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also **Albatenius, Albategni** or **Albategnius** in the Latin Middle Ages; *astronomy, mathematics*.

One of the greatest Islamic astronomers, al-Battānī was born before 244/858,[2] in all probability at or near the city of Ḥarrāan (ancient Carrhae) in northwestern Mesopotamia, whence the epithet al-Ḥarrāanī. Of the other two epithets, al-Raqqī, found only in Ibn al-Nadīīm's *Fihrist*, [3] refers to the city of al-Raqqa, situated on the left bank of the Euphrates, where al-Battaānī spent the greater part of his life and carried out his famous observations; al-Ṣābi' indicates that his ancestors (al-Battānī himself was a Muslim; witness his personal name Muḥammad and his *kunya* Abū 'Adb Allāh) had professed the religion of the Ḥarranian Ṣabians, [4] in which a considerable amount of the ancient Mesopotamian astral theology and star lore appears to have been preserved and which, tolerated by the Muslim rulers, survived until the middle of the eleventh century. The fact that al-Battāanīl's elder contemporary, the great mathematician and astronomer Thābit ibn Qurra (221/835–288/901) hailed from the same region and still adhered to the Ṣabian religion, seems indicative of the keen interest in astronomy that characterized even this last phase of Mesopotamian star idolatry. As for the cognomen (*nisba*) al-Battānī. no reasonable explanation of its origin can be given. Chwolsohn's conjecture[5] that it derives from the name of the city of Bathnae (or Batnae; Gr., Syr., Βατναι Baṭnaāan) near the ancient Edessa, was refuted by Nallino[6] with the perfectly convincing argument that the possibility of a transition of Syriac ṭ into Arabic *t* (Baṭnāan to Battāan)has to be strictly excluded; since there is no evidence of the existence of a city or town named Battān, Nallino suggests that this name, rather, refers to a street or a district of the city of Ḥarrāan.

Nothing is known about al-Battāanīl's exact date of birth and his childhood. Since he m ade his first astronomical observation in 264/877, Nallino is on safe ground assuming the year 244/858 as a *terminus ante quem for* his birth. His father, in all probability, was the famous instrument maker Jāabir ibn Sināan al-Ḥarrānī mentioned by Ibn al-Nadīm, [7] which would explain not only the son's keen astronomical interest but also his proficiency at devising new astronomical instruments,. such as a new type of armillary sphere.

On al-Battānīl's later life too the information is scanty. According to the Fihrist[8] and to Ibn al-Qufṭi's *Ta'rīkh al-Ḥukamā'*[9] al-Battānī was

... one of the illustrious observers and foremost in geometry, theoretical and practical [lit., computing] astronomy, and astrology. He composed an important *zīj* [i.e., work on astronomy with tables] containing his own observations of the two luminaries [sun and moon] and an emendation of their motions as given in Ptolemy's Almagest. In it, moreover he gives the motions of the five planets in accordance with the emendations which he succeeded in making, as well as other necessary astronomical computations. Some of the observations mentioned in his Zīj were made in the year 267 h.[10] [a.d. 880] and later on in the year 287 h. [a.d. 900]. Nobody is known in Islam who reached similar perfection in observing the stars and in scrutinizing their motions. Apart from this, he took great interest in astrology. which led him to write on this subject too; if his compositions in this field [I mention] his commentary on ptolemy's *Tetrabiblos*.

He was of Ṣabian origin and hailed from Ḥarrāan. According to his own answer to ja'far ibn al-Muktafī's question, he set out on his observational activity in the year 264 H. [a.d. 877]and continued until the year 306 H. [a.d. 918]. As an epoch for his [caralog of] fixed stars in his Zīj he chose the year 299 H. [a.d. 911].[11]

He went to Baghdad with the Banuaposl-Zayyāt, of the people of al-Raqqa. on account of some injustice done them [12] On his way home, he died at Qaṣr al-Jiṣṣ in the year 317 H. [a.d. 929.].[13]

He wrote the following books: *Kitāb al-Zīj [Opus asteronomicum*]. in two recensions; [14]*Kitāb Maṭāli' al-Burūj* [" On the Ascensions of the Signs of the Zodiac"]; [15]*Kitāb Aqdār al-Ittiṣālāt* [" On the Quanities of the Astrological Application"]. composed for abu'l-Ḥasan ibn al-Furāt: *Sharḥ Kitāb al-Arba'a li-Baṭlamiyūs* ["Commentary on Ptolemy's *Tetrabiblos"*].[16]

It seems to have been a widespread belief among Western historians that al-Battānī was a noble, a prince, or even a king of Syria. Not the slightest allusion to it can be found in Arabic writers, so the source to it can be found in Arabic writers, so the source of this misunderstanding must be sought in Europe. The earliest reference quited by Nallino [17] is Riccioli's *Almagestum novum*, [18] where al-Battani is called "dynasta Syriae." J. F. Montucla [19] makes him a "commandant pour les califes en Syrie" and J. LaLande[20] a "prince arable," as does J.-B. Delambre [21] probabley on LaLande's authority, since he expressly says that he used a copy, formerly in LaLdne's possession, of the 1645 Bologna edition of al-Battānī's Zīj. although its tilte contains no reference to the author's alleged nobility.[22]

From al-Battānī's work, only one additional fact on his life can be derived: he mentions in his Zīj[23] that he observed two eclipses, one solar and one lunar, while in Antioch, on 23 January and 2 August A.D. 901, respectively.

The book on which al-Battānī's fame in the East and in the West rests is the Zīj. his great work on astronomy. Its original title, in all probability, was that indicated by Ibn al-Nadīm and Ibn al-Qifṭī: Kitāb al-Zīj. or just al-Zīj. Later authores also often call it al-Zīj al-Ṣabi' ("The Ṣabian Zīj")[24] The word Zīj, derived from the Middle Persian (Pahlavi) Zīk (modern Persian, zīg), originally meant the warp of a rug or of an embroidery. As Nallino points out[25] by the seventh century this had become a technical term for astronomical tables. In Arabic, it soon assumed the more general meaning "astronomical treastise," while for the tables themselves the word *jadwal ("little river")* came into use.[26]

Of the two recensions mentioned by Ibn al-Qifṭī, the first must have been finished before 288/900 because Thābit ibn Qurra, who died in February 901, mentions one of its last chapers. [27] Since the manuscript preseved in the Escorial[28] and the Latin version by Plato of Tivoli (Plato Tiburtinus) contain the two observatgions of eclipses mentioned above, the first of which occurrred immedialtely before, and the second six months after, Thābit's death, Nallino concluds[29] that they must both have been copied (or translated) from the second recension.

