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Alfraganus and the Elements of Astronomy

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ALFRAGANUS AND THE ELEMENTS OF ASTRONOMY

Assoc. Prof. Yavuz UNAT*

Alfraganus Life

Abû'l Abbas Ahmad b. Muhammad b. Kathîr al-Farghânî al-Hâsîb, known as Alfraganus in the West, was the one of the famous astronomers who worked during al-Ma'mûn's dynasty (813-833). His name was given by Ibn al-Nadîm as Muhammad b. Kathîr,[1] but Abu'l Faraj wrote it as Ahmad b. Muhammad b. Kathîr.[2] Ibn al-Qiftî mentioned two Farghânîs, a father whose name is Muhammad and a son whose name is Ahmad b. Muhammad.[3] But all these are names of astronomers who lived in Mâ'mûn's period.

We do not know much about his life. He was born in Farghânâ, Transoxiana, flourished under al-Ma'mûn, and was still living in 861.[4] His studies extended to engineering. Ibn Taghrîbirdî wrote that he supervised the construction of the Great Nilometer in Fustat (old Cairo). This was completed in 861.[5] Ibn Khallikan also reported the construction, giving the name of the engineer as Ahmad Ibn Muhammad al-Qarsânî.[6] The last word, Al-Qarsânî, could be a corruption of 'al-Farghânî'.[7]

Alfraganus also directed the digging of a canal, named al-Jafarî. Al-Mutawakkil entrusted it to the two sons of Musa b. Shakir, Muhammad and Ahmad. They delegated the work to Alfraganus. The canal ran through the new city, al-Jafariyya. But Alfraganus committed a grave error, making the beginning of the canal deeper than the rest. The explanation given for his mistake is related to the fact of his being a theoretical rather than a practical engineer. Al-Ya'qûbî (d. 897) gave another reason for this failure. He said that the stony ground chosen for the city was too hard to dig. He did not mention Alfraganus by name, only said that the canal was entrusted to "Muhammad b. Mûsâ al-Munajjim and those geometers who associated themselves with him."[8]

His Works

Ibn al-Nadîm ascribes only two works to Alfraganus in *The Fihrist*: 1*. The Book of Thirty Chapters, a Summery of the Almagest (Kitâb al-Fusûl Ikhtiyâr*[9] *al-Majistî),* 2. *The Book on the Construction of Sundials (Kitâb 'Amal al-Rukhâmât).*[10]

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* Ankara University, Faculty of Letters, in the Department of the History of Science.
[1] Ibn al-Nadîm, *Fihrist,* vol. I, Leipzig 1348, p. 499.
[2] Abu'l Faraj, *Tâ'rikh Mukhtasar al-Duwal*, Beirut 1890, p. 236.
[3] Julies Lippert, *Ibn al-Qifti's Ta'rîh al-Hukamâ'*, Leipzig 1903, pp. 78, 286.
[4] A. I. Sabra, "al-Farghânî, Abu'l-'Abbâs Ahmad Ibn Muhammad Ibn Kathîr," *Dictionary of Scientific Biography*, vol. IV, 1971. p. 541; H. Suter, "Al-Fargânî," *IA,* vol. IV, Istanbul 1950, p. 565; George Sarton, *Introduction to the History of Science,* Baltimore 1950, vol. I, p. 567.
[5] Ibn Taghrîbirdî, *al-Nujûm al-Zâhira*, Leiden 1851, pp. 742-743.
[6] Ibn Khallikan, *Wafayât al-a'yân*, vol. I, Cairo 1882, pp. 483-485.
[7] Sabra, p. 541.
[8] Al-Ya'qûbî, *Kitâb al-Buldân,* Leiden 1892, pp. 266-267.
[9] Sabra says that this word should no doubt be read ikhtisâr (summary). See, Sabra, p. 543.

