

## The ‘Thābit-Version’ of Ptolemy’s *Almagest* in MS Dresden Db.87<sup>1</sup>

Dirk Grupe

**Keywords:** Almagest, Dresden Almagest, al-Nasawī, Ptolemy, revision, Thābit ibn Qurra.

### Abstract

Various historical sources contain references to an unknown Arabic version of Ptolemy’s *Almagest* which allegedly was produced by Thābit ibn Qurra. The authenticity of these records and the existence of such a text have long been doubted. In the present paper new evidence of a Thābit-version of the *Almagest* is presented. It suggests in particular a close relatedness between that text and the incomplete Latin translation of the *Almagest* in MS Dresden Db.87.

Following its discovery in the early twentieth century, the Latin translation of *Almagest* I-IV in MS Dresden Db.87 was long believed to be translated from Greek.<sup>2</sup> Only recent investigations revealed the Arabic origin of the

<sup>1</sup> This article is an extract from my forthcoming PhD dissertation, supervised by Charles Burnett at the Warburg Institute, London.

<sup>2</sup> See A. Björnbo (1909): “Die mittelalterlichen lateinischen Übersetzungen aus dem Griechischen auf dem Gebiete der mathematischen Wissenschaften”, *Archiv für die Geschichte der Naturwissenschaften und der Technik*, vol. 1 (1909), pp. 385–394; J. L. Heiberg (1911): “Noch einmal die mittelalterliche Ptolemaios-Übersetzung”, *Hermes*, vol. 46 (1911), pp. 207–216; C. H. Haskins (1924): *Studies in the History of Mediaeval Science*, Cambridge Ma., pp. 108-110.

text.<sup>3</sup> Richard Lorch also identified a largely literal correspondence between a non-classical insertion in the Dresden *Almagest*, including three new diagrams, and a passage in the *Commentary on the Sector-Figure* (extant in MS Istanbul, Ahmet III 3464, fols. 199v-222v) composed by the Persian mathematician al-Nasawī (11<sup>th</sup> c.).<sup>4</sup> But while the inserted passage in the Dresden *Almagest* purports to be an original part of Ptolemy's work, it is clear that it has been slightly reworked in al-Nasawī's treatise. It appears thus that both texts, Dresden and al-Nasawī, took the extended discussion of the sector-figure from the same unknown Arabic source; of which the Dresden Text contains an authentic Latin translation whereas al-Nasawī integrated it in a more creative manner into his own commentary.<sup>5</sup>

A comprehensive inspection of the Dresden *Almagest*<sup>6</sup> reveals many examples of a formulaic Latin reproduction of Arabic terms and phrases.<sup>7</sup> While making clear that the entire text is a close translation from Arabic, this phraseology, as well as the content of the text, differ significantly from the known Arabic versions of the *Almagest* by Ḥajjāj and Ishāq/Thābit.<sup>8</sup> Nevertheless, certain characteristic elements in the Dresden text indicate that a joint reception of Ḥajjāj and Ishāq/Thābit was the foundation of a modified Arabic version from which the Dresden translation was made.<sup>9</sup>

<sup>3</sup> See R. Lorch (2001): *On the Sector Figure and Related Texts - Thābit ibn Qurra/ edited with Translation and Commentary*, Frankfurt a.M. (repr. Augsburg 2008); C. Burnett (2000): "Antioch as a Link between Arabic and Latin Culture in the Twelfth and Thirteenth Centuries", in B.v.d. Abeele, I. Draelants, A. Tihon (eds): *Occident et Proche-Orient: Contacts scientifiques au temps des Croisades*, Louvain-la-Neuve, pp. 1–78; C. Burnett (2003): "The Transmission of Arabic Astronomy via Antioch and Pisa in the Second Quarter of the Twelfth Century", in A.I. Sabra, J.P. Hogendijk (eds): *The Enterprise of Science in Islam - New Perspectives*, Cambridge Ma., pp. 23–51.

