the cosmos, as the cosmos is God's creation.[50] Familiarity with *falsafa*, through the works of Ibn Sīnā (d. 1037), became part of the study of *kalām*. The figure who, more than any other, was a harbinger of this development was Ghazālī (d. 1111).[51] In *Deliverance from Error*, his intellectual autobiography detailing his escape from an epistemological crisis, Ghazālī noted that he had delved into the works of the *falāsifa*, and, as is often repeated, found their writings unsatisfying.[52] Not only did *falsafa* fail to answer the nagging questions that had led him to his crisis of faith in the first place, but he concluded that *falsafa* rested on premises that were harmful to religion. Ghazālī's *Tahāfut al-falāsifa* (*The Incoherence of the Philosophers*),[53] at the least, forced the reader to read *falsafa* with a critical mind. Ghazālī concluded *Deliverance* by saying that Sufism was the most effective way to gain knowledge of God.

Further reflection on Ghazālī's statements in *Incoherence* and *Deliverance* suggests that he inoculated religious scholars against selected claims of *falsafa*, but did not forbid the study of *falsafa* and science. He said, after all, in the introduction to *Incoherence*, that one would be wrong to deny all of science.[54] In that respect, two other points about Ghazālī's career are important. The first was that his earlier *Maqāṣid al-falāsifa* (*Intentions of the Philosophers*) showed that he, a luminary of religious scholarship, had achieved some mastery over the contents and argumentative methods of *falsafa*. Second, he allowed in *Deliverance from Error* that neither logic nor the truths of mathematics by themselves were especially harmful. The danger was only that studying mathematics and logic might lead the uninitiated to conclude that the other teachings of *falsafa* were as true as those of the revealed texts, which, to Ghazālī, would be disastrous.[55] Ghazālī's *Incoherence* should be seen as an attack on certain arguments of the *falāsifa*, and not as a wholesale rejection of *falsafa*.[56]

Ghazālī's work facilitated a co-mingling of *kalām*, *falsafa*, and science that we see in the work of Fakhr al-Dīn al-Rāzī. His *Qur'ān* commentary *al-Tafsīr al-Kabīr* (TK hereafter) would be the most important source for Nīsābūrī's GQ. The fact that *kalām* began to ask the same kinds of questions as *falsafa*, and that *mutakallimūn* organized their treatises to parallel *falsafa* texts, was a sign (to the *mutakallimūn* at the least) of the irrelevance of *falsafa*.[57] Critics of *kalām*, who saw *kalām* as part of a slippery slope into *falsafa* and consequent unbelief, propagated tendentious interpretations of Rāzī's purported deathbed repudiation of *kalām*.[58] In Rāzī's TK, in any case, *kalām* was alive and well. Besides the methods of *falsafa*, science, too, became part of the curriculum of *kalām* texts. Rāzī's works on theological metaphysics (*al-'ilm al-ilāhī*/*al-ilāhiyyāt*) *al-Maṭālib al-'āliya* and *al-Mabāḥith al-mashriqiyya* contained information about astronomy.[59] More important, Rāzī's TK included a lengthy excursus on astronomy sparked by Q2:164. Rāzī's excursus, while it did evince skepticism of astronomy's methodology (which will be a topic of the penultimate chapter of the book), was also intended to relate the reader's appreciation of God's creation to understanding the *Qur'ān*. Nīsābūrī's own comments in his earliest work on astronomy indicate that such a sense of wonder helped motivate his interest in astronomy throughout his career. The organization of Rāzī's excursus on astronomy in his *Qur'ān* commentary mirrored the organization of elementary summaries of astronomy.[60] Later elementary summaries of astronomy, in turn, referred to Rāzī on questions of natural philosophy.[61] A later text, Ṣadr al-Sharī'a's (d. 1347) three-part encyclopedia titled *Ta'dīl al-'ulūm* (*Equalization of the Sciences*), the three subjects of which were *fiqh*, *kalām*, and astronomy, represented a deepened relationship between *kalām* and astronomy.[62] In conclusion, many developments in *kalām* occurred as a result of its dialogue with the philosophical sciences. Expertise in *kalām* demanded a real familiarity with the philosophical sciences.

