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Types, function, and organization of the collections of scholia to the Greek mathematical treatises

Abstract: The aim of the contribution is to present the factual data about the main collections of scholia to the Greek mathematical treatises (*Elements*, *Almagest*, the so-called “little astronomy”), along with an analysis of their types, function, and organization within the textual space of the ancient codex. On the basis of these factual data, an assessment is provided of the extent to which these collections may provide a clear-cut answer to the long-standing problem of the origins of the running commentaries that some medieval manuscripts present as sets of scholia.

Keywords: Greek scholia, ancient Greek mathematics, ancient Greek astronomy.

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The collections of scholia to the Greek mathematical treatises provide us with important pieces of information about the interpretive toil and complexity embodied by an annotated text. They can give useful indications on the history of the main text, or contain results or proofs to which we otherwise have no access. They may simply be the outcome of specific annotations of an attentive reader (who may jot down the results used in a proof, add titles, or redact synopses), of the copyist (who can compare divergent versions of what he is transcribing), or of a reviser (who can add lemmas¹, explanatory passages, indices). They can amount to a running commentary accompanying a new edition of the annotated text, or result from the dismemberment of a commentary originally organized as a

¹ In what follows, the term “lemma” will only be used in its mathematical meaning: an auxiliary proposition. In its turn, the term “proposition” will designate a self-contained mathematical argument, namely, an “enunciation” followed by a “proof”; the latter makes reference to a geometric configuration set up in a “construction” and represented by a “diagram”; the geometric entities occurring in the configuration are identified by “denotative letters”. Species of a proposition are the “theorem” (proving a property of an assigned object) and the “problem” (showing how to construct an object according to specific constraints). The term “commentary” will generically denote an exegetic text, whether in the form of a σύγγραμμα or of a ὑπόμνημα.

connected body of text. They can be located in the margins of (any material substratum containing) their reference text, precede it as an introduction of sorts, or make up a seemingly self-contained discursive macro-unit disconnected from the text, eventually resulting in a fictitious recomposition of a formerly dismembered body of writing. Finally, scholia often interfere with their reference text, giving rise to textual quirks ranging from easy-to-detect interpolations to argumentative loopholes that may baffle interpreters for centuries.

The present contribution has a specific and a strategic aim. The specific aim is to present the main factual data about the extant collections of scholia to the Greek mathematical treatises, along with an analysis of their types, function, and organization within the textual space of the ancient codex. The strategic aim is to discuss, on the basis of these factual data, the extent to which these collections may provide a clear-cut answer to the long-standing problem of the origins of the running commentaries that some medieval manuscripts present as sets of scholia.

1 A typology of mathematical scholia

All (mathematical) scholia share some basic features: their mutual disconnectedness, their metatextual character, their paratextual position. Several categorizations can be used to differentiate them: their script (whether majuscule or minuscule), date of composition, date of transcription (whether first or later hand in a given manuscript), origin (whether as extracts from other writings or not), form (length, shape, set-up, type of argument), content (technical, historical, textual), location with respect to the main text (liminar, marginal, interlinear). On the basis of some of these criteria, I offer in the following list a typology of the scholia to Greek mathematical texts that seems to me to capture the main species of this literary sub-genre.

- Liminar scholia: connected, non-marginal series of annotations placed immediately before the beginning of a treatise and normally discussing its principles and its deductive structure.
- Comment scholia: unconnected, marginal annotations containing a full-fledged argument aimed at completing, correcting, or supplementing a specific *locus* (ranging from a word to an entire proposition) of the main text.
- παραγραφαί: very short, non-argued marginal annotations explaining a mathematical passage either by an operative indication (for example, “because a tangent cuts a circle at only one point”), or, much more frequently, by a reference to a canonical text (*Elementa*, *Data*, *Conica* ...) such as διὰ τὸ ἰγ’ τοῦ γ’ τῶν στοιχείων: number of proposition, book, treatise.

- Diagrammatic scholia: marginal annotations in the form of diagrams not accompanied by a discursive explanation.
- Schematic scholia: small text cells organized hierarchically as a flow diagram and offering a summary of the main text, or providing supplementary information.
- Tabular scholia: marginal annotations in the form of numerical tables or of calculations arranged in a tabular set-up.
- Interlinear scholia: (short) interlinear annotations clarifying specific lexical or mathematical points.

Mathematical scholia may be linked with the related text by suitable marks, but in this contribution I will not deal with the issue.

2 The main scholiastic corpora: *Elements*, *Almagest*, the “little astronomy”

2.1 *Elements*

The Danish scholar J. L. Heiberg, the philologist to whom we owe so many editions of Greek mathematical works, published over 1450 scholia to the *Elementa* (henceforth *El.*): about 1380 in his critical edition of the Euclidean treatise², about 50 in a dedicated study (1888), and finally 33, contained in Escorial. Φ.III.5³, in the *Paralipomena* to his edition (1903, 338–344). The main results obtained by analysing this huge *corpus* can be summarized as follows⁴.

Well-organized introductions to *El.* are extant in the form of liminar scholia. As mentioned above, they focus on the principles (definitions and assumptions) or on the deductive structure of the subsequent books. A very long (and incomplete at its beginning) liminar scholium to *El.* is contained in Vat. gr. 190 (ff. 3r–13v), the oldest witness of the treatise (IXth century *in.*)⁵: it begins with an overview of all definitions of book 1, followed by extracts from Proclus’ commentary thereon. It appears that this “introduction” was allotted a preassigned space,

² *Euclidis Elementa* 5.1–2, whose numbering by book.scholium I will follow, preceded by *sch.*

³ Assigned by Heiberg to the XIth century but in fact written in an imitative script dating to the XIIIth century *p. m.* (Pérez Martín 2009, 67–68).

