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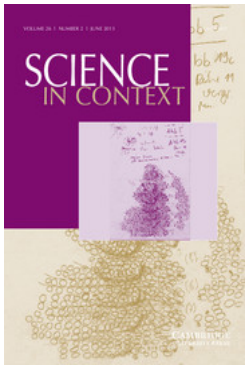

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Greek-Arabic-Latin: The Transmission of Mathematical Texts in the Middle Ages

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Argument

During the Middle Ages many Greek mathematical and astronomical texts were translated from Greek into Arabic (*ca.* ninth century) and from Arabic into Latin (*ca.* twelfth century). There were many factors complicating the study of them, such as translation from or into other languages, redactions, multiple translations, and independently transmitted scholia. A literal translation risks less in loss of meaning, but can be clumsy. This article includes lists of translations and a large bibliography, divided into sections.

Much of the achievement in the mathematical sciences in the Islamic Middle Ages was based on translations from Greek made in the ninth century. Our information on the translators must be collected from ascriptions in the manuscripts, references in bio-bibliographical works such as the *Fihrist* (late tenth century), and statements by redactors such as Naṣīr al-Dīn al-Ṭūsī (thirteenth century). Sometimes a work was translated more than once. Among translators active in the mathematical field were Isḥāq ibn Ḥunayn and Qusṭā ibn Lūqā. Several mathematical works are represented as being a "correction" (*iṣlāḥ*) by the polymath Thābit ibn Qurra (d. 901). With some works the Arabic translation is not identical in content to the extant Greek text. Sometimes this may reasonably be attributed to changes made in Greek before translation, but it must be remembered that the extant Greek manuscripts were mostly written after the translations were made and that the Arabic translators went to some trouble to obtain good manuscripts. Therefore it is likely that for many passages Arabic translations carry a better text than the extant Greek manuscripts.

When in turn Arabic scientific writings came to be translated into Latin, thus beginning or nourishing the resurgence of learning in the twelfth century, the Greek writings in Arabic translation were translated too. Many translations were made by Gerard of Cremona (d. 1187), as we learn from ascriptions in manuscripts and from a list appended to the famous *Vita* presumably written by his pupils. Other, and earlier, translators were Adelard of Bath, John of Seville, Hermann of Carinthia, Robert of Chester, and Plato of Tivoli. In many cases we can only guess the identity of the translator.

The above sketch is a greatly simplified account of the process of transmission. Thus Syriac was often an intermediary between Greek and Arabic. An example is

Archimedes' *Sphere and Cylinder*, in which there is a complaint inserted in the text that the Syriac translator had omitted part of the preliminary material.[1] In the Arabic-Latin transmission a major complicating factor is constituted by Hebrew texts: many texts were translated from Arabic into Hebrew (mostly in the thirteenth and fourteenth centuries); others were originally written in Hebrew; Hebrew texts were translated into Latin and Latin texts into Hebrew. We may note in passing that Arabic texts were sometimes written in Hebrew script. There were also direct translations from Greek into Latin, mostly in Sicily.

Some ideas were transmitted, but it is not known how. For instance, the horary quadrant described by Robertus Anglicus was well known to the Arabs, but whether Robertus had a translation in front of him or whether someone explained its construction and use to him with the help of an actual instrument is not known. In some cases, for example, the "Ṭūsī couple," it is not known whether the idea was transmitted or rediscovered in the West.

Even in the case of unambiguous translation there are problems. One is the existence of revisions, sometimes by the translator himself.[2]

In the case of Theodosius' *Sphaerica*[3] (first century), there are two Arabic texts that appear to be translations; in each case there exists a similar, but not identical, text – presumably a redaction. One of the putative translations, which is anonymous, was translated into Latin by Gerard of Cremona and the other, apparently the version of Qusṭā ibn Lūqā, was translated into Hebrew by Jacob ben Makhir and/or Moses ibn Tibbon (thirteenth century). In Latin there is a redaction by Campanus (thirteenth century), often coupled with his redaction of the *Elements*, but it is not known whether the base-text was Gerard's or another (lost) translation. The scholia to the *Sphaerica* – of one of which at least eleven forms are known in Arabic or implied by translation – present formidable problems of transmission.

Another example is the transmission of Ptolemy's *Planisphaerium*.[4] The text itself, which is lost in Greek, was translated by an unknown translator into Arabic; and a Latin translation was made by Hermann of Carinthia – evidently from a recension slightly different from the text carried by the extant Arabic manuscripts.[5] Extant in Arabic is some material by Maslama al-Majrīṭī (d. 1007–08) relevant to the text: some

[1] See R. Lorch, "The Arabic Transmission of Archimedes' *Sphere and Cylinder* and Eutocius' Commentary" (1989), *Ar. Math. Sci.*⋆ I, this on pp. 96, 109. For al-Ṭūsī's comment on the omission, see F. Sezgin, *Geschichte des arabischen Schrifttums*, Leiden, vol. V (1974), p. 128.