In the preface to the Zīj, [30] al-Battani tells us that errors and discrepancies found in the works of his predecessors had forced him to compose this work in accordance with Prolemy's admonition to later generations to improve his theories and inferences on the basis of new observations, as he himself had done to those made by Hipparchus and others.[31] The Arabic version of the *Almagest*, on which he relied, seems to have been a translation from the Syriac, which Nallino shows on several occasions was not free from errors. All quotations from the *Almagest* are carefully made and can be verified.

A comparison of the Zīj with the *Almagest* at once reveals that it was far from al-Battānī's mind to write a new Almagest. To demonstrate this, it suffices to point out a few striking differences:

The arrangement of the fifty-seven chapters is dicated by practical rather than by theoretical considerations. Thus, contrary to al-Farghānī, who, writing half a century before al-Bettānī, devotes his nine first chapers[32] to the same questions that are treated in *Almagest* I, 2–8 (shpherical shape of the heavens and of the earth: reasons for the earth's immobility: the earth's dimensions and habitability: the two primary motions; etc.), al-Battānī starts his Zīj with purely pratical defionitions and problems: the division of the celestial sphere into signs and degrees, and prescriptions for multiplication and division of sexagesimal fractions. In chapter 3, corresponding to *Almagest* I, 11, he develops his theory of trigonometrical functions (see below); in chapter 4 he presents his own observations that resulted in a value for the obliquity of the ecliptic (23°35′) that is more than 16′ lower than Ptolemy's (23°51′20″; *Almagest* I, 12);[33] the next chapers (5–26), corresponding roughly to *Almagest* I, 13–16 and the whole of Book II, contain a very elaborate discussion of a great number of problems of spherical astronomy, many of them devised expressly for the purpose of finding solutions for astrological problems.

The Ptolemaic theory of solar, lunar, and planetary motion in longitude is contained in chapters 27–31. Then follows a discussion of the different eras in use and their conversion into one another (chapter 32),[34] serving as an introduction to the next sixteen chapters (33–48), in which detailed prescriptions for the use of the tables are given (chapters 39 and 40 deal with the theory of lunar parallax and the moon's distance from the earth, necessary for the computation of eclipses). Chapters 49–55 treat of the the chief problems in astrology: chapter 55 has the Arabic title "Fī ma'rifat maṭāli' al-burūj fī-māa bayna 'l-awtād fī-arbā' al-falak" (" On the Knowledge of the Ascensions of the Signs of the Zodiac in the Spaces Between the Four Cardinal Points of the Sphere"),[35] which is identical with Ibn al-Nadīm's title of one of al-Battānī's minor works. It is possible that this chapter actually existed as a separate treatise, but it is also possible that it was only due to an error that we find it listed separately in the *Fihrist* and in later biographies.

Of the two last chapters, 56 deals with the construction of a sundial indicating unequal hours (*rukhāama*, "marble disk"), and 57 with that of a novel type of armillary sphere, called *al-bayḍa* ("the egg"), and of two more instruments, a mural quadrant and a *triquetrum* (Ptolemy's τεταρτημόριον *Almagest* I, 12, and ῤγανον παραλλακτικόν *Almagest* V, 12).

Contrary ton Ptolemuy's procedure in the *Almagest*, the practical aspect of the Zīj is so predominant that it sometimes impairs the clarity of exposition and even evokes a totally wrong impression. this is felt more' than anywhere else in chapter 31, which deals with the theory of planetary motion. The Arabic text consists of little more than five pages, only three of which deal with the theoretical (i.e., kinematic) aspect of the problem. Here the reader trained in Prolemy's carefully and sometimes slightly circumstantial way of exposing his arguments, and familiar with al-Farghāanīi's excellent *epitome*, will needs be struck by the brevity and—this is worse—by the insufficiency and inaccuracy of al-Battānī's outline. to point out some particularly bewildering features; [36] No distinction is made between, on the one hand, the theory of the three superior planets and Venus, and, on the other, the ingenious and intricate mechanism devised by

Ptolemy to represent Mercury's perplexing motion. With the aid of only one figure, which is wholly defective and misleading, al-Battānī tries—and of course fails—to demonstrate the motion of all of the five planets alike. In this figure, reproduced here (Fig. 1), the equant (*punctum aequans*), the essential characteristic of the Ptolemaic theory, is not indicated, nor is it referred to in the accompanying text, according to which the center, *M*, of the deferent itself is to be regarded as the center of mean motion (!). Moreover, the nodes of the planetary orbit are placed at right angles to the line of apsides (which of course is not true of any of the five planets), and for the planet' position in the epicycle, in the two cases indicated in the figure, the very special points are chosen in which the line earth-planet is tangent to the epicycle.