<sup>4</sup> See Lorch (2001), pp. 355-375.

<sup>5</sup> See Lorch (2001), p. 357.

<sup>6</sup> An edition of the text, including an English translation, is forthcoming.

<sup>7</sup> This can be studied in the passage edited in Lorch (2001).

<sup>8</sup> This can be seen again in the passage edited by Lorch, which, apart from additions to Ptolemy's text, also contains a reformulated presentation of Ptolemy's 'first case' of the sector-figure. Further, Arabisms in the Dresden text that speak against a direct dependency on the known Arabic versions appear in the mathematical terminology, where expressions such as 'multiplicacio... in...' (cf. Appendix) correspond to Arabic 'ḍarb...fi...' which, however, is not used by Ḥajjāj or Ishāq/Thābit in a geometrical context.

<sup>9</sup> The combined use of the two Arabic main traditions is apparent from the very beginning of the Dresden Text, which starts 'Preclare fecerunt qui corrigentes scienciam philosophie, o Syre, diviserunt...' (fol. 1r;14f.). While the content of this phrase differs considerably from the Greek original, the occurrence of 'scienciam philosophie' has a parallel only in Ishāq/Thābit whereas the participle 'corrigentes' may be inspired by Ḥajjāj's 'mukhliṣīn' if read as second

A striking feature of the Dresden *Almagest* is inserted references to Euclid's *Elements* and to earlier places in the *Almagest* itself, located where Ptolemy has silently presupposed the reader's knowledge of the respective theorems. To enable precise cross-referencing, a count of Ptolemy's theorems has been introduced, which in the Dresden manuscript, however, has survived only in the references themselves.<sup>10</sup> In addition, Ptolemy's thus separated theorems were supplemented and standardized in the manner of Euclidean propositions (see the example in the Appendix where additions have been highlighted). In this context also the above-mentioned insertion on the sector-figure in the Dresden *Almagest* needs to be understood as part of a systematic completion and formalization of Ptolemy's work.

Starting from Lorch's discovery of distinctive parallels between the Dresden *Almagest* and al-Nasawī's *Commentary*, a more comprehensive comparison of both texts<sup>11</sup> offers evidence that al-Nasawī also quotes the mathematical theorems that precede the sector-figure in the *Almagest* not according to the dominant traditions of Ḥajjāj and Ishāq/Thābit but in agreement with the revised Dresden version (see Appendix). In particular, al-Nasawī treats the manifold insertions that occur throughout the Dresden text as if they were original to the *Almagest*. It thus appears that, at least since the eleventh century, and at least in eastern parts of the Arab world, a revised version of the *Almagest* circulated which al-Nasawī either preferred or was limited to, and which would serve a century later as the source of the Dresden translation.<sup>12</sup>

Across the historical bibliographical evidence available on different Arabic versions of the *Almagest* (collected and published by Paul Kunitzsch)<sup>13</sup> there is only one possibility for agreement with the 'after-Ishāq' Dresden revision. It is a hitherto unidentified version of the *Almagest* which several sources ascribe to Thābit ibn Qurra (9<sup>th</sup> c.). The oldest record of such a text goes back to Abū 'Alī al-Muḥassin al-Ṣābi' (10<sup>th</sup> c.), who says that Thābit, after his improvement of Ishāq's translation, produced another, even more

form participle; cf. the transcriptions of the opening sentences of Ḥajjāj and Ishāq/Thābit in P. Kunitzsch (1974): *Der Almagest - Die Syntaxis Mathematica des Claudius Ptolemäus in arabisch-lateinischer Überlieferung*, Wiesbaden, p. 132f.

<sup>10</sup> References to Euclid's *Elements* in the Dresden *Almagest* were noticed by Lorch (2001), p. 357. An example of a cross-reference, though not numbered, can be seen in the Appendix.