[2] For Gerard's revision of his translation of the *Almagest*, to correct obvious mistakes and to bring the translation nearer the Arabic, see Ptolemäus, *Der Sternkatalog des Almagest*, ed. P. Kunitzsch 1986–1991, vol. II, p. 4, and P. Kunitzsch "Gerard von Cremona als Übersetzer des *Almagest*," in *Festgabe für Hans-Rolf Singer*, ed. M. Forstner, 1991, 338. For the revision, perhaps in the thirteenth century, of Gerard's translation of the *Elements*, see Id., "Findings in Some Texts of Euclid's *Elements*," in *Festschrift für Helmuth Gericke*, Stuttgart 1985, this on p. 120.

[3] For details of this example, see R. Lorch, *Math. Prob.*⋆, 159–183.

[4] For details see P. Kunitzsch and R. Lorch, *Maslama's Notes on Ptolemy's Planiphaerium . . .* , 1994.

[5] One manuscript, in Kabul, has not been examined. The recension used by Hermann is supported by quotations in Maslama's notes (see below).

notes to the text, an Extra-Chapter, and some "Chapters indispensable for whosoever wants to construct an astrolabe." Hermann translated some of the notes along with the text; a second translator (unknown) translated most of the rest of the notes and the Extra-Chapter; a third translator (also unknown) translated the same notes and a couple more, the Extra-Chapter and the Astrolabe chapters. Presumably, the second and third translators had Hermann's text in front of them, but their identity and the circumstances of their activity remain unknown. In addition, there exists a Hebrew translation of the *Planisphaerium*, apparently made from Hermann's Latin.

Sometimes a translator had the help of a native speaker. Thus Gerard worked on the *Almagest* with one Galippus; and in the translation of Avicenna's *De anima*. Iohannes Avendauth translated the single words into the vernacular and Dominicus Gundisalvus translated these into Latin.[6] But to what extent such methods were used by others – or even by these translators when working on other texts – is simply not known.

Of the translators from Arabic into Latin Gerard is known for being very literal; Hermann, by contrast, is usually interpretative. The literary defects of a literal translation are obvious, but if an interpretative translator does not understand the text, or does not understand it fully, the result can be worse. This is forcibly expressed by al-Kindī in the introduction to his treatise on the armillary instrument: he says that the Arabic translators of the *Almagest* had difficulties with Ptolemy's complicated style and feared:[7]

> when applying their own ideas to the meanings of his words, that they might slip away from its true sense. [So,] in translating them into Arabic,they clung tightly to the order of the words, giving every word successively its Arabic counterpart and not departing [from their order, *or* from their literal meanings]. And in order to avoid mistakes they left it to the students of what they had translated of his books and his writings to discover their [*sc.* the books'] meanings. Not everyone who translated something of his books did this, but [only] people of firm judgement and very good command of Greek – [and this they did] in order not to miss either of these things, viz. the understanding of the meanings of the book and the correct rendering of its [single] words. For a man willing to elucidate meanings translates his [own] views without understanding the meanings of that [*sc.* the text] and thus meets both things: to miss the meanings and to miss the words as well. In this there lies for those who study the[se] people's translation a loss in understanding aright something of the idea of the book's author. But whoever repeats its [i.e. the book's, *or* his, the author's] words as they stand – even if it is difficult to understand them – will strike the right understanding of the thoughts of the book's author, even if this be reached with pains. (Celentano 1982, 21)

[6] See P. Kunitzsch *Der Almagest. Die Syntaxis Mathematica des Claudius Ptolemäus in arabisch-lateinischer Überlieferung*, 1974, pp. 85–86.

[7] I am grateful to Prof. Kunitzsch for allowing me to reproduce our joint translation, which depends in several places on readings different from Celentano's text.

The "pains" will be recognized by anyone who has struggled with Gerard's literalisms. An example of these is the description of the 25th star in Ptolemy's constellation Draco: "*Declivior duarum que sequuntur istas ex eis que sequuntur occidentem ad septentrionem*," which means "the more northerly of the two [stars] following those on the western side" (Kunitzsch *Der Almagest* 1974, 106).

