THE INTERNATIONAL INSTITUTE OF ISLAMIC THOUGHT AND CIVILIZATION (ISTAC)

A TRANSLATION OF TREATISE VIII (ON ECLIPSES) OF AL-BIRUNI'S AL-QANUN AL-MAS'UDI

A THESIS SUBMITTED TO
THE INTERNATIONAL INSTITUTE OF ISLAMIC THOUGHT
AND CIVILIZATION (ISTAC) IN
PARTIAL FULFILLMENT FOR THE M.A. DEGREE

BY :
NORZAKIAH BT. SAPARMIN

KUALA LUMPUR, MALAYSIA
SHAWWAL 1420/JANUARY 2000

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master (M.A.) in **Islamic Science**

Prof.Dr.Paul Lettinck
Supervisor

This thesis was submitted to ISTAC and is accepted as partial fulfilment of the requirements for the degree of Master (M.A.) in **Islamic Science**

Prof.Dr.Wan Mohd.Nor Wan Daud
Deputy Director
and Students Academic Advisor

This thesis was submitted to ISTAC and is accepted as partial fulfilment of the requirements for the degree of Master (M.A.) in **Islamic Science**

INTERNATIONAL INSTITUTE OF ISLAMIC THOUGHT & CIVILIZATION

Prof.Dr.Syed Muhammad Naquib al-Attas
Founder-Director

THE INTERNATIONAL INSTITUTE OF ISLAMIC THOUGHT AND CIVILIZATION

(ISTAC)

A TRANSLATION OF TREATISE VIII (ON ECLIPSES) OF AL-BĪRŪNĪ'S *AL-QĀNŪN AL-MAS'ŪDĪ*

A THESIS SUBMITTED TO
THE INTERNATIONAL INSTITUTE OF ISLAMIC THOUGHT AND CIVILIZATION (ISTAC) IN
PARTIAL FULFILLMENT FOR THE M.A. DEGREE

BY:

NORZAKIAH BT. SAPARMIN

KUALA LUMPUR, MALAYSIA
SHAWWAL 1420/JANUARY 2000

Dedicated to,

Mawlana Shaykh Muhammad Nazim Adil al-Haqqani (ق)

..... *a star from heaven.*

بسم الله الرحمن الرحيم

And the sun runs unto a resting place,
For him: that is the decree of (Him),
The Exalted in Might, the All-Knowing.

And the moon, We have measured for her
Stations (to traverse) till she returns
Like the old (and withered)
Lower part of a date-stalk.

It is not permitted to the sun to catch up the moon,
Nor can the night outstrip the day:
Each (just) swims along in (its own) orbit.

(Surah Yassin: 38-40)

TABLE OF CONTENTS

ACKNOWLEDGMENT

All praise is due to Allah Almighty and His Beloved Prophet Muḥammad (pbuh), that by His Grace and by His Support that this dissertation has finally came out into the light of the day.

I would like to express an immense gratitude to my supervisor, Prof. Dr. Paul Lettinck, who first suggested to me this topic and had never given up in helping and encouraging me to successfully complete the translation. I was indebted to him for his willingness to spent his time in reading and studying the text, and his patience and effort to help me to understand some of the most difficult parts of the text, especially on the part concerning Menelaus Theorems.

I also owe a profound acknowledgment to Prof. Dr. Syed Muhammad Naquib al-Attas, the Founder-Director of ISTAC, for giving me the opportunity to seek knowledge at this beautiful institution and received me as one of his students here. My gratitude also due to Prof. Dr. Wan Mohd. Nor Wan Daud for opening the way for me to be admitted at this institution and facilitated me with all the necessary helps to make my academic life here more meaningful. My appreciation also goes to all the professors here at ISTAC who had illuminated me with their teachings; to the Registrar, Haji Mat Ali Mat Daud, for all the administrative and financial helps which I had received since I came here to ISTAC; to the library and administration staffs for all their help and cooperation; and last but not least, to all my colleagues and friends here at the institution who had helped me in one way or another to make my life here more academically enriching.

A note of gratitude is also due to my former teacher, Prof. Abdul Aziz Sachedina, whose teachings never fail to enlighten me and whose kindness I will always remember. My special gratitude and thankfulness are reserved for my parents, Haji Saparmin bin Marji and Hajah Hatijah bt. Ibrahim, whose understanding and sacrifices made me indebted to them for eternity.