Nīsābūrī's early education in the foreign, philosophical sciences, particularly astronomy

The integration of science into religious scholarship was due not just to developments in *kalām*. Certain of the philosophical sciences had direct religious applications apart from *kalām*. In other cases, the inclusion of these foreign, philosophical sciences within a tradition of religious scholarship was the result of the evolution of these sciences themselves. Details of the foreign, philosophical sciences that Nīsābūrī would have studied to prepare to write *Sharḥ Taḥrīr al-Majisṭī* deserve attention for their role in the development of the intellectual tradition to which Nīsābūrī belonged. Of all the foreign sciences, mathematics, especially geometry and arithmetic, would be the easiest to justify within a tradition of religious education. Ghazālī famously remarked in *Deliverance* on the ineptitude of one who would criticize

these branches of mathematics. Like logic, mathematics was epistemologically certain.[63] The *mutakallimūn*'s skepticism about metaphysical inductions drawn from observations could not shake mathematics' conclusions.[64] Mathematics, too, had useful practical applications. Arithmetic (*'ilm al-ḥisāb*) was important for a variety of practical calculations and for astronomy.[65] Nīsābūrī would eventually write a popular text on arithmetic, *al-Risāla al-shamsiyya*, a.k.a. *al-Shamsiyya fī al-ḥisāb* (*The Solar Epistle on Arithmetic*).[66] He dedicated this text to Jamāl al-Dīn ibn Ibrāhīm ibn Muḥammad al-Ṭabasī.[67] More advanced branches of mathematics had other applications: algebra was useful for calculating inheritance shares and Nīsābūrī incorporated algebra into proofs in *Sharḥ Taḥrīr al-Majisṭī*; plane trigonometry (and conics) could be applied to calculating prayer times; and spherical trigonometry was important for determining the direction of Mecca.[68] Proficiency in mathematics was a *sine qua non* for the study of Ṭūsī's recension of Ptolemy's *Almagest*.

Geometry (*'ilm al-handasa*) was a separate discipline, important as well for the study of astronomy, in particular the proofs in Ptolemy's *Almagest*. Geometry was relevant to the construction of instruments.[69] Ṭūsī, in 1248, completed a recension of the Arabic translations of Euclid's *Elements*, the most important text for geometry.[70] Nīsābūrī cited Ṭūsī's recension of the *Elements* in the first book of *Sharḥ Taḥrīr al-Majisṭī* and throughout the rest of *Sharḥ Taḥrīr al-Majisṭī*.[71] Mathematics, then, was not only unobjectionable, but also a philosophical science that could serve religious ends.

The inclusion of material on astronomy in religious texts was facilitated by developments in the history of Islamic astronomy and astrology. From the end of the eighth century through the eleventh, Islamic astronomy consisted primarily of updating the parameters and improving computations inherited first from India and then from Greece. Islamic astronomers pointed out and analyzed physical inconsistencies in the earliest translations. Islamic astronomers in those early centuries studied two types of texts. First, they studied Arabic translations of Ptolemy's *Almagest* and the texts derived from them. Second, they studied the astronomical handbooks (Arabic *zīj*, pl. *azyāj*/*zījāt*),[72] handbooks accompanied by tables of planetary positions (and other information), similar in arrangement to Ptolemy's *Handy Tables*, but relying, as well, on Indian and Persian antecedents.[73]

Aside from some components of the *azyāj*, Islamic astronomers, despite their precision and insight, were still operating fundamentally within the Hellenistic Ptolemaic paradigm during this period.[74] Islamic astronomy had yet to change on a theoretical level in a way that would facilitate (a) its greatest achievements, (b) a genre of non-technical introductory summaries of astronomy that might suit a religious scholar,[75] and (c) astronomy's inclusion in religious texts.