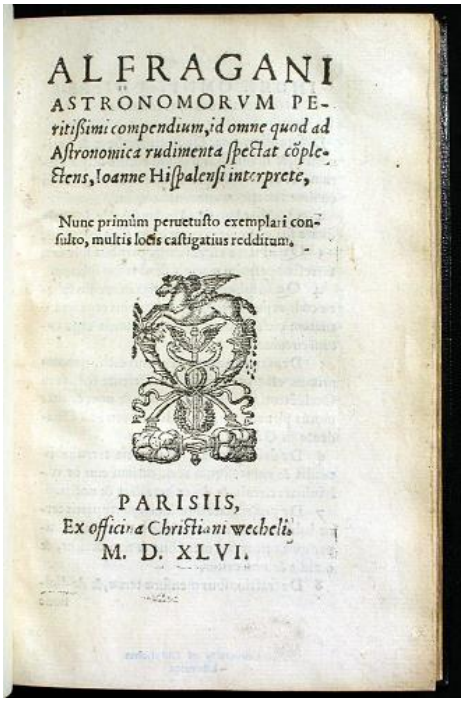
Ibn Qiftî gives his two works under the title of "Muhammad b. Kathîr": 1. *The Book of Chapters, (Kitâb al-Fusûl),* 2. *The Book of Chapters, a Summary of the Almagest (Kitâb al-Fusûl Ikhtiyâr - or Ikhtisâr - al-Majistî).* He ascribes only one of his works under the tittle of "Ahmad b. Muhammad b. Kathîr al-Farghânî": 1. *The Science of the Construction of the Spheres and the Motions of the Stars (Ilm Hay'at al-Aflâk wa-Harakât al-Nujûm).*[11] Except *The Book on the Construction of Sundials*, all these books are the same, *The Elements of Astronomy*. There are two works on astronomy which was written by Alfraganus; *On the Construction of the Astrolabe (Fî San'at al-Asturlâb)* and *On the Astronomical Tables of al-Khwârizmî (Ilâ al-Zîj al-Khwârizmî).* However, the last book is missing. His other works are;

1. *Al-Kâmil fî al-Asturlâb*

2. *Cadwal al-Farghânî*

3. *R. fî Ma'rifat al-awqât allatî yakûn al-qamar fîhâ fawq al-'Ard aw tahtahâ*

4. *Hasâb al-Aqâlîm al-Sab'a*


ALFRAGANI
ASTRONOMORVM PE-
ritiſsimi compendium, id omne quod ad
Aſtronomica rudimenta ſpectat cõple-
ctens, Ioanne Hiſpalenſi interprete,

Nunc primùm peruetuſto exemplari con-
ſulto, multis locis caſtigatius redditum.

PARISIIS,
Ex officina Chriſtiani wechelꝛ
M. D. XLVI.

Figure. 1 *The cover page of the Latin translation of Alfraganus' book of astronomy.*

The Elements of Astronomy

This book was written about 833 (certainly before 857). It was about celestial motions including a complete study on the science of the stars and consisted of thirty chapters. The introduction to the book reads as

[10] Ibn al-Nadîm, p. 1343.
[11] Lippert, pp. 78, 286.

follows; "This book named as *The Elements of Astronomy* is one of the books tprepared for this science and the most compact of that. It is classified by Ahmed b. Muhammad b. Kathîr al-Fargânî al-Hâsib (Alfraganus), the big sheikh, writer, God rest his soul. In the name of God, Most Gracious, Most Merciful. Thank God and peace be upon Mustafa! Thank God who is one and unique. God bless him who is virtuous and his family. This book, *The Element of Astronomy*, is written by sheikh Ahmed b. Muhammad b. Kathîr al-Fargânî al-Hâsib. The book consists of thirty chapters."[12]

The Chapters are as follows;

Chapter 1 is about the Arabic and Persian years, the names of their months and days and the differences between them. In this chapter, he describes the years of the Arabs, Syrians, Romans, Persians, and Egyptians, giving the names of their months and days and the differences between their calendars.

Chapter 2 is about likeness of the heavens to a sphere.

Chapter 3 is about likeness of the earth with all its interior which are lands and seas to a sphere.

Chapter 4 is about the central position of the earth.

Chapter 5 is about the two primary movements of the heavens; the daily and the yearly movement. Those are the basic concepts of Ptolemy in *Almagest*.

Chapter 6 is about the inhabited quarter and day and night.

Chapter 7 is about the parts of the inhabited quarter.

Chapter 8 is about the seven climates.

Chapter 9 is about the names of well-known lands and cities in all climates.

Chapter 10 discusses ascensions of the signs of the zodiac in the direct spheres and the oblique spheres.

Chapter 11 mentions the equal and the unequal hours.