LIST OF ASTRONOMICAL NOTATION

E	East
W	West
N	North
S	South
♈	Vernal Equinox
A	Apogee
Π	Perigee
☽	Moon
☉	Sun
λ	True Longitude
λ_m or $\bar{\lambda}$	Mean Longitude
$\dot{\lambda}$	True Angular Velocity
$w_{☽}$	Tropical (or mean) Lunar Angular Velocity
$w_{☉}$	Solar Mean Angular Velocity
$q(a_m)$ or q	Solar Equation
$p(c, a_v)$ or p	Lunar Equation
Ω	Lunar Node

ABSTRACT

The aim of this thesis is to translate more than half of Treatise VIII of al-Bīrūnī's *al-Qānūn al-Mas'ūdī*, which is one of the major works of astronomy produced by the great polymath Abū Rayḥān al-Bīrūnī (d. ca. 1050). It was written in the 1030s under the patronage of Sulṭān Mas'ūd of Ghazna (d. 1040), whom al-Bīrūnī dedicated his work to, and thus bearing the Sulṭān's name on the work. The work is intended to be as an astronomical guide book or a reference book for the use of practicing 11th century astronomers and astrologers to solve any of the standard problems of astronomy known at that time. It is a comprehensive work, comprised of eleven treatises on various topics of astronomy including detail calculation and mathematical problems on daylight length, spherical and trigonometric problems, planetary motion and etc.

The treatise that we had selected for the translation is Treatise VIII which covers on two topics: eclipses and crescent visibility. For our purpose here we translated only on the part on eclipses, which constituted about 72 pages of the edited edition of the whole treatise. It has eleven chapters which covers topics such as the angular velocity (*buht*) of the luminaries and the rate of elongation (*sibq*), conjunction and opposition of the luminaries, the various kinds of lunar shadow, the time limits of which eclipses are inhibited to occur, the calculation of the apparent diameters of the luminaries and the shadow diameter, the calculation of eclipse magnitude and the time between the eclipse phases, and the description on the colors of eclipses. The translation then is followed by some remarks on the text on which we elucidated on any technical and mathematical difficulties that need to be explained.

INTRODUCTION

1. The Development of Islamic Astronomy from 8th to 11th century.

The translation of *Zīj al-Sindhind (Indian Astronomical Table)* by Muḥammad b. Ibrāhīm al-Fazārī and Ya'qūb b. Ṭāriq around the year 770 C.E.[1] under the patronage of Caliph al-Manṣūr of the 'Abbasid Dynasty, has been considered by historians of science as the landmark for the emergence of astronomy as a scientific endeavor in the Islamic Civilization.[2] Being transferred from various origins, either the source is native to the Arabs themselves, or foreign—Greeks, Indians, Persians, Syrians, Babylonians, to a mention a few—the science was studied, analyzed, criticized, reformed, revolutionized and preserved for future generations in the writings of many distinguished Muslim astronomers. The history of Islamic astronomy can be divided into two great periods: the first period is between the 8th and 11th century and the second period is after 11th century and beyond with the 11th century as the turning point.

Both al-Fazārī and Ya'qūb b. Ṭāriq were accomplished astronomers themselves and have been regarded by later Muslim scholars as the astronomers who introduced Indian astronomy into the Arabic speaking world. Another astronomer who had also written a work within this tradition of Indian astronomy was Muḥammad b. Mūsā al-Khwārizmī (d. c. 860), whose treatise is also entitled *Zīj al-Sindhind (Indian Astronomical Table)*.[3] With the starting of the great translation period of the 9th century, of which many Greek astronomical and mathematical texts were began to be translated, the influence of Indian astronomy began to recede in the background due to the more exact nature of Greek astronomy which has greater philosophical and physical foundation as an exact science

[1] All the years are in C.E., hence, this notation will not appear again in the text. However, if there are 2 years separate by a slash, then the first one is in A.H. and the next one is in C.E.

[2] Régis Morelon, "Eastern Arabic Astronomy between the Eighth and the Eleventh Centuries," in *Encyclopedia of the History of Islamic Science*, 3 vols. (1996), 1: 20, hereafter cited as "Eastern Arabic Astronomy."

[3] Ibid., 21.