But in the eleventh century, the religious criticism leveled upon particular aspects of the foreign sciences became increasingly vehement. Astrology at

times postulated the planets as independent causes and transmitted *falsafa*'s theory of the elements.[76] Those principles, as Ghazālī remarked, offended those concerned with God's omnipotence. Astronomy, primarily because of its association with astrology, was maligned. Simultaneously, scientists' critiques of Ptolemaic cosmology and planetary theory intensified; the most famous proponent of such critiques was Ibn al-Haytham (d. ca. 1040).[77] Islamic astronomers began to propose new theories for planetary motion to take the place of those of Ptolemy, which were deemed to be philosophically and observationally flawed.[78] The result was the flourishing of a theoretical astronomy with no ties to astrology, and few explicit ties to *falsafa*, and which thus encountered few obstacles to its incorporation into religious texts.[79]

Ibn al-Akfānī's (d. 1348) treatise *Irshād al-qāṣid ilā asnā al-maqāṣid* best described the state of the discipline of astronomy as Nīsābūrī knew it. Astronomy was known as *'ilm hay'at al-aflāk* (*'ilm al-hay'a* for short), literally "science of the configuration of the orbs," and Ibn al-Akfānī divided it into four basic courses of investigation.[80] The first was the orbs as a whole, their arrangement with respect to each other, and demonstrations that they move while the earth is stationary. The second area involved celestial motion. Activities in this area included proving the sphericity of the celestial motions, calculating the motions of the planets through the zodiac, and computing eclipses. The third broad area of study was geography, with particular attention to the earth's inhabited and uninhabited portions. These first three areas together comprised the study of phenomena arising from the daily motion of the heavens about the earth. The fourth area involved the computation of planetary sizes and distances.

Applied aspects of astronomy were classified by Ibn al-Akfānī under wholly separate headings including *'ilm al-mawāqīt* (religious timekeeping), *'ilm al-ālāt al-ẓilliyya* (science of shadow instruments [e.g. sundials]), and most significantly *'ilm al-zījāt wa-'l-taqāwīm* (the science of astronomical handbooks and calendars).[81] I will return to such details of practical astronomy later in the book. Texts on *'ilm al-hay'a* can be classed into two broad categories. An example of the first category would be Ptolemy's *Almagest* which used geometrical techniques to construct models that would reproduce available observations. Ibn al-Akfānī incorrectly attributed to Ibn al-Haytham's criticisms which I just introduced (and to which I will return in Chapter 5 and Appendix C), a new genre of *hay'a* literature.[82] These newer *hay'a* texts summarized the findings of the *Almagest* without the geometrical proofs, but with an emphasis on the physicality of the orbs. Chapter 5 will show that *hay'a basīṭa* texts would in the end advance beyond the sophistication of texts written in the tradition of the *Almagest*. *Hay'a* texts received special attention at the Marāgha Observatory that Hülegü constructed.

To conclude, the study of an elementary, non-technical summary, perhaps within the context of *kalām* or *tafsīr*, probably piqued Nīsābūrī's

interest for subsequent study of astronomy. These were the elementary summaries upon which the excursus on astronomy in TK was based. Next, Nīsābūrī would have turned to the examination of the observations and geometrical proofs, found in the *Almagest*, that underpinned the physical models which the *'ilm al-hay'a* summaries presented. The first two chapters of the *Almagest* would call Nīsābūrī's attention to the mathematical prerequisites for the serious study of the *Almagest*. At this point, Nīsābūrī would have commenced his earliest text with a known date, *Sharḥ Taḥrīr al-Majisṭī*.

The institutional context of Nīsābūrī's early education

This chapter has so far used trends in Islamic intellectual history to place Nīsābūrī's earliest education within a religious intellectual tradition. We can begin to answer the question of the institutional context of Nīsābūrī's career by investigating the relationship of Nīsābūrī's scientific work to, in particular, intellectual traditions fostered in the *madrasa*. The *madrasa* was (and to some extent remains) a foundation for the study of Islamic law, an institution some consider to be the most significant locus for intellectual life in pre-modern Islam.[83] Makdisi argued that study of the foreign, philosophical sciences was not widespread in the early *madrasa*.[84] But Makdisi's paradigm that the *madrasa* was the focal point of medieval Islamic education[85] has been criticized and modified. Jonathan Berkey stressed several times in *The Transmission of Knowledge in Medieval Cairo* how education centered on the student–teacher relationship and was never restricted by any institutional mechanism.[86] Even Makdisi stressed the informal character of *madrasa* education, particular in comparison to the West. Education was centered more around the student–teacher relationship than the institution itself; no course catalogue or schedule of study from a *madrasa* of Nīsābūrī's era has ever been found. Michael Chamberlain has gone so far as to argue for the *madrasa*'s peripherality, and pointed out that sometimes shaykhs gained prestige by refusing posts in a *madrasa*.[87] What both Berkey and Chamberlain have acknowledged through their criticisms of Makdisi is that, at some point, organized religious learning did take place in *madrasa*s and that there must have been texts that students read in a certain order. They also have accepted implicitly that there was some type of religious scholarly tradition associated with *madrasa*s.