Chapter 12 is about the spheres of each planet and their distances from the earth.

Chapter 13 describes the movements of the sun, moon, and fixed stars in longitude.

Chapter 14 is about the movements of the five planets in longitude.

Chapter 15 is about the retrograde motions of the planets.

Chapter 16 is about the magnitudes of the eccentricities and of the epicycles.

Chapter 17 is about revolutions of the planets in their orbit.

[12] See, Yavuz Unat, *al-Fargânî, The Elements of Astronomy,* textual analysis, translation into Turkish, critical edition & facsimile, edited by Şinasi Tekin & Gonul Alpay Tekin, Harvard University 1998, p. 107.

Chapter 18 is about the movement of the moon and of the planets in latitude.

Chapter 19 is about the order of magnitude of the fixed stars and the positions of the most remarkable among them.

Chapter 20 is about the lunar mansions.

Chapter 21 is about the distances of the planets from the earth.

Chapter 22 is about the magnitudes of the planets in comparison with the magnitude of the earth.

Chapter 23 is about the transits in meridian.

Chapter 24 is about the rising and the setting, and the ascensions, the descensions and the occultation.

Chapter 25 is about the phases of the moon.

Chapter 26 is about the emergence of the five planets.

Chapter 27 is about the parallax.

Chapter 28 is about the lunar eclipses.

Chapter 29 is about the solar eclipses.

Chapter 30 is about the intervals of the eclipses.

Figure 2. *Picture of Alfraganus' crater on the Moon.*

The Elements of Astronomy was a summary of *Almagest*. It was entirely descriptive and nonmathematical. Although it was mainly a summary of Ptolemy's *Almagest*, some sections of the book were different.

Chapter 1 does not correspond to the *Almagest*. It considers the years of the Arabs, Syrians, Romans, Persians, and Egyptians, giving the names of their months and days and the differences between their calendars. Almagest does not have such information. Chapters 2, 3 and 4 are connected with basic principles of Ptolemaic astronomy. In Chapter 5, Alfraganus gives the value of the greatest inclination between the equator and the ecliptic as $23^0\ 35'$. This value is different from Ptolemy's. Ptolemy's value is given as $23^0\ 51'$.[13] Alfraganus' value of $23^0\ 35'$ is more precise than the value in the *Almagest*.[14]

Alfraganus gave the distance per degree at the equator, and in Chapter 8 determined the diameter of the earth to be 6,500 miles.[15] However the idea of the shape of the earth as a sphere was not a new one. The Greeks divided the spherical earth into 360 degrees, but differing sources gave different information about the length of a degree. We know today that the correct measurement is about 111 kilometers per degree at the equator. In the third century BCE, the Greek astronomer Eratosthenes, the director of the library in Alexandria, came up with the remarkably accurate calculation of 110 kilometers (59.5 nautical miles) per degree; in the second century BCE, the great Alexandrian geographer, Ptolemy calculated the length of a

[13] See, Ptolemy, "Almagest," *Great Books of Western Word,* XIV, trans. into English by R. Catesby Taliferro, Chicago-London-Toronto 1952, p. 31.
[14] Al-Farghânî, *Jawâmi' 'Ilm al-Nujûm wal-Usûl al-Harakât al-Samâwîya,* trans. into Latin by Jacob Golius, Frankfurt 1986, p. 18.
[15] Ibid, p. 31.

degree to be 93 kilometers (50.3 nautical miles).[16] Alfraganus calculated it and decided that the value should be 111 kilometers (56 2/3 nautical miles).[17] In this case, his value was more accurate than Ptolemy's.

In chapter 21, Alfraganus give the greatest distances of the planets from the earth and the diameters of the planets.[18] However, Ptolemy had stated only the distances of the sun and the moon and also the magnitudes of the sun and the moon, but not of the other planets.[19] However, it is easy to determine the diameters and the magnitudes of the planets by analogy from what he did for the sun and the moon.