The translators of al-Ma'mūn (reigned 813-33) such as Isḥāq b. Ḥunayn (d. 911), Thābit b. Qurra (d. 901) and Qusṭā b. Lūqā (d. c. 900) have done a great service in rendering the Greek astronomical texts into Arabic.[4] Among the major ones are the *Almagest*, the *Planetary Hypotheses*, the *Phaseis* and the *Handy Tables* of Ptolemy; the *Data*, the *Optics*, the *Catoptrica* and the *Phenomena* of Euclid; and the *Spherica* of Menelaus.

With the texts available in Arabic, the astronomers and the mathematicians were ready to study, to comment and to analyze, to repeat the ancient observations and to construct new ones, to confirm the achievement of the ancient astronomers and to correct the mistakes made by them, and to improve the method of the ancients' calculation and observation in order to achieve more accurate results. The period of 9th and 10th century is the period when the knowledge of Greek astronomy and mathematics began to diffuse and solidify into the scholarship of Islamic learning. Hence, most of the Muslim astronomers during this period were working under the framework of the Hellenistic astronomy. In other words, their activities in this beginning stage of the development of Islamic astronomy were mainly concentrating on understanding, commenting, critically analyzing and improving some of the ancients' method of calculation and observation—be it from the Greeks or the Indians, Persians or the Syrians, or even from the ancient sources of the Babylonians and the Chaldeans.

Among the distinguished astronomers during this period were al-Khwārizmī (fl. 830), al-Marwarūdhī (fl. 832), al-Jawharī (fl. 832), Sind ibn 'Alī (d. after 864), Ibn Kathīr al-Farghānī (d. c. 850) and Yaḥya Ibn Abī Manṣūr (fl. 830). All of them have rendered their services during the reign of Caliph al-Ma'mūn.[5] Later, we have Ḥabash al-Ḥāsib (d. c. 864-874), Abū Ma'shar al-Balkhī (d. 886), Abū Yūsuf al-Kindī (fl. 860), Banū Mūsā and Thābit ibn Qurra (d. 901), who are all active during the second half of 9th century.

---

[4] Ibid.

[5] George Saliba, *A History of Arabic Astronomy* (New York: New York University Press, 1994), 14, hereafter cited as *HAA*.

The astronomical activities were then continued through the works of 10th century astronomers such as Abū al-'Abbās al-Nayrīzī (d. 922), Muḥammad Ibn Jābir al-Battānī (d. 929), Abū al-Wafā' al-Būzjānī (d. 998), Abū Ja'far al-Khāzin (d. c. 961-971), 'Abd al-Raḥmān al-Ṣūfī (d. 986), Abū Sahl al-Kūhī (fl. 970-1000) and Abū Maḥmūd al-Khujandī (d. c. 1000). Abū Rayḥān al-Bīrūnī (d. 1050) came later, and many of these astronomers and their works were mentioned later by al-Bīrūnī in his *al-Qanūn al-Mas'ūdī*.

Yaḥya ibn Abī Manṣūr, for example, had been appointed by Caliph al-Ma'mūn to head a team of astronomers to conduct observations at the observatories of Baghdad and Damascus, including at an observatory at the famous *Bayt al-Ḥikmah*. Although the observations were done under the Ptolemaic framework, this was the first extensive and systematic observations ever done since the time of Ptolemy. Their accurate observations on the motion of the celestial bodies resulted in recalculating the astronomical parameters that had been set by Ptolemy 700 years earlier. They also discovered a more accurate value of the precession of the fixed stars and its connection with the motion of the solar apogee. Most of the results of the observations were recorded in the famous treatise *al-Zij al-Mumtaḥan* (*The Verified Table*), which was extensively utilized by later astronomers including al-Bīrūnī and Ibn Yūnus of Egypt (d. 1009).[6] Thābit ibn Qurra, the translator-cum-astronomer, had proved mathematically, using Euclid's *Elements*, the motion on an eccentric orb, the choice of time intervals for calculating the irregular motion of the moon and a general formula for determining the time of visibility of heavenly bodies.[7] Another eminent astronomer worth mentioning here is al-Battānī. Reputed for being a great observer, he made many important and precise observations from a private observatory at Raqqa in Syria. He observed and calculated a more accurate value of the obliquity of the ecliptic, the position of the solar apogee and proved that annular eclipse is possible due to the variation of the apparent diameter of the luminaries.[8]

[6] Morelon, "Eastern Arabic Astronomy," 26.
[7] Ibid., 34-46.
[8] Ibid., 46-47.