Makdisi tried to deduce a standard curriculum, a curriculum in which science was marginalized, on the basis of *waqf* deeds (*waqfiyyāt*).[88] To do so, Makdisi had to assume a perfect correlation, a correlation that was too rigid, between the *waqfiyya*'s stipulations for instruction and the instruction that actually occurred in the *madrasa*.[89] Any association of Nīsābūrī's texts with the *madrasa* would certainly demonstrate these texts' inclusion in a tradition of religious scholarship even if instruction in the philosophical sciences was not specified in the *waqfiyya*.[90] If we can document the use of

Nīsābūrī's work within *madrasa*s, we have further justification for examining how science was integrated into a tradition of religious scholarship.

Direct evidence for Nīsābūrī's work being studied in a *madrasa*

The best evidence for the study of Nīsābūrī's scientific works within a *madrasa* comes from direct reports, like that of the astronomer Fatḥ Allāh Shirvānī (d. 1486). Shirvānī mentioned, in the introduction to his commentary on Naṣīr al-Dīn al-Ṭūsī's *al-Tadhkira fī 'ilm al-hay'a* (*Memoir on Astronomy*), that he studied the *Tadhkira* with Nīsābūrī's commentary on it under the supervision of Qāḍī Zādah Rūmī (d. 1436) in Ulugh Beg's *madrasa* in Samarkand.[91] Shirvānī's report is substantiated by a letter written by a mathematician contemporary with Shirvānī, Jamshīd al-Kāshī (d. 1429). Kāshī reported to his father that he had studied the *Tadhkira* with Nīsābūrī's commentary in Samarkand.[92] Kāshī also noted the presence of Qāḍī Zādah Rūmī (the author of a gloss on *Sharḥ Taḥrīr al-Majisṭī* in addition to the most famous commentary on Jaghmīnī's [first half of the thirteenth century] *Mulakhkhaṣ*) as the foremost master of astronomy there, the existence of a *madrasa*, and the presence of study-circles (*ḥalaq*)[93] on astronomy. Kāshī did not specify that the study of astronomy took place within the *madrasa* itself.[94] Still, Kāshī's letter suggested that Shirvānī's personal experience was not isolated.

If others of Nīsābūrī's works were studied in a *madrasa*, their study might encourage students to read his scientific texts. According to an early twentieth-century Shiite scholar, Muḥsin Amīn (d. 1952), Nīsābūrī's commentary on morphology, *Sharḥ al-Shāfiya li-'bn al-Ḥājib* was still studied during his own early education at the end of the nineteenth century in Najaf, Iraq.[95] A study of the *madrasa*s of nineteenth-century Najaf mentions that there were scholars in those *madrasa*s who specialized in astronomy.[96]

I have not found a direct report of GQ, Nīsābūrī's only other printed work, being studied within a *madrasa*. Nevertheless, all of the bio-bibliographical sources on Nīsābūrī which I have examined presented him primarily as a *Qur'ān* commentator, found him squarely within the tradition of Rāzī (d. 1210), and never questioned Nīsābūrī's ideas or approach. The *tafsīr*'s subject matter alone would theoretically render the *tafsīr* suitable for study within a *madrasa*. Perhaps the best piece of evidence for the positive reception of GQ was its publication in the margins of Ṭabarī's *Jāmi' al-Bayān*, in the 1992 Beirut *Dār al-ma'rifa* edition, a reprint of the 1905–6 Cairo edition and one central to serious study of the *Qur'ān* and Islamic law.