Alfraganus agrees with Ptolemy on the theory of precession, but thinks that it affects not only the stars, but also the sun's apogee. Ptolemy says that the theory of precession affects all the planets except the sun. Elements of the orbits of the sun are constant.[20] On the other hand, according to Alfraganus, the apogee of the sun moves by the fixed stars, thus there are two movements of the sun; the movement in the eccentric, and the movement of its apogee.[21]

Some values given by Alfraganus for the movements of the planets were different from Ptolemy's. Ptolemy gave the anomalistic motion of Saturn as $57^{'}\ 7^{''}$, whilst this motion was given by Alfraganus as $59^{'}$.[22] According to Ptolemy, the eccentricity of the moon was 10; 19^0. On the other hand, Alfraganus said that it was 12; 30^0.[23] The diameter of the epicycle of the moon was 5; 15^0 in the *Almagest*; conversely, it was 6; 20^0 in *The Elements of Astronomy*.[24] The extreme latitude of Venus was given as 6; 22^0 by Ptolemy. However, Alfraganus gave it as 9^0.[25] The elongations of Mars and Venus as given by Alfraganus was different from Ptolemy's value. According to Alfraganus, the elongation was 17^0 for Mars, and 7^0 for Venus. These values were $14^0\ 33^{'}$ for Mars, $5^0\ 36^{'}$ for Venus in the *Almagest*.[26] Ptolemy said that the parallax of the moon was between 0; 10^0 - 0; 25^0. However, the parallax of the moon was given as $1^0\ 44^{'}$ by Alfraganus.[27]

Alfraganus did not repeat some of the mistakes of the *Almagest*. For example, if you look at the distances of the planets from the earth given by Ptolemy, you can see that there is empty space between Venus and the Sun. This is contrary to Aristotelian cosmology. On the other hand, Alfraganus does not make such a mistake.[28] There is no empty space between Venus and the Sun in *The Elements of Astronomy.*

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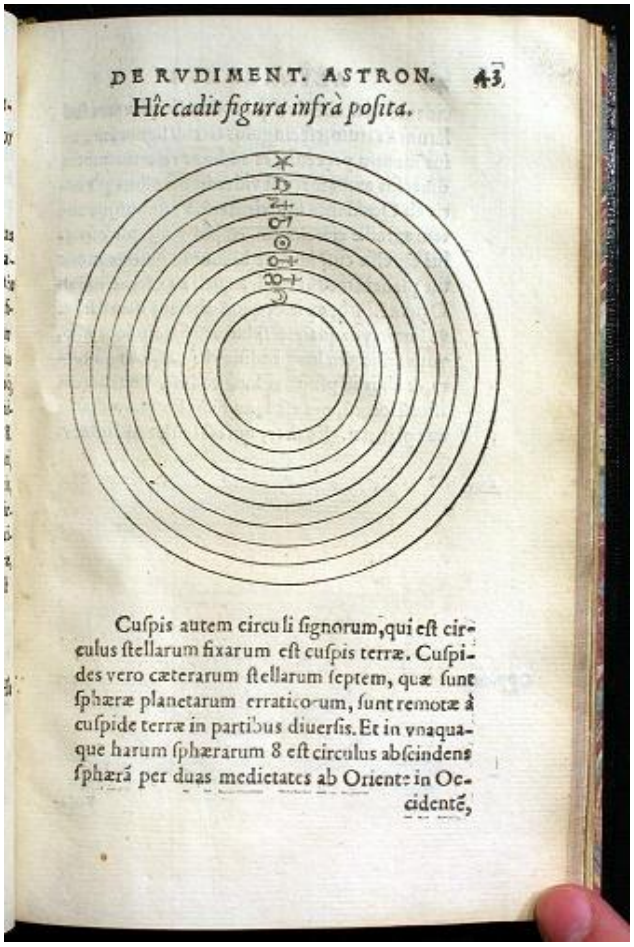
[16] See, J.L.E. Dreyer, *History of the Planetary System from Thales to Kepler*, New York 1953, pp. 176-178; Morris R. Cohen & I.E. Drabkin, *A Source Book in Greek Science*, Massachusetts 1966, pp. 149-153; Syed Hasan Barani, "Muslim Researches in Geodesy," *Al-Bîrûnî Commemoration Volume*, Calcuta 1951, p. 40; Thomas Heath, *A History of Greek Mathematics*, Oxford 1921, pp. 106-107, 220.
[17] Al-Farghânî, 1986, p. 31.
[18] Ibid, p. 81.
[19] See, *Almagest*, V, 13, 14, 15, pp. 167-175.
[20] Ibid, III, 4, pp. 93, 145, 291.
[21] Al-Farghânî, 1986, p. 50: See also Pierre Duhem, *Le systéme du monde,* vol. 3, Paris 1958, pp. 211-214.
[22] *Almagest*, IX, 3, 4, pp. 273-290; Al-Farghânî, 1986, pp. 55-61.
[23] Al-Farghânî, 1986, pp. 64-65.
[24] Ibid, pp. 64-65.
[25] *Almagest,* XIII, 5, pp. 456-457; Al-Farghânî, 1986, p. 74.
[26] *Almagest,* XIII, 7-10, pp. 458-465; Al-Farghânî, 1986, pp. 96-99.
[27] *Almagest*, V, 18, p. 182; Al-Farghânî, 1986, pp. 99-102.
[28] Al-Farghânî, 1986, pp. 80-82; *Almagest*, V, 13, 14, 15, pp. 167-175; Dreyer, 1953, pp. 175, 177-178; O. Neugebauer, *A History of Ancient Mathematical Astronomy*, Berlin-Heidelberg- New York 1975, pp. 919-921.