There were also among the astronomers who wrote commentary on the *Almagest*[9] or a comprehensive work elucidating the major principles of astronomy. For example we have *Kitāb fī Jawāmi' 'Ilm al-Nujūm (Compendium of the Science of the Stars)* written by Ibn Kathīr al-Farghānī, *Commentary on the Almagest* by Abū Ja'far al-Khāzin, *al-Magestiu'sh-Shāhī*, a commentary on the *Almagest* by Abū Naṣr Manṣūr b. 'Irāq (d. 1036) and *Kitāb al-Majisṭī* by Abū al-Wafā' al-Būzjānī. In general, we can include *al-Qanūn al-Mas'ūdī* among this genre of astronomical literature; however, it is more comprehensive, covering detail calculations and observations based on either from the foreign sources or from al-Bīrūnī's direct predecessors and contemporaries.

During their exhaustive studying and analyzing this astronomical heritage of ancient astronomers, the Muslim astronomers began to discover bit by bit its imperfections and flaws especially within the Hellenistic tradition, the major source of Islamic astronomy. These doubts, especially found in Ptolemy's *Almagest*, have appeared as early as in the works of Thābit ibn Qurra, and reached its maturity in the work of Ibn al-Haytham (d. 1039), *al-Shukūk 'alā Baṭlamyūs*. Al-Qabīṣī, the famous astrologer of Sayf al-Dawla, the Ḥamdānid ruler of Aleppo (reigned 945-967), had also claimed that he had written a critique against Ptolemy in his work entitled *al-Shukūk fī al-Majisṭī*.[10] Other astronomers who also had adopted this critical attitude include Abū Ja'far al-Khāzin, Abū al-Wafā' al-Būzjānī, al-Bīrūnī, 'Abd al-Raḥmān al-Ṣūfī and Abū 'Ubayd al-Jūzjānī (c. 1070). Indeed the period between the second half of 10th century and the first half of 11th century is the turning point of Islamic astronomy in presenting a systematic and comprehensive criticism against the Hellenistic astronomy. The respond, i.e. the quest for finding the resolution to the problems, led Islamic astronomy later in the 11th century and beyond to produce

---

[9] The name *Almagest* was coined by the Muslim astronomers from the Greek word ***megistē***, meaning "the greatest" with the article *al-* put in front. Originally, Ptolemy called his work as ***The Mathematical Arrangement*** while the Greek scholars hailed it as ***The Great Arrangement***. J. L. Berggren, ***Episodes in the Mathematics of Medieval Islam*** (New York: Springer-Verlag, 1986), 127, hereafter cited as *EMMI*.

[10] *HAA*, 20.

exceptional and original astronomers like al-Zarqālī (fl. 1075), Kharaqī (d. 1138), al-Biṭrūjī (end of 12th century), Jaghmūnī (c. 1221), Mu'ayyad al-Dīn al-'Urḍī (d. 1266), Naṣīr al-Dīn al-Ṭūsī (d. 1274) and Ibn al-Shāṭir of Damascus (d. 1375). Many of them are original contributors to astronomy, disengaging their theories from the grasp of Hellenistic framework and building models of the heavens that are non-Ptolemaic.

In short, *al-Qanūn al-Mas'ūdī* was a result of an astronomical activities that has started about 250 years earlier, accumulated in time, compared and synthesized through the ingenuity of al-Bīrūnī. It is the first text in its nature which is so encyclopedic and so comprehensive, encompassing all the major sources of his time. Moreover, due to al-Bīrūnī's critical attitude toward some of the Ptolemaic theories and original contribution based on his own calculation and observations, this work fits in the period of the turning point of Islamic astronomy. Let us quote Régis Morelon's recapitulation[11] of al-Bīrūnī's accomplishment as manifested in this *al-Qanūn al-Mas'ūdī*:

> Al-Bīrūnī accomplished this synthesis brilliantly; it was the crowning achievement of the first period of Arabic astronomy, remaining within the general framework erected by Ptolemy. It was his contemporary Ibn al-Haytham who began to break free of that framework, a development that might have not been possible without the precise contribution of al-Bīrūnī.

2. Al-Bīrūnī and his *al-Qanūn al-Mas'ūdī*.

Abū Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī was born in Khwārizm in 362/973 and died around 442/1050 probably at Ghazna in Aghānistān.[12] Since the prime of his life was mostly occurred in the first half of the eleventh century, longer than that of Ibn Sīnā who died earlier in 1037, it is only right to consider this period, as far as the history of science is

---

[11] Morelon, "Eastern Arabic Astronomy," 55.