Evidence for the presence of Nīsābūrī's science texts in *madrasa* libraries

The most important indirect evidence for the study of Nīsābūrī's scientific texts in a *madrasa* is the presence of Nīsābūrī's works on astronomy and

astrology in the libraries that were attached to *madrasa*s and mosques. One can glean this information from the flyleaves of MSS.[97] The mere presence of these MSS in these libraries means that they were deemed suitable for inclusion in such libraries, but does not prove conclusively that the texts were ever studied in a particular mosque or *madrasa*. Still, Makdisi did not dismiss the possibility that the presence of these books in the *madrasa* library might encourage the possibility of their being taught, either in the *madrasa* or externally.[98]

By the end of the fourteenth century, the rulers of the Deccan had begun to establish *madrasa*s, and a member of that line, Fīrūz Shāh Bahmānī, was an enthusiast of astronomy and natural philosophy.[99] We have a report that reads: "Mīr Faḍlullah Anjū (14th–15th c.) – the instructor of the young Fīrūz Shāh Bahmānī – is said to have introduced in Deccan Niẓāmuddīn 'Araj's [i.e. Nīsābūrī's] Commentary on Tadhkirah . . . It is also reported that Sulṭān Fīrūz Bahmānī used to lecture thrice a week on a commentary of Tadhkirah, al-Ṭūsī's *Taḥrīr al-Uqlidis* (recension of Euclid's Elements) besides other textbooks of natural philosophy."[100] Unfortunately, that report did not specify where Fīrūz Shāh Bahmānī lectured on the *Tadhkira*, or which commentary he used. Certainly, though Nīsābūrī's *Tawḍīḥ* was the most popular commentary on the *Tadhkira* until Jurjānī (d. 1413) wrote. By the middle of the eighteenth century, introductory summaries of astronomy had become part of a prescribed *madrasa* curriculum in India.[101]

Sharḥ Taḥrīr al-Majisṭī was written with a student in mind; the text frequently presented multiple proofs for the same proposition. The most noteworthy example is the multiple demonstrations spurred by Ṭūsī's exposition of the model for Venus. Ṭūsī's text explains that sides of a figure "are known either through algebra (*al-jabr wa-'l-muqābala*) or by a different way through the geometrical method (*al-ṭarīq al-handasiyya*)."[102] Ṭūsī summarized the geometrical proof without elaborating on the algebraic demonstration to which he alluded. Nīsābūrī, however, chose also to provide the details of the algebraic proof, indicating that he was writing for a less-skilled reader.[103]

As far as Nīsābūrī's own lifetime is concerned, religious institutional support of science continued in Ilkhanid Iran after Ṭūsī's death. We already know that Hülegü had placed Ṭūsī in charge of the *waqf* endowment for the Marāgha observatory, and Ṭūsī's sons retained control of the observatory *waqf* past the beginning of the fourteenth century.[104] The Ilkhanid sultan Ghāzān founded a complex at Sham, a suburb of Tabriz. Ghāzān's complex included two *madrasa*s (one *Shāfi'ī* and one *Ḥanafī*) and an observatory.[105] Revenues from a *waqf* endowment supported the observatory[106] and provided for a teaching staff there.[107] While *waqf* deeds are not necessarily a record of what actually transpired in a *madrasa*, these *waqfiyyāt* would have reflected Ghāzān's intentions and we will see that the Ilkhanid Sultan's ministers patronized Nīsābūrī and Shīrāzī.[108]

On the basis of the direct and indirect evidence, then, it seems that works of astronomy, including those of Nīsābūrī, were studied in *madrasa*s. The reactions of later scholars to Nīsābūrī's writings on astronomy attested to their quality and popularity. Such laudatory remarks are found in super-commentaries on Nīsābūrī's works, as well as in later texts not devoted to Nīsābūrī's compositions.[109] His epithet was always *al-shāriḥ* (the commentator), which reflected his works' wide circulation and their ability to render technically sophisticated points accessible to beginners.[110]

Conclusion

We have seen, now, that Nīsābūrī's earliest education was within an intellectual tradition of religious scholarship, and that a wide range of Nīsābūrī's texts were associated with the institution of the *madrasa*. Nīsābūrī's integration of scientific and religious concerns, which shall unfold in the following chapters, was a natural outgrowth of his circle of teachers and patrons at the Ilkhanid court and the institutions that they founded. This chapter's evidence for Nīsābūrī's opus being studied in a tradition of religious scholarship that included astronomy is the starting point for the rest of the book about the role of science in his religious thought. Chapter 2 investigates the period of his life from the beginning of the composition of *Sharḥ Taḥrīr al-Majisṭī*, around 1300, until his 1304 journey from Khorasan to Azerbaijan which he mentioned in the colophon of Book Five of *Sharḥ Taḥrīr al-Majisṭī*. The need to appreciate God's work, a strong justification for the inclusion of astronomy in *kalām* texts (and GQ and TK) would be an important motivation[111] for Nīsābūrī's early work on astronomy.