DE RVDIMENT. ASTRON. 43

Hîc cadit figura infrà posita.

Cuspis autem circuli signorum, qui est circulus stellarum fixarum est cuspis terræ. Cuspides vero cæterarum stellarum septem, quæ sunt sphæræ planetarum erraticorum, sunt remotæ à cuspide terræ in partibus diuersis. Et in vnaquaque harum sphærarum 8 est circulus abscindens sphærã per duas medietates ab Oriente in Occidentẽ,

Figure 3. *A shape from the Latin translation of Alfraganus' book of astronomy.*

Influences of the Elements of Astronomy

The Elements of Astronomy was one of the most popular books on astronomy in both the East and the West, and was used as a textbook on astronomy until the 15th century. Alfraganus was perhaps the first Muslim astronomer to write on astronomy.

By summarizing and simplifying the *Almagest,* Alfraganus had a major influence on Islamic astronomy. Islamic astronomers accepted his ideas, especially the value of precession which was different from Ptolemy's value and the distances and diameters of planets in his work.[29] Ikhwân al-Safâ and al-Battânî made use of Alfraganus' book. Abd al-Aziz al-Qabisî (d. 967) also wrote a commentary on it.

[29] Duhem, vol. 3, p. 214.

Another question asked by Islamic astronomy was the distances of planets from the earth. Of the several attempts made by Islamic astronomers to give an answer, none became as well known as that of Alfraganus.[30]


DE RVDIMENT. ASTRON. 45

vocatur oppoſitio augis. Tunc cùm fuerit planeta in medietate ſphæræ ſuæ longiori, in medietate ſcilicet in qua eſt aux, videtur motus eius in circulo ſignorũ tardior, minus ſc; motu ſuo medio in ſuo circulo, ꝓpter longitudinẽ eius à terra. Si autẽ fuerit in medietate terrę propiori in ſphæra ſua, videtur motus eius in circulo ſignorũ velocior, ſcilicet plus eius medio. Curſus igitur eſt medius, qui ſemper eſt idem per quem videtur moueri planeta in ſphæra ſua egreſſæ cuſpidis ęqualiter. Curſus verò eius equatus eſt, qui videtur de tranſitu eius in circulo ſignorum.

Sol.

Corpus verò Solis eſt compoſitum ſuper ſphę ram

Figure 4. *A page from the Latin translation of Alfraganus' book of astronomy.*

The Elements of Astronomy greatly influenced Western Astronomy. It was translated several times, the first translation of the book into Latin being made by John of Seville in 1137 under the title of *Differentia Scientie Astrorum*. This translation was published in Ferrara in 1493 (*Breuis ac peritulis compilatio Alfragani astronomorum pertissimi totum it continens quod ad rudimenta astronomica est opportunum*).[31] This was reprinted in Nuremberg in 1537 as part of *Continentur in hoc libro Rudimenta astronomica Alfragani. Item Albategnius.... De motu stellarum, ex observationibus tum proprijs, tum Ptolemaei, omnia cum demonstrationibus geometricis & additionibus Ioannis de Regiomonte. Item Oratio introductoria in omnes scientias mathematicas Ioannis de Regiomonte.... Eiusdem introductio in Elementa Euclidis. Item epistola Philippi Melanthonis nuncupatoria.* A second reprint, giving the name of the translator for the first time in print, appeared in Paris in 1546 (*Alfragani astronomorum pertissimi compendium, id omne quod ad Astronomica rudimenta spectat complectens, Ioannis Hispalensi interprete, nunc primum peruetusto exemplari consulto, multis locis castigatus redditum*). It was reprinted by Francis Carmody under the title of *Alfragani Differentie in quibusdam collectis scientie astrorum* (Berkeley, Calif., 1943).[32]