[12] Ibid., 51. For a further detail information on the life and works of al-Bīrūnī please refer to E. S. Kennedy, "Al-Bīrūnī, Abū Rayḥān Muḥammad ibn Aḥmad," in *Dictionary of Scientific Biography* (1970), 2: 148, hereafter cited as "Al-Bīrūnī"; Syed Hasan Barani, "Al-Bīrūnī and His Magnum Opus *al-Qānūnu'l-Mas'udī*," in the preface of Abū Rayḥān al-Bīrūnī, *al-Qānūnu'l-Mas'ūdī*, ed. Osmania Oriental Publications Bureau, 3 vols. (Hyderabad: Osmania Oriental Publications Bureau, 1955), *i-lxxv*, hereafter cited as *al-Qānūnu'l-Mas'ūdī*; and *Al-Bīrūnī Commemorative Volume*, ed. Hakim Mohammed Said (Karachi: Hamdard Academy, 1979), hereafter cited as *BCV*.

concerned, as the Time of al-Bīrūnī.[13] There are more reasons why it is so. Al-Bīrūnī was a scholar of par-excellence, unique in his time and unsurpassed by later generations. His area of expertise covers a broad range of diverse fields including mathematics, astronomy, history, comparative religion, cultural and mythological studies, geography, mineralogy, pharmacology, philosophy and literature. Among his unique and original contribution are his work *al-Āthār al-Bāqiya min al-Qurūn al-Khāliya (The Chronology of Ancient Nations)* and his work on India, *Kitāb fī Taḥqīq ma li'l-Hind*, the only systematic and comprehensive treatise on India ever written by a Muslim scholar.

His competence in mathematics and astronomy had appeared much earlier in life. It was reported that he had studied under Abū Naṣr Manṣūr b. 'Irāq, who himself had studied under Abū al-Wafā' al-Būzjānī.[14] The latter had worked in a large observatory built in the royal palace of Baghdad under the instruction of the Buwayhid Prince, Sharaf al-Dawla (reigned 982-9),[15] and had written an astronomical handbook, entitled *Zīj al-Majistī*, where he proved several theorems on spherical trigonometry.[16] Abū Naṣr Manṣūr was a prince and early on had taken al-Bīrūnī under his patronage. Aside from his *al-Magestiu'sh-Shāhī*, he had written a commentary on the *Spherica* of Menelaus and had been attributed by Naṣīr al-Dīn al-Ṭūsī in his *Kitab al-Shakl al-Qatta' (The Transversal Figure)* as the first mathematician who introduced the law of sines in its most general form.[17] Al-Bīrūnī indeed was very much indebted to both scholars for his knowledge of spherical trigonometry which he applied quite extensively in his *al-Qānūn*.[18]

Al-Bīrūnī in fact was an accomplished astronomer in the first order. He was the first astronomer to set forth, since the time of Ptolemy, the theory that the solar apogee is

---

[13] G. A. Sarton, *Introduction to the History of Science*, 3 vols. (Huntington: Robert E. Krieger Publishing Company, 1975), 1: 693.

[14] Morelon, "Eastern Arabic Astronomy," 51.

[15] Régis Morelon, "General Survey of Arabic Astronomy," in *Encyclopedia of the History of Islamic Science*, 3 vols. (1996), 1: 10, hereafter cited as "General Survey."

[16] See *EMMI*, 135, 174-176.

[17] Aydin Sayili, "Al-Bīrūnī and the History of Science," in *BCV*, 709.

[18] From this point on, *al-Qānūn al-Mas'ūdī* will only be written as *al-Qānūn*.

moving.[19] Moreover, he had calculated quite accurately terrestrial latitude and longitude of some places mentioned in his *Taḥdīd Nihāyāt al-Amākin (The Determination of the Coordinates of Cities)*. When he was at Nandana Fort in India, he measured quite accurately the earth's diameter from a nearby mountain.[20] His observed and calculated value of the precession, 1° in 70 1/3 years, is very close to the modern value of 72 years;[21] and using this value he recalculated the position of many of the stars listed in Ptolemy's catalogue. His intensive studying and observation of the shadow was recorded in his work entitled *Kitāb fī Ifrād al-Maqāl fī Amr al-Ẓilāl (The Exhaustive Treatise on Shadows)*.[22] For the beginners, however, they can refer to his *Kitāb al-Tafhīm li-Awā'il Ṣinā'at al-Tanjīm (The Book of Instruction in the Art of Astrology)*, of which half of the treatise is devoted to the basic principles of astronomy, and the other half on the principles of astrology.[23]