<sup>11</sup> I am grateful to Richard Lorch for sending me a copy of al-Nasawī's treatise.

<sup>12</sup> On the 'Eastern' provenance of the Dresden translation and its production in the early twelfth century see Burnett (2000), *Antioch as a Link*, and Burnett (2003), *Transmission*.

<sup>13</sup> See P. Kunitzsch (1974): *Der Almagest*, pp. 17-34, supplemented in P. Kunitzsch (1975): *Ibn as-Ṣalāḥ – Zur Kritik der Koordinatenüberlieferung im Sternkatalog des Almagest*, Göttingen, pp. 115-123 *passim*.

“improved and clearer”, “good version” of the *Almagest*.<sup>14</sup> Similar remarks are found in marginal notes to al-Ṭūsī’s *Tahrīr* (MS Paris, BN, ar. 2485), where again – aside from Thābit’s revision of Ishāq’s translation – a later version by Thābit alone is mentioned.<sup>15</sup> Also in the same manuscript, another note mentions that the first book of the alleged Thābit-version contains “two chapters less and four diagrams more”.<sup>16</sup> Finally, Qāḍīzāde al-Rūmī’s fifteenth-century commentary to al-Ṭūsī’s *Tahrīr* contains details from Ptolemy’s star catalogue which Qāḍīzāde describes as having been taken from Thābit’s version of the *Almagest*; most of this data could be identified as stemming alternately from the translations Ḥajjāj and Ishāq/Thābit.<sup>17</sup>

The above accounts are compatible with the evidence from *Dresden/al-Nasawī*. The dependence of the star catalogue in the Thābit-version from Ḥajjāj and Ishāq/Thābit corresponds to the earlier observation of a combined use of these sources also in the Dresden text. Moreover, the formalized revision and completion of Ptolemy’s theorems as in the Dresden *Almagest* can justly be considered a “good”, “improved and clearer” (al-Ṣābi’) presentation. As concerns the modified chapter division, the Dresden manuscript preserves evidence only in prefixed lists of chapter titles (fols. 1r, 16r, 31r-v, 49v). However, for the first book there is only one, not two, entries less than in the classical tradition. Similarly, by the extended discussion of the sector-figure the Dresden text contains three additional diagrams, rather than four, as stated in the note to al-Ṭūsī’s *Tahrīr*. But the Paris manuscript of the *Tahrīr* offers further evidence about the Thābit-version which partly resolves these discrepancies. A marginal note at the beginning of al-Ṭūsī’s discussion of *Alm.* I,10 says that in Thābit’s version the chapter had been merged with the previous one, as well as with the following table of chords (*Alm.* I,11).<sup>18</sup> Although in the Dresden manuscript the table of chords still appears as an independent entry in the table of contents (fol. 1r;11), this title might have been reinserted at a later stage. The preceding two chapters (i.e. *Alm.* I,9 and I,10), however, became indeed inseparably merged by a modified formulation of the text (MS Dresden Db.87, fol. 6r;25 et seqq.).

<sup>14</sup> Al-Ṣābi’'s remark, preserved in a quotation by al-Qifī (13<sup>th</sup> c.), is edited in Kunitzsch (1974), p. 25.

<sup>15</sup> See Kunitzsch (1974), p. 26.

<sup>16</sup> See Kunitzsch (1974), p. 31f.

<sup>17</sup> See Kunitzsch (1975), p. 122f.

<sup>18</sup> MS Paris ar. 2485, fol. 4v;9 in the margin: hādhā al-faṣl wamā qablu min bāb ḥā’ fī nuskhāt Thābit wa l-jadāwil min bāb yā’.