[30] Seyyed Hossein Nasr, *Science and Civilization in Islam,* 1987, p. 182.
[31] Sarton, *Intro.,* vol. II, pp. 169-171; Sevim Tekeli, *Modern Bilimin Dogusunda Bizans'in Etkisi*, Ankara 1975, pp. 42-43.
[32] F.J. Carmody, *Arabic Astronomical and Astrological References in Latin Translations, A Critical Bibliography*, Berkeley-Los Angeles 1959,

Its second translation into Latin was made by Gerard of Cremona, before 1175 (*Liber de aggregationibus scientie stellarum et principiis celestium motuum*,). The translation was published by Romeo Campani in 1910 with his notes and his preface (*Alfragano Il Libro dell aggregazione delle stelle*, Città de Castello, 1910).[33]

The Elements of Astronomy was translated into Hebrew by Jacob Anatoli about 1231-1235 under the title of *Qizzur almagesti.*[34] It consisted of thirty three chapters. This Hebrew translation of the book served as a basis for the third Latin translation made Latin by the Heidelberg professor, Jacob Christmann (*Muhammedis Alfragani Arabis Chronologia et astronomica elementa)*. It was published in Frankfurt in 1590 and again in 1618.[35]

DE RVDIMENT. ASTRON. 47

Orbiculus circũ,a, cir culus breuis

Notula cir cũferentiæ eius adhæ rẽs unus ex 6 planetis.

Cuſpides autem circulorũ breuiũ ſunt,compo ſitæ ſuper alios circulos egreſſæ cuſpidis, præ ter primos, quorum mentionẽ fecimus. Suntq; illi alii eis æquales in magnitudine, & ſuperfi cies eorũ in ſuperficieb.eorũ. Sed cuſpides circu lorum breuiũ,quę ſunt cõpoſitę ſuper hos circu los egreſſæ cuſpidis,mouentur motibus æqualib. in tẽporibus æqualib.ſuper cuſpides circulorum egreſſæ cuſp dis primorũ. Nominaturq; circu lus ſuper quẽ eſt cuſpis circuli breuis,circulus e greſſæ cuſpidis, deferens cuſpidẽ circuli breuis. Circulus verò primus ſuper cuius cuſpidẽ fit mo tus circuli breuis æqualis, nominatur circulus egreſſæ cuſpidis æquans motum,

Vna-

Figure 5. *A page from the Latin translation of Alfraganus' book of astronomy.*

Finally, in 1669, in Amsterdam, Jacob Gollius published a new Latin text with the original Arabic (*Muhammedis Fil. Ketiri Ferganensis. qui vulgo Alfraganus dicitur. Elementa Astronomica. Arabice & Latine. Cum notis ad res exoticas sive Orientales, quae in iis occurrunt*).[36] This translation was reprinted by Fuat Sezgin with his preface under the title of *Jawâmi' 'ilm al-Nujûm wa-Usûl al-Harakât al-samâwîya* in 1986.[37]

pp. 113-114; Sabra, 1971, p. 544; Tekeli, 1975, pp. 42-43.
[33] Carmody, 1959, p. 115; Sabra, 1971, IV, p. 544; Tekeli, 1975, p. 44.
[34] Sarton, *Intro.,*vol. II, pp. 565-566.
[35] Carmody, p. 116; Sabra, p. 544.
[36] Sabra, p. 544.
[37] Al-Farghânî, *Jawâmi' 'Ilm al-Nujûm wa-Usûl al-Harakât al-Samâwîya,* trans. into Latin by. Jacob Golius, Frankfurt 1986.