Al-Bīrūnī was also reputed to be a very skillful and rigorous observer. At the age of 17, by using a graduated ring, he observed the meridian solar latitude during equinoxes and succeeded in calculating the terrestrial latitude of Kāth. Later, as a young man at the age of 21, he worked with al-Khujandī whom earlier had built a large mural sextant on a mountain above Rayy under the instruction of the Buwayhid prince, Fakhr al-Dawla (reigned 977-79). Al-Bīrūnī gave an account of this sextant in his treatise entitled *Ḥikāyat al-Ālāt al-Musammāt al-Suds al-Fakhrī (Account of the Instrument Known as the Fakhrī Sextant)*. 3 years later in 997, he arranged with Abū al-Wafā' al-Būzjānī that the latter should observe a lunar eclipse at Baghdad while he observe it at Kāth in order to

---

19 *HAA*, 74.

20 Abū Rayḥān al-Bīrūnī, *Kitāb Taḥdīd Nihāyāt al-Amākin Litaṣḥīḥ Masāfāt al-Masākin*, trans. Jamil Ali, *The Determination of the Coordinates of Positions for the Correction of Distances between Cities* (Beirut: American University of Beirut, 1967), 183-191, hereafter cited as *Kitāb Taḥdīd*.

21 Preface of *al-Qānūnu'l-Mas'ūdī*, *xliii*.

22 Abū Rayḥān al-Bīrūnī, *Kitāb fī Ifrād al-Maqāl fī Amr al-Ẓilāl*, trans. and comm. E. S. Kennedy, *The Exhaustive Treatise on Shadows*, 2 vols. (Aleppo: Institute for the History of Arabic Science, 1976).

23 Abū Rayḥān al-Bīrūnī, *Kitāb al-Tafhīm li-Awā'il Ṣinā'at al-Tanjīm*, trans. R. Ramsay Wright, *The Book of Instruction in the Art of Astrology* (London: Luzac & Co., 1934), hereafter cited as *Kitāb al-Tafhīm*.

determine the longitudinal differences between the two cities.[24] Later in his life he helped to establish centers of astronomical observations and researches at Baghdad, Damascus and Ghaznah during the reign of Sulṭān Mahmūd (d. 1030) of the Ghaznavid Dynasty.[25] In addition, he had written works related to observation and astronomical instruments such as a treatise on astrolabe, *Kitāb fī Istī'āb al-Wujūh fī Ṣan'at al-Asṭurlāb* and a treatise on transits entitled *Tamhīd al-Mustaqarr li-Taḥqīq Ma'nā al-Mamarr (Smoothing the Basis for an Investigation of the Meaning of Transits).*

His proficiency in many languages such as Khwārazmian (his mother tongue), Arabic, Persian, Sanskrit, Greek, Syriac and Hebrew, gave him an advantage above other scholars in terms of collecting research material and information. We have his translation of an Indian astronomical handbook called *Karanatilaka*, from Sanskrit to Arabic, which he entitled it as *Ghurrat al-Zījāt*. He even had translated from Arabic into Sanskrit Euclid's *Elements* and Ptolemy's *Almagest*, probably from the request of the Pandits of India regarding Greek astronomy.[26] Thus, it is not surprising that the Pandits conferred him the title *Vidya Sagar* (Ocean of Learning) in respect to his erudition in many branches of knowledge.[27] Among his colleagues and followers, he was hailed as the Master (*al-Ustādh*).

Indeed, many of al-Bīrūnī's astronomical and mathematical activities that we have mentioned above appeared again in his *al-Qanūn*. The work, which was written later in his life (1030-35) served as a compilation of what he had studied and acquired since he commenced to study astronomy. It is encyclopedic, comprising most of the knowledge of astronomy during his time and with enough supplement of his own contribution and originality. Moreover, it is complete with detail calculations and mathematical problems

[24] Kennedy, "Al-Bīrūnī," 562-563.
[25] Preface of *al-Qānūnu'l-Mas'ūdī*, *iii*.
[26] Ziauddin Ahmad, "Al-Biruni, His Life and His Works," *Islamic Culture* 5 (1931): 348.
[27] M. S. Namus, "Al-Bīrūnī the Greatest Astrologer of the Times," in *BCV*, 546.

and served as an astronomical guide book for the use of practicing 11th century astronomers and astrologers to solve any of the standard problems of astronomy known at that time. The whole text comprised of 11 treatises, which each of the treatises is divided into several chapters, culminating to about 1482 pages in the original edition. It is written in Ghaznah during the time when al-Bīrūnī was under the patronage of Sulṭān Mas'ūd (d. 1040), the son of Mahmūd. The *al-Qanūn* then was dedicated to the Sulṭān, hence the name *al-Qanūn al-Mas'ūdī*.