It is easy to point out all these errors and, as G. Schiaparelli has done at Nallino's request,[37] to show how the figure ought to look, were it drawn in accordance with Ptolemy's theory (Fig. 2). But Schiaparelli's surmise that al-Battānī's correct figure was distorted by some unintelligent reader or copyist does not exhaust the question. For, if so, who would dare at the same time to mutilate the text in such a way that the equant disappears from it altogether? And which uninitiated reader might have had the courage to suppress in this context the theory of Mercury, without which Ptolemy's system of planetary motions remains a torso? Since the Escorial manuscript and Plato of Tivoli' translation[38] have both the same erroneous figure and text, the alleged mutilation must have occurred, at the latest, in the eleventh century, during the lifetime of the great Spanish-Muslim astronomer al-Zaeqālī (Azarquiel) or of one of his renowned

predecessors. To me it seems utterly improbable that an arbitrary disfiguring of one of the crucial chapters of al-Battānī's great *Zīj* could have escaped their attention and that no measures should have been taken to delete such faulty copies and to restore the original text. I am inclined, thus, to ascribe the matter to al-Battānī's carelessness rather than to anything else, in view of the circumstance that no other reasonable conjecture seems to square with the facts. Similar examples can be adduced from the writings even of the greatest astronomers; in this contest I refer to a grave slip (although of lesser consequence) committed by al-Bīrūnī, which I have pointed out in an earlier paper.[39] It need not be emphasized that al-Battānī actually knew better: to prove this, it suffices to mention that his tables of planetary motion. far more elaborate than Ptolemy's, could not have been drawn up without a thorough familiarity with the Ptolemaic system, including all its finesses and intricacies.

While al-Battānī takes no critical attitude toward the Ptolemaic kinematics in general, he evidences, as said before, a very sound skepticism in regard to Ptolemy's practical results. Thus, relying on his own observations, he corrects—be it tacitly, be it in open words—Ptolemy's errors. This concerns the main parameters of planetary motion no less than erroneous conclusions drawn from insufficient or faulty observations, such as the invariability of the obliquity of the ecliptic or of the solar apogee.

The Islamic astronomers' interest in the question of the variability of the obliquity of the ecliptic started astonishingly early. This is the more remarkable because the effect, being on the order of magnitude of 0.5″ a year, is definitely of no practical use. According to lbn Yūnus (*d*. 399/1009),[40] the first measurement since Ptolemy was made shortly after 160/776, yielding 23° 31′, which was 4′-5′ too low;[41] after this he reports quite a number of different values, all in the vicinity of 23° 33′, made during and after the time of al-Ma'mū (*d*. 215/830). Hence, al-Battānī's determination is nothing exceptional, but it is important forus because hegives a careful description of the procedure by which his value (23° 35′), which squares perfectly with the modern formula, was obtained.

In chapter 28 of the *Zīj*, al-Battānī discusses his observations of the lengths of the four seasons, from which, employing Hipparchus' method as described in *Almagest* III, 4, he infers that the sun's apogee and its eccentricity have both changed since antiquity: the apogee, found at 65° 30′ by Hipparchus and erroneously claimed to be invariable by Ptolemy, had moved to 82° 17′, and the eccentricity had diminished from 2^{p} 29′ 30″ to 2^{p} 4′ 45″ (1^{p} = 1/60 of the radius).

Despite contrary assertions, however, al-Battānī was not the first since Ptolemy tocheck on these values. According to al-Bīrūnī,[42] who relies on Abū Ja'far al-Khāzin's (*d*. *ca*. 350/961) commentary on the *Almagest*, the first observminations serving the purpose of a new determination of the apogee were carried out, on the basis of the specially devised new "method of the four *fuṣū*," [43] in the Shammāsiyya quarter of Baghdad in a.d. 830. In spite of this methodological improvement, the result was extremely poor: it yielded a value no less than 20° too small. One year after, Thābit ibn Qurra or the Banū Mūsā, using the old Ptolemaic method, obtained the excellent value 82° 45′.[44] Comparing this with Hipparchus' value (65° 30′) and rejecting Ptolemy' obviously wrong confirmation of the latter, he (or they) found that the motion of the apogee amounts to 1° in sixty-six years. Then, from the fact that he had also found the same value for the motion of precession, Thābit concluded that they must of necessity be identical—in other words, that the apogee of the sun remains fixed once and for all in regard to the fixed stars (for this type of reasoning and concluding, European scholasticism has invented the term "Ockham's razor").

Al-Battānī's value for the sun' apogee (82° 17′)is not quite as good as Thābit's (or the Banū Mūsā's), although the perfect accordance of the latter with the one resulting from the modern formula must be considered to some degree accidental: for a.d. 831, Leverrier's formula yields 82° 50′ 22″ (Thābit. 82° 17′). It is of interest in this context that Hipparchus' value, 65° 30′ (ca. 140 b.c.). also squares exceedingly well with the modern,65° 21'.

Thus, it is evident that al-Battānī has no special claim to the discovery of the motion of the solar apogee. Apart from this, he was no more able than Thaābit to decide whether this motion was identical with that of precession. It was only 150 years later that al-Biīrūniī furnished the theoretical foundation for such a distinction,[46] but even he had to admit that the data at his disposal did not allow him to make a conclusive statement. The first who actually made a clear (and very correct) numerical statement concerning the proper motion—1° in 299 Julian years, or 12.04″ in one year (modern: 1.46″), was al-Zarqaāliī (second half of the eleventh century)of Toledo. But his result is impaired by his belief in the reality of trepidation, which he shared with Thaābit.

Al-Battaāniī's value for the eccentricity of the solar orbit (2^{p}4′ 45″), corresponding to an eccentricity in the modern sense of 0.017326 (instead of 0.016771, according to our modern formula, for a.d. 880) must be called excellent, while Ptolemy's value (0.0208 instead of 0.0175)is much too high. [47]

Among al-Battaānī's many other important achievements is his improvement of the moon's mean motion in longitude;[48] his measurements of the apparent diameters of the sun and of the moon and their variation in the course of a year, or of an anomalistic month, respectively, from which he concludes that annular solar eclipses (impossible, according to Ptolemy) must be possible;[49] and his new and elegant method of computing the magnitude of lunar eclipses.[50]

For the precession of equinoxes, he accepts and confirms Thaābit's value (1° in sixty-six years), far better than Ptolemy's (1° in 100 years), but about 10 percent too fast (correct, 1° in seventy-two years). Accordingly, his tropical year ($365^d5^h46^m24^s$)is too short by 2^m22^s(correct, $365^d5^h48^m46^s$), while Ptolemy's ($365^d5^h55^m12^s$) is too long by 6^m26^s.