2

NĪSĀBŪRĪ'S EARLY SCIENTIFIC THOUGHT

After presenting a brief history of Nishapur and Khorasan in the thirteenth and early fourteenth centuries, Chapter 1 provided a hypothetical reconstruction, on the basis of GQ and the first five chapters of Nīsābūrī's *Sharḥ Taḥrīr al-Majisṭī* (*Commentary on the Recension of the Almagest*), of the contents of Nisaburi's early education. The history of *kalām*, and Islamic philosophy and science, was a reflection of how all these fields (along with *tafsīr* and *fiqh*) had begun to coalesce into a broad tradition of religious scholarship that was the locus for Nīsābūrī's early training. Now, Nīsābūrī's own texts shall speak more directly as to the role science played in this tradition of religious scholarship. This chapter focuses on *Sharḥ Taḥrīr al-Majisṭī*, Nīsābūrī's earliest text that can be dated.

By the time Nīsābūrī began to write *Sharḥ Taḥrīr al-Majisṭī*, his commentary on Ṭūsī's recension (*Taḥrīr al-Majisṭī*) of the Arabic translations of Ptolemy's *Almagest*, Nīsābūrī had encountered other seminal texts of Ṭūsī. Nīsābūrī referred to Ṭūsī's best-known work of astronomy, the *Tadhkira*, as early as Book Two of *Sharḥ Taḥrīr al-Majisṭī*.[1] Ṭūsī's demonstrable influence on Nīsābūrī was not confined to scientific matters. In the first chapter of the first book of *Sharḥ Taḥrīr al-Majisṭī*, Nīsābūrī referred to another text, *Sharḥ al-Ishārāt wa-'l-tanbīhāt* (*The Commentary on Pointers and Admonitions*), itself a commentary on Ibn Sīnā's (d. 1037) *al-Ishārāt wa-'l-tanbīhāt* (*Pointers and Admonitions*).[2] The *Ishārāt* was a work in the genre of metaphysics (*ilāhiyyāt*),[3] and Ṭūsī completed his commentary on the *Ishārāt* in 1246 at the request of Muḥtasham Shihāb al-Dīn. Ṭūsī's commentary rebutted many of the critiques of Ibn Sīnā found in Fakhr al-Dīn al-Rāzī's (d. 1210) earlier commentary on the *Ishārāt*, entitled *Lubāb al-Ishārāt* (*The Pith of the* Ishārāt).[4] Both Rāzī's *Lubāb al-Ishārāt* and Ṭūsī's *Sharḥ al-Ishārāt* were indications of how certain positions in philosophical debates came to have religious ramifications and of how *kalām* encroached on the terrain of *falsafa*.[5] Nīsābūrī's reference to *Sharḥ al-Ishārāt*, on its own, shows that Nīsābūrī's education included, by 1300, *falāsifa* (Ibn Sīnā)

and thinkers, such as Fakhr al-Dīn al-Rāzī, who wrote on *kalām* and who accepted many of the *mutakallimūn*'s positions.

There is, to my knowledge, no secondary literature on *Sharḥ Taḥrīr al-Majisṭī*; the text itself remains unedited. In order to understand how religious scholarship motivated Nīsābūrī's earliest interest in science, one needs a survey of the relevant contents of *Sharḥ Taḥrīr al-Majisṭī*. Due to this need for an introduction to his scientific thought, this chapter will summarize the relevant scientific material from *Sharḥ Taḥrīr al-Majisṭī*, mostly from the first five books completed before Nīsābūrī's 1304 trip to Azerbaijan. Readers interested in an in-depth, technical presentation of the same material should see Appendix B. Subsequently, the chapter will address the religious motivations for Nīsābūrī's earliest study of astronomy and the significance of this material from *Sharḥ Taḥrīr al-Majisṭī* for broader themes in his intellectual biography.