Apart from the marginal notes in the Paris manuscript, al-Ṭūsī himself mentions in his *Tahrīr* a Thābit-version of the *Almagest* and provides some additional details. Al-Ṭūsī likewise discusses the sector-figure similar to the extension in *Dresden/al-Nasawī*, and he declares the three additional illustrated cases in that discussion to be a particular feature of the Thābit-version.<sup>19</sup> A similar remark by al-Ṭūsī may also explain the difference in one diagram, by which the Dresden text falls short of the stated four additional diagrams in the Thābit-version. When talking about Ptolemy’s sixth theorem in *Alm.* I,13 (H73f.), al-Ṭūsī says that in Thābit’s version the case with the intersection point on the opposite side is also discussed.<sup>20</sup> Since the Dresden *Almagest* contains again a corresponding insertion in its text (fol. 13r;11f.), it is conceivable that a related diagram has been omitted during the transmission due to its symmetric similarity with the previous drawing. Alternatively, the ‘parallel’ case of that theorem, which is likewise discussed in an insertion in the Dresden text (12v;26f.), may very well have once been illustrated. Al-Ṭūsī mentions yet another difference about the Thābit-version from the classical tradition, in the discussion of the addition theorem of chords in *Alm.* I,10 (H41f.). In this case, he says that Thābit replaced the original proof with a different argument, which included also a new diagram. This new proof, which al-Ṭūsī reproduces in full (MS Paris ar. 2485, fol. 5r;28-5v;1), is identical with Theon of Alexandria’s simplified and more general proof of the addition theorem.<sup>21</sup> This intervention is once more confirmed in the Dresden manuscript, where Ptolemy’s proof and diagram are likewise replaced with those from Theon’s commentary (fols. 8r;28-8v;5).

From the above observations, it is plausible to suggest that the various historical references between the tenth and the fifteenth centuries to a Thābit-version of the *Almagest* all refer to the same text. Substantial parts of Book I of that version survived in al-Nasawī’s *Commentary on the Sector-Figure*, while MS Dresden Db.87 contains an authentic Latin translation of the full text of its first four books. Furthermore, fragments at least of its books VII and VIII have been preserved in Qāḍīzāde’s commentary to al-Ṭūsī.

Also Thābit ibn Qurra’s authorship of that “Thābit”-Version seems plausible. All sources agree in ascribing the text to Thābit, and ‘Euclidizing’ the *Almagest* also matches Thābit’s mathematical skills and interests well.

<sup>19</sup> MS Paris ar. 2485, fol. 10v;14f.: wa fī nuskhat Thābit ayḍan qad zīdat nazā’ir hādhihi al-ashkāl al-thalātha allatī awradnāhā.

<sup>20</sup> MS Paris ar. 2485, fol. 10r;23: wa zāda Thābit fī nuskhatihi shaklan li-kawnihimā mutalāqatayni fī jihat jīm.

<sup>21</sup> Cf. Theon (ed. Rome), pp. 484f.

Moreover, the most creative modification in the Thābit-version, i.e. the extended discussion of the sector-figure, has a direct parallel in a treatise by Thābit ibn Qurra,<sup>22</sup> and also the different terminology in *Dresden/al-Nasawī* suggests Thābit's influence. In particular, the rare formulation that geometrical lengths can be 'multiplied' by one another (see Appendix and above, note 8), appears in two of Thābit ibn Qurra's other writings; it was identified by Lorch as typical of Thābit's arithmetical, or algebraic, understanding of Euclidean geometry, especially in connection with the *Almagest*.<sup>23</sup>

According to present knowledge, the primary transmission of Thābit's revised *Almagest* is lost. Although the text was known and accessible to various Arabic and Latin writers at least until the fifteenth century, it appears not to have acquired a wide circulation. This impression is further enhanced by the fact that the oldest witness of Thābit's text, al-Ṣābi', was a member of Thābit's own family;<sup>24</sup> and the cited annotations to al-Ṭūsī's *Tahrīr* possibly go back to Qāḍīzāde al-Rūmī again.<sup>25</sup> While this would further reduce the small number of independent witnesses, there is in particular no evidence that knowledge of Thābit's revision of the *Almagest* ever reached the Arab West.