Al-Battaānīi's catalog of fixed stars[51]is far less comprehensive than Ptolemy's (489 as against 1,022 stars). The latitudes and magnitudes are taken over (perhaps with a few corrections) from the *Almagest*, while the longitudes are increased by the constant amount of 11° 10′, which corresponds, for the interval of 743 years between the epochs of the two catalogs (a.d. 137 and 880), to the motion of precession indicated, viz., 1° in sixty-six years.

While Ptolemy's *Almagest* is often cited, his *Tetrabiblos* is mentioned on only one occasion (end of chapter 55). It is uncertain whether al-Battaānīi knew and used Ptolemy's Geography. [52] Ptolemy's *Hypotheses* (called by later authors Kitaāb al-Iqtiṣāṣ or Kitaāb al-Manshūraāt)[53] are made use of in chapter 50, which deals with the distances of the planets, but al-Battaānīi ascribes the underlying theory of contiguous spheres, according to which the distances are computed, to "more recent scientists [who lived] after Ptolemy." Since al Farghaānīi mentions no name at all in this connection, [54] it seems probable that al-Battaānīi's reference to "scientists after Ptolemy" reflects a passage from Proclus' *Hypotoyposis*,[15] in which Ptolemy's name also does not occur, and that Ptolemy's authorship became known only when, some time before al-Biīrūnīi, the *Hypotheses* were translated into Arabic.

Of other astronomical works from antiquity, only Theon of Alexandria's *Manual Tables* are mentioned. In the section of chapter 6 dealing with geographical questions,[56] al-Battaānīi refers to "the ancients" without further specification. Nallino [57] has shown that this expression, there, means Greco-Syriac sources.

In spite of the circumstance that al-Battaānīi, as demonstrated before, has a good deal in common with the Banū Mūsā, Thābit, and al-Farghaānīi, no reference whatever appears in his Ziīj to his Islamic predecessors. In his terminology he abstains from using foreign (Persian or Indian) words, as found in earlier writings of his countrymen, such as *awj* for the apogee of the eccentric (circumstantially called by al-Battaānīi *al-bu 'dal-ab'ad min al-falak al-kharārij al-markaz,* "the [point having] maximum distance in the eccentric"), *jayb* for the sine (al-Battaānīi: *watar munaṣṣaf*,"half-chord," or just *avatar*, "chord"), *buht* for the (unequal) motion of a planet in the course of one day (a concept not used by al-Battaānīi),*jawzahar* for the ascending node (al-Battaānīi: al-ra's, "the head [of the dragon]"), *haylaāj*) for the asttological "significator" or "aphet" (Gr.:αφετης al-Battaānīi: *daliīl*), and so on. [58] His aversion to foreign terms, however, certainly springs not from any "putism of language" but, rather, from the circumstance that the words in question did not occur in the *Almagest* translations at his disposal; this explains why in some cases he does not hesitate to employ clumsy transliterations of Greek terms, such as *affiījiyūn* for 'απόγειον ("apogee") and *Fariījiyūn* for περίγειον ("perigee").

Al-Battaānīi uses the sine instead of the chord (of twice the angle), following the example of his Arab predecessors who had fused into one whole the new Indian notion (*Siddhaānts*) and the old Greek notion. Besides the sine he also employs the cosine (*avatar ma¯yabqaā li-tamaām... ilaā tis'In*, "the sine of the complement of...to 90°") and the versine (R—cosine, called *water raāji'*," returning sine"), for which later authors also employed the term *jayb ma°kūs* ("inverted sine"), as opposed to *jayb mustawiī* ("plain sine") or *sahm* ("arrow"), whence the medieval Latin *Sagitta*. Tangents and cotangents do not occur in al-Battaānīi's formulas, which therefore often become as clumsy as Ptolemy's. He uses them only in his gnomonics, where they refer, as in the *Siddhaāntas*, to a twelve-partite gnomon. For the cotangent, he employs the term ẓill *mabsūṭ* ("umbra extensa" called by others also *ẓill mustawī*, "umbararecta"); for the tangent, *ẓill mautasih* ("umbra extensa"; called by others *ẓill ma°kū* ("umbraversa"). [59] By applying considerations based on the principle of orthographic projection, al-Battānī introduced new and elegant solutions into spherical trigonometry. In Europe, this principle was adopted and developed by Regiomontanus (1436–1476).

The epoch of al-Battānīi's chief era (*Ta'rīkh Dhi'I Qarnayn*, "Epoch of the Two-Horned [Alexander]") is Saturday (mean noon, Raqqa), 1 September 312 b.c., which precedes by thirty days the epoch *Dhu'IQarnayn* used by all other Arabic authors: Monday, 1 October 312 b.c., It is combined with the Julain year; for the months he uses the "Syrian" names: *aylūl* (September), *tishrīn* I and II, *kanū* I and II, *subāṭ, ādhaār, niīsaān, ayyār, haziīraān tammūz, and āb*. The epoch of the Coptic era (Ta'rīkh al-Qibṭ) is Friday, 29 August 25 b.c., while all other Arabs used this term to denote one of the following three: the era of Nabunassar (1 Toth = 26 February 747 b.c.), the era of Philippus Arrhidaeus (12 November 324 b.c., mentioned in the *Almagest* as the "era of Alexander's death"), or the era of Diocletian (29 August 284, also called Ta'rīkh al-Shuhadā', "era of the martyrs").[60]

A Latin translation of the Zīj made by the English Robertus Retinensis (also cited as R. Ketenensis, Castrensis, or Cestrensis; Nallino believes the correct form to be Cataneus), [61] who flourished about the middle of the twelfth century, has not survived. The only Latin version extant is the one by Plato of Tivoli, who flourished in Barcelona in the first half of the twelfth century. This translation was printed twice. The *editio princeps* (Nuremberg, 1537) carries the title *Rudimenta astronomica Alfragrani [sic]*[62]*Item Albategnius peritissimus de motu stellarum ex observationibus tum propriis tum Ptolemaei, omnia cum demonstrationibus geometricis et additionibus Ioannis de Regiomonte;* the title of the second edition (Bologna, 1645), printed without al-Farghānī's *Elements*, is *Mahometis Albatenii de scientia stellarum liber cum aliquot additionibus Ioannis Regiomontani. Ex Bibliotheca Vaticana transcriptus*.