The science upon which Nīsābūrī depended for *Sharḥ Taḥrīr al-Majisṭī*

The *Almagest* (Ar. *al-Majisṭī*), the text upon which *Sharḥ Taḥrīr al-Majisṭī* ultimately depended, was the best-known work of the Hellenistic astronomer Ptolemy (fl. 125–50 CE). The *Almagest* derived, from observations, geometric models of the heavens.[6] According to the *Almagest*'s presentation, these models were two-dimensional: the planets' motions were represented by combinations of circles. In Ptolemy's (and Nīsābūrī's) lifetime, scientists believed the cosmos to be composed of nesting three-dimensional orbs (hollowed-out spheres).[7] Thus, a component of a recent scholarly debate was the question of whether Ptolemy intended his models to be simplifications of physical orbs, or not.[8] According to the latter view, Ptolemy would not have intended the circles to be a shorthand for a real cosmos of physical orbs; the two-dimensional models would be simply a means of calculating and predicting planetary positions.[9] At any rate, Islamic astronomers, including Nīsābūrī at this point in his career, were certainly considering a three-dimensional interpretation of the *Almagest*'s models.[10] Broadly speaking, Nīsābūrī was very concerned with how *Sharḥ Taḥrīr al-Majisṭī* portrayed the cosmos (that God created).

The *Almagest* was a classic of scientific exposition drawing on a wide range of observations of planetary motions. *Sharḥ Taḥrīr al-Majisṭī* was not a direct commentary on the Arabic translations, but rather a commentary on Ṭūsī's recension (*Taḥrīr al-Majisṭī*) of the al-Ḥajjāj and Isḥāq ibn Ḥunayn/Thābit ibn Qurra Arabic translations of the *Almagest*.[11] Ṭūsī completed *Taḥrīr al-Majisṭī* in 1247 while in residence at the *Ismā'īlī* Assassin stronghold in Alamut.[12] Ṭūsī's recension also abbreviated some of the demonstrations and, at times, included new observational data and provided new theoretical

insights.[13] In particular, Ṭūsī devised a new, innovative mechanism to account for certain planetary motions, and that mechanism was part of the beginning of a series of theoretical innovations that continued in Islamic astronomy into the sixteenth century.[14] A comparison of the number of surviving MSS of Ṭūsī's recension versus the number of surviving MSS of the Arabic *Almagest* translations attests to how *Taḥrīr al-Majisṭī*'s updated observations and theoretical innovations served to render the earlier Arabic translations obsolete.[15] Though observational precision was a marked concern of Nīsābūrī's, everything the first two chapters of this book say indicates the importance of observational precision for all Islamic astronomers.

Ibn al-Akfānī's schematization of astronomy, which Chapter 1 introduced, mentioned other important texts of astronomy that were related to the *Almagest*, and Nīsābūrī cited some of these texts in *Sharḥ Taḥrīr al-Majisṭī*.[16] All of these texts that Ibn al-Akfānī listed, many of whose titles indicate their connection with the *Almagest*, focused on deriving geometrical models of the planets' motions from available observations.[17] On the least difficult, summary (*mukhtaṣar*) level, there was al-Abharī's (fl. 1240) *al-Majisṭī*; on the second, intermediate (*mutawassiṭa*) level there was Jābir ibn Aflaḥ's (fl. mid-12th cent.) *Hay'a*; in the third, detailed (*mabsūṭa*) level there was al-Bīrūnī's (d. 1048) *al-Qānūn al-Mas'ūdī* and al-Nayrīzī's (d. early 10th cent.) *Sharḥ al-Majisṭī*.