Thus, al-Bīrūnī began his *al-Qānūn* with a dedication and gratitude to the Sulṭān. Compare to his father Maḥmūd, who was more occupied in expanding the Ghaznavid empire, Mas'ūd showed a keen interest towards the pursuit of learning and scholarship. Hence, within this conducive environment that al-Bīrūnī completed his *al-Qānūn*. In the preface of this monumental work, al-Bīrūnī stated some of the methods which he applied during the course of the writing of *al-Qānūn*:

> I have truly done what every one is bound to do in his [particular] science, which is to accept the judgments [or contributions] of the previous [people of] the science, and to correct fearlessly any shortcomings that is discovered...., and to preserve what has been discovered as a record for future generations. We attached for each calculation in each chapter its defects, and it is mentioned what we have understood of the calculation so that [future] thinkers will avoid following us and the door of seeking the right [knowledge] of [the matters] that are not clear to us will be opened for him or adjustment of our mistakes or what we forgot in the calculation.[28]

In spite of all his accomplishments, al-Bīrūnī remained a humble man of learning, admitting his weaknesses and limitations, and hoping that future generations will succeed further than what he and his contemporaries had accomplished.

Let us state briefly the content of each treatises. Treatise I introduces the reader to the basic principles of astronomy and the various kinds of years and months in different cultures. Treatise II treats the subject of calendars, chronologies of ancient people and festivals of the Jews, Christians, Muslims and Persians. Treatise III is devoted to the

---

[28] Al-Bīrūnī, *al-Qānūnu'l-Mas'ūdī*, 4-5.

principles of trigonometry. Treatise IV is on the problems of spherical astronomy such as the inclination of the ecliptic and the determination of the celestial longitude and latitude. Treatise V deals on the problem of geodesy and mathematical geography, and in here al-Bīrūnī also mentioned the inhibited parts of the world and its division into various climates. Treatise VI explains the subject of time differences for different localities, the solar motion and the equation of time. Treatise VII is devoted exclusively for the problems of lunar motion, complete with the table of lunar equation. Treatise VIII is on the solar and lunar eclipses and on the theory and technique of observing the new moon. Treatise IX is on the subject of the fixed stars, while Treatise X deals on the planets. The last treatise, Treatise XI, is devoted to the problems of astrological operations.[29]

Most of the treatises have about the same format. First, al-Bīrūnī gave us an introduction to the subject matter, and then an elucidation of the astronomical problems related to the subject under discussion, and finally the third part is the resolution which basically involves some mathematical calculation or theories that have been expounded either by the Greeks, the Hindus or the Muslim astronomers, and sometimes accompanied with al-Bīrūnī's own suggestions and observations. There are also a few materials derived from the Persians, the Syrians, and even from the Chaldeans and the Babylonians.[30] Overall he depended quite heavily on Ptolemy's *Almagest* and to some extent on Ptolemy's *Planetary Hypotheses (Kitāb al-Manshūrāt)*, and also some references from Euclid's *Elements* and the *Spherica* of Menelaus. From the Hindus, he relied on their *Brāhmasphuṭasiddhānta* and on Brahmagupta's *Khaṇḍakhādyaka*.[31]

---

[29] For a further detail description on the contents of *al-Qānūn al-Mas'ūdī* see E. S. Kennedy, "Al-Bīrūnī's Masudic Canon," *Al-Abhath* 24 (1971): 59-81, reprinted in E. S. Kennedy, *Studies in the Islamic Exact Sciences* (Beirut: American University of Beirut, 1983), 573-595, hereafter cited as "Masudic Canon" and *SIES* respectively.

[30] Seyyed Hossein Nasr, *An Introduction to Islamic Cosmological Doctrines* (Albany: State University of New York, 1993), 111.

[31] Kennedy, "Masudic Canon," 67, 69-72.