A Spanish translation, made at the order of King Alfonso el Sabio (1252–1284), is preserved in the Bibliothèque de i’Arsenal in Paris.[64]

Although no Hebrew translation of the Zīj seems to have existed, its impact on Jewish scholarship was great. It was mentioned and praised by Abrāhām bar Ḥiyyā’ (*d. ca*. 1136) and Abrāhām ibn ’Ezrā (*ca*. 1090–1167). Maimondides (1135–1204) follows al-Battaānī closely, but without mentioning his name, in the eighth treatise of Book III of his *Mishne* Tōrā which bears the title “Hilkāt qiddūsh. ha-ḥōdesh.”[65]In chapters 12–14 the parameters used (mean motion in longitude of the sun and of the moon, mean anomalistic motion of the moon, equation of the sun) are exactly the same as in al-Battānī’s tables, except that the values for the solar equation are rounded off to minutes.[66] In his prescriptions for determining the limits of visibility of the new moon, too, Maimonides closely follows the elegant method devised by al-Battānī.

Among Islamic astronomers and historians, al-Battānī holds a place of honor. The great al-Bīrūnī composed a book entitled *Jala’ al-Adhhān fi Zīj al-Battānī* (“Elucidation of Genius in al-Battānī’s zīj”),[67] and Ibn Khaldūn (1332–1406)[68] counts his works among the most excellent in Islamic astronomy.

In Byzantine writings, al-Battānī’s name is mentioned as ὁΠατανη Greek translations apparently have not existed. A great many medieval Latin authors who knew the Zīj or at least mention the name of its author can be enumerated. Among them are Henry Bate (1246-*ca*. 1310), who, in composing his *Magistralis composition Astrolabii anno* 1274 *scripts*, makes ample use of the contents of the Zīj— not without giving its author due credit for it; Gerard of Sabbionetta; Albertus Magnus; Lēvi ben Gersōn (in the Latin translation of his *Astronomy*); [69]and, not least, Regiomontanus, whose keen interest in the work is evident from the great number of annotations in his handwriting found in his copy of Plato of Tivoli’s (1423–1461)*Theoricae planetarum*, printed and edited by Regiomontanus, [70] mentions al-Battānī’s name on only one occasion (fol. 18r), [71] where he relates that “Albategni” contrary to those who defended the theory of trepidation, claimed that the stars move 1° in sixty years and four months, [72] and always toward the east. Since all Arab astronomers, in accordance with the text and the translations extant, state that al-Battānī accepted a motion of 1° in sixty-six years, [73] it is a mystery how this erroneous value, which cannot be due to a copyist’s slip, could have found its way into Peurbach’s book. As for his masterful presentaion of planetary kinematics according to Ptolemy, it is a matter of course— in view of what I have said about al-Battānī’s chapter 31 [74]— that it could not be modeled after al-Battānī’s fallacious chapter, while the influence of al-Farghānī seems perceptible in many places.

The indebtedness of Copernicus to al-Battānī is well known. He quotes him fairly often, especially— as does Peurbach—in the chapters dealing with the problems of solar motion and of precession.[75] Much more frequent references to him are found in Tycho Brahe’s writings and in G. B. Riccioli’s *New Almagest*;[76] in addition, Kepler and—ony in his earliest writings— Galileo evidence their interest in al-Battānī’s observations.

From the point of view of the history of astronomy, the names of two men are to be mentioned, although with a totally different weight. In 1819 Delambre published his Histoire de l’sastronomie du moyen âge.[77] In chapter 2 he devotes fifty-three pages to a very thorough analysis of the *Zīj*, on the basis of the Bologna edition of plato of Tivoli’s translation. Even to the modern reader the chapter is of interest, in spite of the fact that a certain superciliousness, characteristic of all Delambre’s historical works, in sometimes embarrassing. For it is, of course, not as interesting to learn how one problem or the other could have been solved in a less circumstantial way as it would be to get an insight into the historical situation in which al-Battānī’s work came into being. This, however, was beyond Delambre, for even if he had possessed a sufficient knowledge of Arabic (he had none at all), the only extant manuscript would not have been within his reach. Thus he had to rely on Plato of Tivoli’s version, whose errors and misunderstandings naturally led him astray in more than one case.

Eighty years after Delambre, in 1899, the young Italian orientalist C. A. Nallino published his model edition of the complete Arabic text of al-Battaānī’s *Zīj*.[78] The two other volumes, containing a Latin translation and exceedingly detailed and learned commentaries, followed during the next eight years. In a time like ours, characterized by the abuse of superlatives, it is hard to describe Nallino’s work in appropriate terms. Al-Battānī Arabic style, which at first sight looks simple and straightforward, but which reveals itself difficult and even obscure on many occasions, is rendered here in a Latin whose purity and clarity deserve the highest praise. In reading this book, which is Nallino’s *magnum opus*, one understands that it was not due purely to a whim that he decided to compose it in Latin. As for the technical aspect, Nallino’s work bears witness to a great familiarity with the mathematical and astronomical problems occurring in al-Battaānī’s *Zīj*, and no less with the historical facts that form its background. This third Latin translation, written eight centuries after the first two, will always stand as one of the masterpieces of the history of science.

Until recently it was believed that none of the three minor works (all of astrological content) listed in the *Fihrist* and in Ibn al Qifṭī’s *Ta’srīkh al-ḥukamā’*[79] had survived, since, on the one hand, the authenticity of a manuscript preserved in Berlin seemed dubious[80] and, on the other, the only extant manuscript expressly titled “Commentary on Ptolemy’s *Tetrabiblos*,” which figures still in Casiri’s catalog,[81] could no longer be found in the Escorial library as stated by H. Derenbourg[82] in 1884 and confirmed by Nallino in 1894 and by Father Pedro Blanco Soto in 1901.[83] Fortunately, however, the lost manuscript seems to have been recovered: in H.-P.-J. Renaud’s new catalog,[84] it is listed as no. 969, 2 (not 966, as in Casiri), under the title *Kitāb al-arba‘ maqālāt fī ahkām ‘ilm al-nujūm*, the copy dating from 939/1533 and comprising sixty folios. The word *sharḥ* (“Commendtary”) does not appear in the title, but Renaud’s and Casiri’s descriptions read “Commentary” on Ptolemy’s *Quadripartitum*” (i.e., *Tetrabiblos*). It will require a special study to establish whether the Berlin and the Escorial manuscripts are identical in text. The fact that the latter also contains tables (which the Greek original does not have) suggests the existence in the text of rules and prescriptions for their use that might justify calling it a “commentary.”