### Appendix

The subtraction theorem of chords in *Alm.* I,10 (H37f.) as it appears in al-Nasawī's *Commentary on the Sector-Figure* (left) and in the Dresden *Almagest* (right; additions to the classical tradition have been underlined in the Latin).

MS Istanbul, Ahmet III, 3464, fols. 205v et seq.:

MS Dresden Db.87, fol. 7v:

الشكل الثالث إنّ بطلميوس أراد أن يبرهن على أنه إذا كان في الدائرة وتران معلومان ووصل فيما بينهما بوتر فإن ذلك الوتر يكون معلوما فجعل الشكل الثاني مقدّمة له	[Tercia figura primi sermonis] <u>Ut scierimus duorum arcuum duas</u> <u>cordas circuli alicuius, corda</u> <u>superhabundantis quod est inter duos</u> <u>arcus nobis scietur.</u>
---	---

<sup>22</sup> Thābit ibn Qurra's treatise *On the Sector Figure*, edited in Lorch (2001).

<sup>23</sup> Lorch (2001), p. 20.

<sup>24</sup> Cf. F.C. de Blois (1995): "Ṣābi'", in *Encyclopedia of Islam*, new ed., vol. 8, Leiden, pp. 672-5, paragraphs 1 and 8. This relation was mentioned to me by Paul Kunitzsch.

<sup>25</sup> See Kunitzsch (1975), pp. 118f.

مثاله نصف دائرة قطرها  $ad$  ووتر [ان]  $ab$  اج معلومان ونصل  $bc$ .  
 Sit medietas circuli  $abcd$ , sitque diametrum ipsum  $ad$ , sintque prescite due corde  $ab$   $ac$ . Excopulemus lineam  $bc$ .

فأقول إن  $bc$  معلوم  
 برهانه إننا نصل خطي  $bd$   $cd$  فيكون هذان الخطان معلومين كما قد تبين من قبل أنه إذا كان وتر قوس ما معلوما فإن وتر تمامه عن نصف الدائرة معلوم وأحاطت دائرة بشكل ذي أربعة أضلاع يكون ضرب  $ab$  في  $cd$  مع ضرب  $ad$  في  $bc$  مساويا لضرب  $ac$  في  $bd$  كما قد تبين في الشكل الذي قبل هذا ولكن ضرب  $ab$  في  $cd$  معلوم والذي يكون من ضرب  $ac$  في  $bd$  أيضا معلوم فيبقى المجمع من ضرب  $ad$  في  $bc$  معلوما فلنقسم ذلك على  $ad$  معلوم وهو القطر المعلوم فنصير وتر  $bc$  معلوما

Dico quia  $bc$  scietur.

Racio. Copulabimus enim duas lineas  $bd$   $cd$ , sed est manifestum quia ipse due linee sunt prescite. Diximus namque quia quando fuerit alicuius arcus corda prescita, corda minoritatis illius arcus a medietate circuli erit scita. Et ipse circulus est circuicio figure quatuor laterum et est figura  $abcd$  unde quod est ex multiplicacione  $ab$  in  $cd$  et quod est ex multiplicacione  $ad$  in  $bc$  est equale ei quod ex multiplicacione  $ac$  in  $bd$  hoc quod est ostensum in figura huic precedenti. Et quod est ex multiplicacione  $ab$  in  $cd$  est prescitur et quod est ex multiplicacione  $ac$  in  $bd$  est prescitur. Igitur remanet quod est ex multiplicacione  $ad$  in  $bc$  scitum et diametrum  $ad$  est prescitur, igitur  $bc$  est scita.

Igitur cum fuerint due corde duorum arcuum alicuius circuli prescite, corda superhabundantis quod est inter ipsos duos arcus erit scita.

وذلك ما اردنا ان نبين Et hoc est [quod] demonstrare voluimus.