In the following tables the texts are given either by the names that appear to be well established or by descriptions. The translators are given as far as evidence allows. In Table 1 and Table 2 most of the mathematical and astronomical texts translated from Greek into Arabic are listed. The first table contains the *Elements*, the Middle Books and the *Almagest* and the second table contains the rest. Texts marked with an asterisk are lost in Greek. A name in brackets refers to a translation that survives only in fragments or not at all. A name appearing after an oblique stroke refers to the redactor or improver. A question mark before a personal name means that it is not certain if the person translated the work in question. A question mark in brackets means that the translator of the work is not known. A dash in the third column means that there is no known translation of the work into Latin. In Table 3 are listed the works originally written in Arabic that were translated into Latin. Table 4 contains the direct translations from Greek into Latin.

Table 1: Greek Mathematical Works Translated into Arabic

Work	**Tr. into Ar.**	**Tr. into Latin**
Euclid, *Elementa*	Ḥajjāj (twice)	1. Adelard
	Isḥāq/Thābit	2. Hermann
		3. Gerard
Euclid, *Phenomena*	Abū ʿAlī b. ʿĪsā	–
Autolycus, *De sphaera que movetur*	Isḥāq/al-Kindī/Thābit	Gerard
Autolycus, *De ort. et. occ.*	Qusṭā/Thābit	–
Theodosius, *Sphaerica*	(?)	1. (?)
		2. Gerard
	Qusṭā/Thābit	–
Theodosius, *De. loc. hab.*	Qusṭā	Gerard
Theodosius, *De d. et noct.*	Qusṭā	–
⋆Menelaus, *Sphaerica*	1. (?)	–
	2. Isḥāq	
		Gerard
	3. Abū ʿUthmān	–
	4. Redaction Māhānī	–
Hypsicles, *De asc. sign.*	1. Qusṭā/al-Kindī	Gerard
	2. Isḥāq/Thābit	–
Ptolemy, *Almagest*	1. (?)	–
	2. Ḥajjāj	Gerard
	3. Isḥāq/Thābit	

Table 2: Greek Mathematical Works Translated into Arabic

Work	Tr. into Ar.	Tr. into Latin
Euclid, *Data*	Isḥāq/Thābit	(Gerard)
Euclid, *Optica*	1. (?)	–
	2. Isḥāq	–
⋆Euclid, *Lib. divisionum*	(?)/Thābit	(Gerard)
⋆Euclid, on weights	(?)/Thābit	–
Archimedes, *Dim. circ.*	(?)/Thābit	1. ?Plato
		2. Gerard
Archimedes, *De S. et cyl. et Eutoc. com.*	Qusṭā/Thābit	(Gerard)
⋆Archimedes, *L. Assumptorum*	Thābit	–
Archimedes, *Opera minora et fragm.*	(?)	–
Apollonius, *Conica*	Al-Ḥimṣī, Thābit/	
	Banū Mūsā	(Gerard)
Apollonius, *Opera minora*	(?)	–
Aristarchus, *De mag. et d. Solis et Lun.*	? Qusṭā	–
Geminus, *Liber introd. Pt. ad art. sper.*	(?)	Gerard
⋆Diocles, *De spec. comb.*	? Qusṭā	–
Nicomachus, *Intro in ar.*	Thābit	–
⋆Ptolemy, *Planisphaerium*	(?)	Hermann
Ptolemy, *Hypotheses*	(?)/Thābit	–
⋆Ptolemy, *Optica*		Eugenius of Palermo
⋆Pappus, *Comm. in Eucl. X*	Abū ʿUthmān	(? Gerard)
⋆Pappus, *Comm. in Plan.*	Thābit	–
Diophantus, *Arithmetica*	Qusṭā	–
Theon, *Comm. on Almagest*	(?)	–
Serenus, *On sections of a cylinder*	(?)	–
⋆Simplicius, *Commentary on Elements*	(?)	–

Table 3: Arabic Mathematical Works Translated into Latin

Work	Tr. into Latin
Al-Khwārizmī, *Arithmetic*	(?)
Al-Khwārizmī, *Algebra*	1. Robert of Chester
	2. Gerard
Al-Khwārizmī, *Astronomical tables*	Adelard/Robert of Ches.
Thābit ibn Qurra, *De hiis qui indigent . . .*	Gerard
Thābit ibn Qurra, *De anno solis*	Gerard
Thābit ibn Qurra, *De motu octave spere*	John of Seville? Gerard?