In this context,[85] Nallino mentions that the Egyptian 'Alī ibn riḍwān (latinized as Haly Heben Rodon, *d*. 453/1061) states that he has never come across any paraphrase (*glossa*) of the *Tetrabiblos* at all, whereas abu'sl-Hasan ‘Alī ibn Abi'l-Rijaāl (Albohazen Haly filius Abenragel, *fl. ca*. 1050) counts al-Battānī among those who, like Ptolemy, attributed special importance to astrological prognostications made on the basis of eclipses that occur during the years of planetary conjunctions. Nallino evidently believes this refers to *Tetrabiblos* II, 6, [86] which deals with the same subject matter. The case, however, is different. In the Saib (Ismā‘īl Sā'ib) Library at Ankara there is preserved a volume (no. 1/199) containing three different works, the second of which (fols. 27r–42v) bears the title *Kitā* [*Muhammad ibn*] Jābir *b*. Sinā *al-Harrānī fī dalāil al-qirānāt wa'l-kusūfāt* ("Jābir... al-Battānī's Book on the Significations of Conjunctions and Eclipses").[87] It is undoubtedly this book, not listed in any of the great oriental bibliogrphies, on which bears Albohazen's remark. Judging from a cursory inspection of a photostatic copy in the possession of the Institute for the History of Science of the University of Frankfurt, I see no reason to doubt its authenticity.

Another manuscript, entitled *Tajrīd usū tarkīb al-juyūb*[88] ("Construction of the Principles of Establishing [Tables of] Sines"), also carries al-Battānī's name. From the fact that al-Battānī, at least in his *Zī* avoids using the term *jayb* (plural, *juyūb*) for "sine," [89] it might be inferred that this manuscript is spurious.

For a number of other definitely spurious works existing only in Latin translations, see the list (with comprehensive discussions) found in Nallino.[90]

NOTES

1. The transliteration system used in this article is that of the *Encyclopaedia of Islam*, 2nd ed., with the following simplifications: *j instead of d; q* instead of *K* (NB: *qu* is pronounced *ku*, not as English *qu*); no underlinings to indicate compound consonants: *kh* instead of *kh* for the Scottish *ch*-sound, *th* and *dh* for the English voiceless and voiced *th*, respectively.

2. Of two numbers separated by a slash, the first indicates the year according to the Muslim calender and the second its beginning according to the Christian Calender. In quotations from Arabic texts, Muslim years are denoted by H. (Hegira), and the corresponding christian years are added in brackets, Note that the Muslim year is 3 percent shorter than the Julian.

3.*Kitāb al-Fihrist* (composed *ca*. a.d. 987 by Ibn al-Nadïm), G. Flügel, *ed*. (Leipzig, 1871–1872), I, 279. *See also* C.A. Nallino, *Al-Battānï sive Alhutenii Opus astronomic um, ad fidem codicts escurialensis arabice editum, latine versum, adnotat ionibus instrucvtan*, I (Milan. 1903), viii ff. This *magnum opus* (Vol. II, 1907; Vol. III, 1899), cited hereafter as O.A., will always remain the chief' source of' information in Arabic astronomy and on al-Battānï in particular.

4. See B. Carra de Vaux, "al-Ṣābi'a," in *Encyclopaedia of Islam*, Ist ed., IV; and, for comprehensive information (although obsolete in certain parts), D. Chwolsohn, *Die Ssabier und der Ssabismus*, Vols. I/II (St. Petersburg, 1856).

5.*Die Ssabier*, I, 611.

6. O.A., I, xiii.

7. Fithrist. p, 285.

8. p. 280

9. J. Lippert, ed. (Leipzig, 1903), p. 280. Ibn al-Qiftï, the author of this "History of Learned Men," died in 646/1248. His chapter on al-Battānï (which I follow in my translation), according to his own words, relies on Ṣā‘id al-Andalusï. It contains information not found in the *Fihrist*.

10. Owing to a scribal error, the *Fihrist* and Qifṭï have 269.

11. Instead of 299/911, read 267/880 (scribal error). The epoch of the catalog is actually 267/880.

12. The meaning, evidently, is "because unjust taxes had been requested of them," The text leaves open whether "them" includes al-Battānï. Cf. Nallino, *O.A*., I. viii. As for the Banu'l-Zayyāt, Nallino (*ibid*., pp. xvii f.) considers it almost certain that they are the descendants of the famous poet and vizier ‘Abd al-Malik ibn Abān al-Zayyād (executed by Caliph Mutawakkil in 233/847). It was to his great-grandson's son, Abü Tālib Ahmad al-Zayyād, that Ibn Wahshiyya dictated, in 318/930, his alleged "translation from the Syriac" of his hook on the Nabataean agriculture.

13. In Ibn Khallikān' (*d*. 681/1282) biographical dictionary (Eng, trans, by Mac Guckin de Slane, Paris-London, 1843–1871, IV, 317–320; Arabic original: *Ibn Challikan, Vitate illustration Virorum*, F. Wüstenfeld, Göttingen, 1835–1842, no, 719 [cited

after O.A., I, iix, n. 6]), the place of al-Battānï's death is called Qasr al-Hadr .Nallino has shown (O .A .,p .xviii)that Jiss (of which Hadr is nothing but a graphical corruption)is the correct form .

14. Ibn al-Nadïm and Ibn Khallikān add the words "a first and a second; the second is better."

15. Ibn al-Nadïm adds the words *fi mā bayana arbā'al-falak* ("in the spaces between the four cardinal points of the sphere"). The book gives mathematical solutions of the astrological problem of finding the direction of the *aphet* (tasyïr al-dalïl).