The text that we have translated here is the first half of Treatise VIII from the edited edition of *al-Qānūn al-Mas'ūdī*.[32] The treatise itself is divided into 17 chapters; the first 11 chapters are on the various problems related to eclipses and the last 6 chapters are on the theories of the crescent visibility. This first 11 chapters discussed among other things the angular velocity (*buht*) and the rate of elongation (*sibq*) of the luminaries, conjunctions and oppositions between the sun and the moon, description of different kinds of eclipses, the lunar shadow, the time frame on which the occurrence of eclipses are limited, the apparent diameter of the luminaries and the shadow, and the computations of solar and lunar eclipses which include matters like eclipse magnitude, the various colors of eclipses, the condition of eclipses occurring at sunset or sunrise, the calculation of time for different phases of eclipse, and the inclination of eclipses.

In each chapters, al-Bīrūnī started first with a short general introduction before he explained the problems under discussion. His sources for this part of *al-Qānūn* are mostly derived from Book IV of the *Almagest*, especially on matters like the calculation of conjunction and opposition, the ecliptic limits, eclipse magnitude, and the calculation of time and inclination. There is also a reference from Book II of the *Spherica* in Chapter 5 of which al-Bīrūnī applied Proposition 5 of Menelaus to calculate the maximum difference of lunar longitudes. From the Hindus, al-Bīrūnī adopted their method of calculating the apparent diameter of the luminaries and the shadow, and their description of the colors of eclipse.

Although al-Bīrūnī depended quite heavily on the *Almagest*, his work is not a mere copying of Ptolemy's without he himself understood the principles and theories behind the astronomical problems. In most of the discussions, he did not present the problems and the calculations exactly the same as they are found in the *Almagest* without adding his own comment, modifying some of the procedure of the computation, suggesting a more accurate

[32] Al-Bīrūnī, *al-Qānūnu'l-Mas'ūdī*, 875-947.

way of calculation, for example in the application of spherical trigonometry, and sometimes he was quite critical on some views of Ptolemy, for example in Ptolemy's seemingly disregard of the inclination of the lunar orb. In addition, there are several materials included by al-Bīrūnī which are not found in the *Almagest* such as the table of the true angular velocities of the luminaries, the computation of the apparent conjunction, the table of surface area which occurs on a circle for different values of chord for the calculation of eclipse magnitude, the colors of eclipses, cases of eclipses occurring near sunrise and sunset, discussion on annular eclipse, and his application of spherical trigonometry and Menelaus Theorem on the calculation of eclipse magnitude, the eclipse times for different phases of eclipse, and the inclination angle of solar eclipse.

As a reputable observer, however, it is quite strange that al-Bīrūnī did not mention at all in this treatise any of the eclipses that he had observed previously while doing his observational activities. However, he did mention in Chapter 3 of Treatise VII, which is on the lunar motion, that he has observed three lunar eclipses: that of 19 February 1003 at Jurjān, of 14 August 1003 also at Jurjān, and that of 4 June 1004 at al-Jurjāniya of Khwārazm.[33] It was also reported that he has observed a solar eclipse at Lamghān, Kabul, on 8 April 1019. We can guess that maybe because in Treatise VII, he used the eclipses to calculate the lunar motion, but for Treatise VIII here, there is no urgency to mention any of the eclipses due to the fact that the theories and the calculations which he presented in this treatise are in their general form.

The translation is divided into two parts: the first part is the translation of the text itself and the second part is our remarks, elucidating any parts of the text which are not clear and straightforward. For the latter, we often quoted materials from the *Almagest* and benefited from Ptolemy's parameters and examples for further clarification. The number on the margin refers to the page number and the line on which the text is situated in the

[33] Kennedy, "Masudic Canon," 69.

edited edition. For example, number 875.5 means that the text is in page 875 and in line 5 of the page.

We have tried in our best capacity to translate and understand the whole text in its entirety. However, there are some parts of the text, including specific phrases and words, that we have difficulty in comprehending their meanings. Al-Bīrūnī's language, moreover, can be quite challenging. His writings and explanation are rarely explicit and straightforward. We found a few grammatical mistakes and there are words which are still misspelled, maybe due to the carelessness of the copyists of the manuscripts or they were missed by the editors. Nevertheless, we have been able to understand most part of the texts, and if there are any parts which are quite confusing and inexplicable, we tried our best to mention them in the remarks. Hopefully, any readers of the history of Islamic astronomy can come up with a better suggestion and understanding than what we have accomplished here.