George Sarton said that *The Elements of Astronomy* was translated into French in the 14th century and that this translation was based on an Italian translation by Bencivenni.[38] The 24th chapter of *The Elements of Astronomy* was also published with Sacrobosco's *Sphaera* in 1556 and in 1564.[39]

The Elements of Astronomy exerted a great deal of influence upon European astronomy before Regiomontanus. There are many references to it in medieval writers and there is no doubt that it was responsible for the spread of Ptolemaic astronomy, at least until this role was taken over by Sacrobosco's *Sphaera.* Even then, *The Elements of Astronomy* continued to be used until the 15th century.[40]

Sphaera Mundi (*The astronomy, Tractatus de sphaera*) (c. 1233) written by Sacrobosco, the English mathematician and astronomer, was derived from Alfraganus and al-Battânî.[41] *The Elements of Astronomy* served as the foundation for Sacrobosco's *Sphaera*. In universities throughout Western Christendom the *Sphaera* was used as a textbook. In the age of printing it went through more than 200 editions before it was superseded by other textbooks in the early 17th century.[42] The Italian writer and scientist Ristoro d'Arezzo (c. 1282) used Alfraganus in his work, *Della composizione del mondo colle sue cagioni.*[43] The Encyclopedist Gerson ben Solomon derived material from Alfraganus, Ibn Sinâ and Ibn Rushd for his *Sha'ar hashamayim (Gate of Heaven)* (c. 1280?).[44]

The *Theorica Planetarum* of Gerard of Sabbioneta the Italian astrologer who flourished c. 1255-1259, was a summary of Ptolemaic astronomy as explained by Alfraganus and al-Battânî.[45]

The Italian astrologer, Guido Bonatti derived certain astronomical knowledge from Alfraganus in *Liber astronomicus* (*Astronomiae tractatus decem*).[46]

In the *Astrologia,* the English physicist and astronomer, William the Englishman, (c.1200) gave the distances of the planets from the earth. This information was taken from Alfraganus.[47] Roger Bacon (1214-1294) had also stated the distances of the planets and the diameters of the planets in the *Opus Majus.* In this work, he used Alfraganus.[48]

Alfraganus influenced the Italian poet Dante Alighieri (1261-1321). Dante's main source of astronomical knowledge was Alfraganus, whom he studied thoroughly in the Latin translation. Dante's cosmology in the *Il convivio* and the *Divina Commedia* was adopted from Alfraganus' *Elements of Astronomy*. He quoted

[38] Sarton, *Intro.*, vol. III, p. 463.
[39] See, Carmody, pp. 113-116; Sabra, p. 542; Tekeli, pp. 66, 84.
[40] Duhem, vol. 3, p. 185.
[41] Sarton, *Intro.,* II, pp. 617-618; see also John of Sacrobosco, "On the Sphere," trans. into English by Lynn Thorndike, *A Source Book in Mediaeval Science,* Massachusetts 1974, pp. 442-451.
[42] Owen Gingerich, "Islamic Astronomy," *Scientific American,* 1986, p. 70.
[43] Duhem, vol. 4, p. 202. Sarton, *Intro.*, vol. II, pp. 928-929.
[44] Sarton, *Intro.,* vol. II, p. 886.
[45] Ibid, p. 987.
[46] Ibid, pp. 988-989.
[47] Ibid, p. 620.
[48] Ibid, pp. 952-967; Dreyer, 1953, pp. 234, 258.

Alfraganus or his book only twice in the *Convivio.*[49] Jacopo di Dante Alighieri, Dante's son also used Alfraganus.[50]