16. Not listed by Ibn al-Nadïm.

17.*O.A*., I, xvii, n. 1.

18. Bologna, 1651, 11, xxix.

19.*Ili.stoire dens mathematiques*, new ad. (Paris, 1797–1800), I,363.

20.*Astronomic*, 3rd ed. (Paris, 1792), I, 123.

21.*Histoire de l'astronomie, du moyen âge* (Paris, 1819; repr. New York—London, 1965), pp. 4, 10.

22. In this title, the author is called "Mahometus, filius Geber, filius Crueni, qui vocatur Albategni." The strange name Cruenus is obviously due to a misreading of Sinanus, which may have been found spelled Cinenus.

23. Ch. 30, O.A., I, 56.

24. Thus Ibn Khallikān and Ḥājjï Khalïfa (1017/1609–1067/1657); *see Haji Khalfae Lexicon bibliographbicum et encyclopaedicum, ed*, and trans., with commentary, by G. Fügel (Leipzig-London, 1835–1858), III, 564, no. 6946.

25.*O.A*., I, xxxi, n. 3.

26. In Byzantine Greek, the word is found as ζη̄α and identified with σβταξα; See *O.A*.., I, xxxi, n. 5.

27. Ch. 57, which treats the theory of trepidation, refuted by al-Battānï but accepted by Thābit. The reference to al-Battānï is found in Thaābit's letter to Isḥā ibn Ḥunayn, Preserved by Ibn Yü. See *O.A*., I, 298.

28. Originally no. 903 (M. Casiri, *bibliotheca arabico-hispanica Escurialensis*, Madrid, 1760, I, 342–343), now no. 908. Unbelievable as it sounds, only this copy of one of the most important books written in the Middle Ages has survived in the Arabic original.

29.*O.A*., I, xxxii.

30. Ch. I, *O.A*., 1, 5.

31.*Almagest*, III, 1 (German trans. by Karl Manitius, *Des Claudius Ptolemāus Handbuch der Astronomic*, Leipzig. 1912, p. 141). The wording there is a little different and contains no such express "admonition" or "order" (*amr*).

32. Except for ch. 1, which deals with the various eras and their mutual conversations, practically identical with al-Battānï's ch. 32. Cf. J. Golous' ed. and Latin trang: *Muhammedis fil. Ketiri Ferganensis, qui vulgo Alfraganus dicitur, Elementa astronomica* (Amsterdam, 1669).

33. See W. Hartner, "The Obliquity of the Ecliptic According to the Hou-Han shu and Ptolemy," in *Silver Jubilee volume of the Zinbun-Kagaku-Kenkyusyo* (Kyoto, 1954), pp. 177–183;repr. in Hartner's Oriens-Occidens (Hildesheim, 1968), pp. 208–214.

34. See n. 32.

35. See p. 508 and n. 15.

36. See the figure and the accompanying text, *O.A*., III, 96 f. (Arabic) and *O.A*., I, 64 f. (Latin), from which Figure 1 in the text is reproduced.

37.*O.A*., I, 237 f. Figure 2 in the text is reproduced from Schiaparelli's.

38. Nallino, *O.A.*, 1, lxii, states that the Arabic original, from which Plato of Tivoli translated, and the Excorial MS (written, according to Nallino, about 1100) must both have belonged to the same archetype.

39. "Mediaeval Views on Cosmic Dimensions and Ptolemy's Kitāb al-Manshūrā," in *Mèlanges Alexandre Koyrè*, I (Paris, 1964), 254–282; repr. in W. Hartner, Oriens-Occidens (Hildesheim, 1968). pp. 319–348.

40. Bibliothèque Nationale, MS Ar. 2495, p. 222 (cited after *O.A.*, I, 157).

41. For an exact verification and comparison with modern formulas (Newcomb, de Sitter), the effect of refraction and of solar parallax has to be taken into account; by this the values derived from observation are reduced by about 40", which of course is of no interest here (see n. 33).

42. Mas'ūdic Canon, VI, chs. 7 and 8 (*al-Qānūnal-Mas'ūdī*, pub, by The Dā'irat al-Ma'ārif Oṣmānia, II (Hvderabad-Dn., 1374/1955), pp. 650–685. Cf. W. Hartner and M. Schramm, "Al-Bīrūnī and the Theory of the Solar Apogee: An Example of Originality in Arabic Science," in A.C. Crombie, ed., *Scientific change* (London, 1963), pp. 206–218.

43. Observation of the sun's passage through the points 15' Taurus, 15' Leo, 15' Scorpio, and 15' Aquarius.

44. According to the *Kitā fī sanat al-shams bi'l-arṣād*, Ms London India Office no. 734, fol. 6r, II, 13 ff.

45. Schaiparelli (*O.A.*, I, 215) gives the erroneous value 83° 50´51´´ for A.D. 884.

46. Cf. Hartner and Schramm (n. 42), pp. 216–218.

47. Cf. *O.A.*. 1, 213, For comparing the ancient with the modern values (elliptic eccentricity), the former must of course be halved: $2^p4'45''/60 = 0.034653 = 2\ 0.017326$.

48. C.f. *O.A.*, I, 225 f.

49. Cf. *ibid.*, 58, 236. He either is unaware or avoids mentioning that his own observations of the moon's apparent diameter at apogee ($d_1 = 29.5'$) *and at perigee* ($d_2 = 35.3'$) *are in the ratio 5:6. According to Ptolemy's and his own theory, they ought to be in the ratio 17:33, or nearly 1:2.*)

50. Cf. *ibid.*, 99 f.

51. Arabic text, *O.A.*, III 245–274; Latin, *O.A.*, II, 144–177.

52. Cf. *O.A.*, I, xli and 20 (end of ch. 4.).

53. See W. Hartner, "Mediaeval Views on cosmic Dimenstions" (n.39), and B. R. Goldstien, "The Arabic Version of Ptolemy's *Planetary Hypotheses*," in *Transactions of the American Philosophical Society*, n.s. **57** , pt. 4 (1967).