Table 3: Continued

Work	Tr. into Latin
Thābit ibn Qurra, *De figura sectore*	1. (?) 2. (?) 3. Gerard
Thābit ibn Qurra, *Liber karastonis*	Gerard
Qusṭā ibn Lūqā, *Spera solida*	1. (?) 2. Stephanus Arlandi (from Hebrew)
Aḥmad b. Yūsuf, *De proportione et prop.*	Gerard
Aḥmad b. Yūsuf, *De arcubus similibus*	Gerard
Abū Kāmil, *Algebra*	(?)
Al-Farghānī, *Astronomy*	1. John of Seville 2. Gerard
Al-Battānī, *Astronomy*	Plato of Tivoli
Al-Kindī, *De aspectibus*	Gerard
Banū Mūsā, *Liber trium fratrum*	Gerard
Al-Nayrīzī, *Commentary on the Elements*	Gerard
ʿAbd al-Bāqī, *Comm. on Elements X*	Gerard
Ibn al-Haytham, *Optics*	? Gerard
Ibn al-Haytham, *De speculis comburentibus*	? Gerard
Ibn al-Haytham, *De mundo et celo*	1. (?) 2. Gerard
Ibn Muʿādh, *De crepusculis*	Gerard
Ibn Muʿādh, *Tabule Jahen*	Gerard
Ibn al-Ṣaffār, *On the astrolabe*	1. John of Seville 2. Plato of Tivoli
Al-Zarqālluh, *Saphea*	Profatius & John of Brescia, 1263
Jābir ibn Aflaḥ, *Islāḥ al-Majasṭī*	Gerard
Al-Biṭrūjī, *De motibus celorum*	Michael Scot
Abraham bar Hiyya, *Liber embadorum*	Plato of Tivoli
Anon., *On the hyperbola*	John of Palermo
Abū Bakr, *Liber mensurationum Liber Saydi Abuothmi, Liber Aderameti*, Anon., *Liber augmenti et diminutionis*[8]	?Gerard

[8] These texts on mensuration are found together, in the same order in all manuscripts. Gerard is presumed to be the translator from their presence in MS Paris BN lat. 9335. The same goes for short anonymous pieces on a problem about triangles, on the problem of two mean proportionals, on the construction of the regular heptagon, a theorem about the sides of right triangles, a theorem about the sides of scalene triangles, and theorems about three lines in continuous proportion. See Clagett, *Archimedes in the Middle Ages*, V, 591–603.

Table 4: Greek Mathematical Works Translated Directly into Latin[9]

Work	Tr. into Latin
Euclid, *Elements*	(?), apparently one translator
Ptolemy, *Almagest*	
Euclid, *Data*	(?), possibly one translator
Euclid, *Optica*	
Euclid, *Catoptrica*	
Anon, *De Ysoperimetris*	(?)
Ptolemy, *De analemmate*	William of Moerbeke, all translations dated 1269
Hero/ps.-Ptolemy, *Catoptrica*	
Archimedes, *De lineis spiralibus*	
Archimedes, *De centris gravium* + Eutocius' commentary	
Archimedes, *Quadratura parabolae*	
Archimedes, *Dimensio circuli*	
Archimedes, *De sphaera et cylindro* + Eutocius' commentary	
Archimedes, *De conoid. et sphaeroidalibus*	
Archimedes, De insidentibus aquae	

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Introduction

The aim of this bibliography is to give to somebody coming new to the subject some indication of the literature on the transmission of the mathematical sciences. With a few exceptions there are no references to the transmission of other sciences: there is almost nothing here on medicine, astrology, or philosophy. No doubt an argument could be made for including almost any book on the exact sciences in the Middle Ages, be it text or study, but here only editions of medieval texts and studies closely connected with translation are normally included. However, some of the entries in section 8, which otherwise contains items difficult to place elsewhere, are standard references which "every schoolboy knows," but which the beginning student may not. For an introduction to medieval mathematics and astronomy the reader is referred to Professor Sezgin's *GAS* and for medieval western mathematics to Dr. H. L. L. Busard's forthcoming compendious treatise on the subject. In general the literature indicated in *GAS* is not mentioned in this bibliography – this applies particularly to section 1.

In each section (except 6 and 8) the order of items is basically alphabetical by last name of the modern author, but in sections 1 and 2 this is altered so that items on

[9] Translations made in the ancient world, e.g. Cicero's translation of Aratus' *Phaenomena*, are not included. The Euclid items and the *Almagest* seem to have been translated in Sicily in the third quarter of the twelfth century. *De ysomerimetris* was apparently translated in Sicily or South Italy in the last quarter of the century.

one ancient author or medieval translator are put together in a sequence; in section 1 the name of the author is to be found in the main alphabetical order of the section. An asterisk (⋆) after a short title refers the reader to section 6, Volumes of Collected Papers.[10]

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[10] Of making bibliographies there is no end. This one has been honestly put together, but the compiler is fully aware that there are serious omissions; perhaps also doubtful items have been included. Readers are asked to send to the compiler (address: IGN, Postfach, D–80306 München) notice of any gross errors.

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