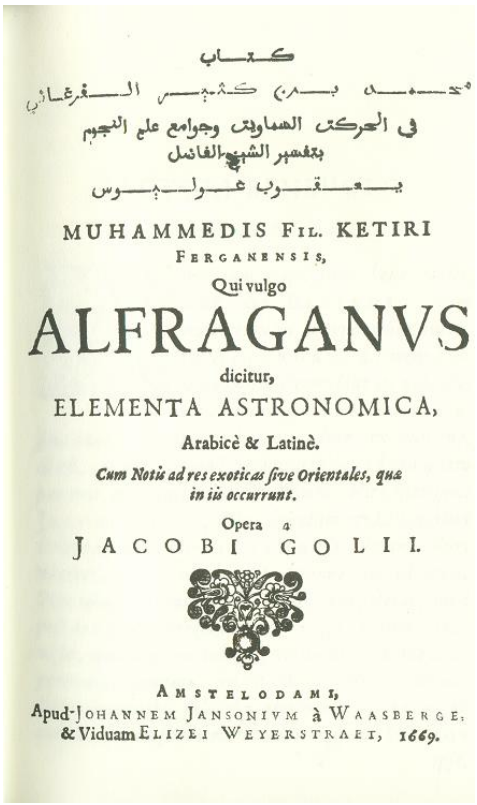

كتاب
محمد بن كثير الفرغاني
في الحركات السماوية وجوامع علم النجوم
بتفسير الشيخ الفاضل
يعقوب غوليوس
MUHAMMEDIS FIL. KETIRI
FERGANENSIS,
Qui vulgo
ALFRAGANVS
dicitur,
ELEMENTA ASTRONOMICA,
Arabicè & Latinè.
Cum Notis ad res exoticas sive Orientales, quæ in iis occurrunt.
Opera a
JACOBI GOLII.
AMSTELODAMI,
Apud JOHANNEM JANSONIVM à WAASBERGE,
& Viduam ELIZEI WEYERSTRAET, 1669.

Figure 6. *The cover page of the Latin translation of Alfraganus' book of astronomy.*

The theologian, mathematician, astronomer, and physicist Levi Ben Gerson (1288-1344) followed Afraganus with reference to the movement of the apogees in the fifteen books of the *Milhamot Adonai*.[51]

Conrad of Megenbeg's (1309-1374) *Sphaera*, the first astronomical and physical textbook in German was a free translation of the *Sphaera Mundi* of Sacrobosco.[52]

Everything which Robert Grosseteste, a leading figure in the 13th century Aristotelian school of Paris, attributed to Ptolemy in his *Summa philosophiae* was in fact taken from Alfraganus.[53] The famous Renaissance scholar Regiomontanus delivered lectures in Padua in 1464 based upon Alfraganus' work.[54]

[49] Sarton, *Intro.,* vol. II, pp. 479-500 and vol. III, p. 111; Sabra, 1971, p. 542; Duhem, vol.4, p. 222; Tekeli, pp. 66, 84.
[50] Sarton, *Intro.*, vol. III, pp. 500-501.
[51] Ibid. pp. 594-607.
[52] Ibid, pp. 817-821.
[53] Duhem, vol. 4, p. 468; Al-Farghânî, 1986, p. VI.
[54] Al-Farghânî, 1986, p. VI.

Alfraganus greatly influenced Columbus who used Alfraganus' value for the measurement of the earth. Columbus' theoretical basis for the assumption that the western ocean was not vast was borne out by his practical experience as a sailor. According to a note in his own hand in his copy of "Imago Mundi," Columbus navigated by the erroneous calculations of the 9th century Arabian astronomer Alfraganus. Using Alfraganus' value of 56 and 2/3 land miles per equatorial degree, Columbus assumed that he had only to sail approximately 2,500 miles westward from the Canary Islands in order to reach the Orient. Columbus asserted that his voyages had confirmed the cosmography of "Imago Mundi" and the calculations of Alfraganus.[55] Columbus himself thought that he was navigating according to Alfraganus' value and he wrote: "Observe that in sailing often from Lisbon southward to Guinea, I carefully measured the course ... and in agreement with Alfragan I found that each degree answered to 56 and 2/3 miles. So that we may rely upon this measure."[56]

So even if the *Elements of Astronomy* was a summery of the *Almagest*, it was clear that it differed from the *Almagest* in some aspects. By adding astronomical material from his own time and shortening the text, Alfraganus made Ptolemy's *Almagest* clearer. As a result, the *Elements of Astronomy* was used as a textbook rather than the *Almagest.* For those reasons, in my opinion, the *Elements of Astronomy* of Alfraganus was a kind of "supplement" to the *Almagest*. This could be the reason why *The Elements of Astronomy* was very well-used for such a long time by Western as well as Eastern astronomy.

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[55] Pauline Moffitt Watts, "Prophecy and Discovery: On the Spiritual Origins of Christopher Columbus' 'Enterprise of the Indies'," *American Historical Review*, February 1985, pp. 73-102.
[56] J. N. Fiske, The Discovery of America, vol. 1, Boston 1983, pp. 377-78; Watts, pp. 73-102.

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