54. Ch. 21, pp. 80–82; see n. 32.

55.*Procli Diadochi Hipotyposis astrononvcarum positionum*, ed. and trans. into German by K. manitius (Leipzig, 1909), ch. 7, 19 (p. 220), As I have shown in "Mediaeval Views..." (see n. 39), it can no longer be doubted that the idea of contiguous sphres was conceived by Ptolemy. The final proof for the correctness of my assertion has been furnished by Goldstein (see n. 53), who found that the extant Arabic and Hebrew versions of the *Hypotheses* contain the part missing from J. L. Heiberg's edition (*Claudii Ptolemaei opera*, II, *Opera astronomica minora*. Leipzig, 1907, 69–145) at the end of Book I. it has exactly the same parameters and ratios as indicated in my paper.

56.*O.A.*, I. 17–19.

57.*Ibid.*, 165–177.

58. Cf. *ibid.*, xlii f.

59. On the back of astrolabes, preference is given to the terms *ẓill mabsū* for the shadow cast by a vertical gnomon on a horizantal plane, and *ẓill mak'* (sometimes *mankū*) for the shadow of a horizontal gnomon on a vertical plane.

60. For further information, see *O.A.*., I, 242–246.

61. See *O.A.*, I, xlix f. There can be no doubt that the name means Robert of Chester, a friend of Hermannus Dalmata. He was the first to translate the Koran into Latin (1143) and also one of the first translators of Muhammead ibn Mūsā al-Khwārizmī's *Algebra*. See L. c. Karpinksi, "Robert of Chester's translation of al-Khowarizmi," in *Bibliotheca mathematica*, **11** (1911), 125–131. Robertus Retinensis is not identical with Robertus Anglicus, who lived in the thirteenth century.

62. Cf. the other edition of al Farghānī's *Elements*, quoted in n.32. The division into chapters is different in the two editions.

63. for C.A. Nallino's Latin translation and edition, see p. 513.

64. Described by Rico y Sinobas in *Libros del saber de astronomia del Rey D, Alfonso X de Castilla*, V, pt. 1 (Madrid, 1867), 19 f.

65. Cf. *O.A.*., I, xxxiv; and S. Gandz, trans., "The Code of Maimonides, Book III, Treatise 8, Sanctification of the New Moon; With Supplementation and an Introduction by,I. Obermann and an Astronomical Commentary by Otto Neugebauer," in J. Obermann, ed., *Yale Judaica Series*, XI (New Haven, 1956), 47–56.

66.*O.A*.., II, 20, 22, 75, and 78 ff. Note that for the sun's mean motion, the values given in the tables on pp. 22 and 75 differ by 1″ and 2″ for the arguments 9^d and 10^d. The figures on p. 75 are the correct ones: 9^d, 8°52′15″; 10^d, 9°51´23″.

67.*Jalā' al-adhhā fī Zīj al-Battānī*, according to al-Bīrūnī's own bibliogrpahy, published in E. Sachau, ed., *Chronologie orientalischer Völker von Albêrûnî* (Leipzig, 1878), p. xxxxvi.

68. Cf. de slane, trans., *Les prolégoménes d'lbn Khaldūn* (Paris, 1863–1868), III, 148; cf. F. Rosenthal, trans., *Ibn Khldûn, The Muqaddimah*, III (New York, 1958), 136.

69. Cod. Vat. Lat. 3098 (cited after *O.A*.., I, xxxvi).

70. Nuremberg, *ca*. 1473 (the exact year of this incunabulum cannot be established).

71. In the chapter "De moto octavae sphaerae." The folios carry no numbers.

72. "Albategni vero dicebat eas moveri uno gradu in sexaginta annis et quatuor mensibus semper versus orientem."

73. Cf. p. 510.

74. See p. 509.

75. See e.g., Copernicus, *De revolutionibus*, III, 13.

76. See n. 18.

77. See n. 21.

78. See n. 3.

79. See p. 508.

80. Staatsbibliothek, MS no. 5875; see W. Ahlwardt, *Verzeichniss der arabischen Handschriften der Kgl. Bibliothek zu Berlin*, V, 273 f. The MS, written *ca*. 800/1397 by Ahmed ibn Tamīm and comprising 62 folios, lacks the title page and the first pages of the text. At the end is the grammatically incorrect phrase *tamma kitā al-arbaa* [*sic!*] *sharh al-Battānī* ("Here ends the Book of the Four [Maqālas] of al-Battānī's commentary"), which obviously alludes to Ptolemy's *Tetrabiblos*. According to Ahlwardt, no division into four *maqālas* and no sections marked as commentaries (*sharḥ*) are reocgnizable. As Nallino (I, xxi ff,) has shown, the subjects treated and their sequence are, with few exceptions, those of the *Tetrabiblos*.

81. See n. 28. I, 399:" CMLXVI, nr. 2°: Commentarius in

Quadripartitum Ptolemaei de astrorum iudiciis: subiecits tabulis. Auctor est vir clarissimus Mohammad Ben Geber Albategnius."

82.*Les manuscrits arabes de* I'Escurial (Paris, 1884), I, xxiv.

83.*O.A.*, I, xx.

84. “Les manuscrits arahes de I’Escurial décrits d’saprès les notes de Hartwig Darenbourg,” in *Publications de I’École Nationale des Langues Orientales Vivantes*, 6th ser., **5** , 2. fasc. 3 (1941), 116.

85.*O.A.*, I, xxiii.

86. Cited after the anonymous Latin translation *C. Ptolemaei de praedictionibus astronomicis, cui titulum fecerunt Quadripartitum, libri IV. Ed. posterior* (Frankfurt, 1622).

87. This important MS was discovered by Fuat Sezgin, Instant für Geschichte der Naturwissenschaften, University of Frankfurt, It dates from the sixth/thirteenth century.

88. Istanbul, Carullah 1499, fol. 81v, written in 677/1278, consisting of only one page. This MS was discovered by Fuat Sezgin.

89. See p. 511.

90.*O.A.*., I, xxiii–xxxi.

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