Though the *Almagest* relied heavily on observational data, one should note that Ibn al-Akfānī categorized *'ilm al-arṣād* (the science of observations) as a separate division of astronomy. According to Ibn al-Akfānī, the purpose of observations was the completion and perfection (*kamāl*) of *'ilm al-hay'a* and actualizing its practice.[18] Ibn al-Akfānī's esteem of *'ilm al-arṣād* helps account for the level of attention Nīsābūrī paid to observational astronomy in *Sharḥ Taḥrīr al-Majisṭī*, as well as later in his career. The theoretical innovations of Islamic astronomy (which have tended to attract attention from modern scholars) were useless and unnecessary if the best available observations could not corroborate them.[19] Indeed, some of Nīsābūrī's lengthiest comments in *Sharḥ Taḥrīr al-Majisṭī* considered the observations upon which Ptolemy had founded his models for planetary motion. Often, updated observations meant that the models themselves would have to be revised. Sometimes, new observations entailed only changes in the dimensions of the models. In certain cases, though, the very existence of the model itself depended on certain observations. The slightest error in observations could mislead one into devising a model to explain a phenomenon that did not, in fact, exist.

The following several pages will summarize Nīsābūrī's contributions in *Sharḥ Taḥrīr al-Majisṭī* to observational astronomy. Again, readers especially interested in pre-modern astronomy should consult the technical account of this same information found in Appendix B. Afterwards, this chapter will move to the religious significance of the observations.

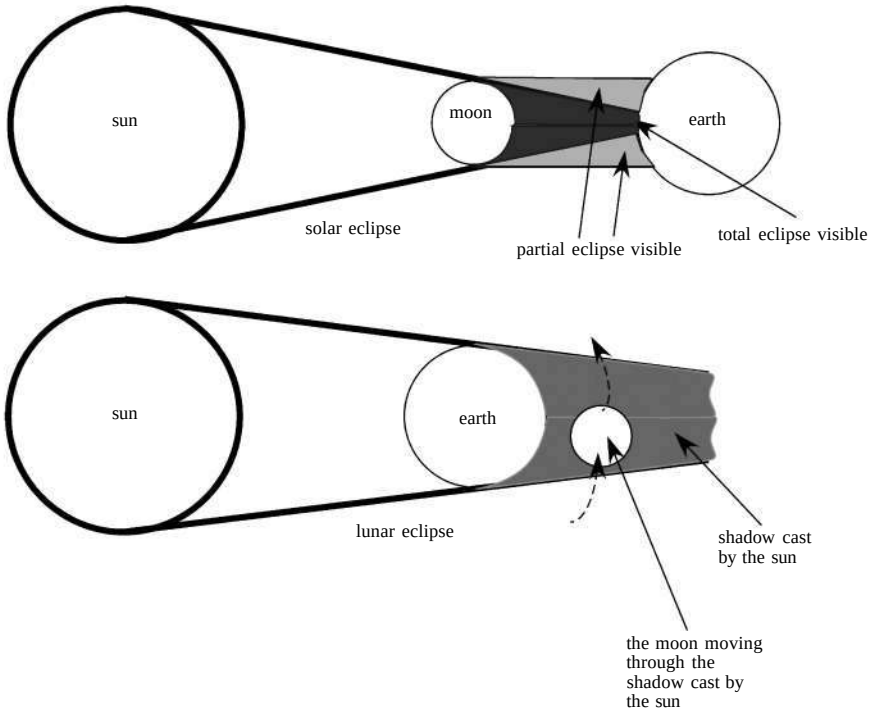

Figure 2.1 Solar and lunar eclipses

Eclipse observations

Beginning with Book Five of *Sharḥ Taḥrīr al-Majisṭī*, Nīsābūrī began to pay a great deal of attention to eclipse observations. An eclipse is when one celestial body, generally the sun or the moon, cuts off the light from another[20] (see Figure 2.1). The moon does pass the sun in its path about every 29.5 days. But because the path of the moon is inclined to the sun's path by about five degrees, the two luminaries, when they pass each other, will not always be in the same plane with the earth, a necessary condition for an eclipse. In the case of a solar eclipse, the sun and moon are in conjunction and share the same position in latitude; during a lunar eclipse, the sun and moon are diametrically opposed (they are in opposition). Predicting these striking phenomena, which were laden with religious significance, as the *Qur'ān* referred to eclipses, required attention to science. Figure 2.1 illustrates solar and lunar eclipses and shows where full and partial eclipses are visible. Note how the timing and visibility of lunar and solar eclipses depend on the position of the moon and the location of the observer on earth.