⁴ See Heiberg 1888 and Vitrac 2003, whose factual data I have checked and completed.

⁵ Edited at *Euclidis Elementa* 5.1.39.1–69.17.

maybe a number of blank folios: the length of the extracts from Proclus greatly increases towards the end, as if the copyist had made a wrong estimation of the space at his disposal (Vitrac 2003, 282).

A liminar scholium of εἰς τὰ τοῦ Εὐκλείδου στοιχεῖα προλαμβανόμενα ἐκ τῶν Πρόκλου σποράδην καὶ κατ' ἐπιτομὴν is located at ff. 1r–13r of Paris. gr. 2344 (XIIth century); this long cento of extracts from Proclus' commentary can also be found⁶, with minor variants, in the XVth-century Vat. gr. 193 (ff. 1r–3v, title ἐπίγραμμα εἰς τὴν Εὐκλείδου γεωμετρίαν, since it is preceded by an epigram treated as a scholium⁷) and in Bon. A 18 (ff. 35r–44v, where it precedes *El.* as προοίμια τῆς γεωμετρίας)⁸, and as section 136 of the pseudo-Heronian *Definitiones* in Paris. suppl. gr. 387 (ff. 84r–93v)⁹. Another introductory compilation, embodying the preceding one, is at ff. 1r–5v of Paris. gr. 2345 (XIIIth century *p. m.*). A schematic synopsis of *El.* 10 can be found *manu Arethae* in Bodl. Dorv. 301 (dated September 888), entitled διαίρεσις τοῦ δεκάτου τῶν Εὐκλείδου στοιχείων (ff. 2r–3v)¹⁰, in Paris. gr. 2344 (ff. 174v–175v), and in its XVth-century copy Magl. XI 53, ff. 22v–25r.

Non-liminar, non-marginal collections of annotations to *El.* can be found in the following manuscripts:

- 1) Vindob. phil. gr. 31, ff. 283r–292v, where they follow *El.* (ff. 1r–254r), *Optica* A (ff. 254v–271v) and *Phaenomena* a (ff. 272r–282v)¹¹: 65 scholia to books 10–13, from *sch.* 10.2 to 13.44.

⁶ The same collection can also be found in the following manuscripts, which depend on Paris. gr. 2344: Bodl. Auct. T.1.22 (XVIth century), ff. 8v–17v, Leid. B.P.G. 7 (1504–1505), ff. 439r–452v, Magl. XI 53, ff. 1–22r, Paris. gr. 2345, ff. 2v–3v, Paris. gr. 2350 (XVIth century), ff. 97r–106v, Paris. gr. 2353 (XVIth century), ff. 16r–20r, Vat. Urbin. gr. 71 (XVIth century), a codex of 50 folios that begins with our text but in fact is entirely made of extracts from Proclus' commentary on *El.* 1.

⁷ The epigram (edited in *Euclidis Elementa* 5.2.XX) is also attested, again at the end of the so-called “book 15” of *El.*, at f. 397v of Bodl. Dorv. 301, after the subscription of the copyist Stephanus and Arethas' possession note, and in Vindob. phil. gr. 31 (XIIth century), f. 254r, Laur. Plut. 28.2 (XIIIth–XIVth century), f. 319r, Laur. Plut. 28.3 (a copy of the subsequent manuscript in this part, but originally *manu Ephrem* ca. 950–960), f. 189r, Laur. Plut. 28.6 (XIIIth–XIVth century), f. 298r.

⁸ What precedes at ff. 1r–34v in the Bologna manuscript (XIth century) is a list of all the principles and enunciations of *El.* and *Data* (about 600 items), often presenting major variants with respect to the same textual units as we read them in the sequel of the manuscript. An *excerptum* like this of the “mathematical content” of a treatise has no parallels in other Greek mathematical manuscripts; it has never been studied.

⁹ *Def.* 136 is edited in *Heronis opera omnia* 4.108.10–156.5, with further variants recorded *ibid.* 5.XV–XVIII. Paris. suppl. gr. 387 is assigned to the beginning of the XIVth century.

¹⁰ A further schematic scholium at f. 4r is edited in *Euclidis Elementa* 5.2.335.6–22. The synopsis itself is edited, on the basis of Paris. gr. 2344 alone, *ibid.* 5.2.87–90.

¹¹ This manuscript is the prototype of the recensions of *Optica* and *Phaenomena* traditionally noted by letters A and a.

- 2) Paris. gr. 2344, ff. 358r–366v, where they follow *El.* (ff. 17r–357v): 17 scholia on the first third of book 10, mainly extracted from the *scholia vindobonensia* (see *infra*).
- 3) Vat. gr. 192 (XIIIth century), ff. 114v–124v, where they follow *El.* (ff. 3r–94v), *Data* (ff. 95r–112r) and Marinus *in Data* (ff. 112v–114r): the first scholium is *sch.* 1.88, related to *El.* 1.23, the last is *sch.* 13.44.
- 4) Vat. gr. 202 (XIIIth century *ex.*), ff. 381v–398r, where they follow the “little astronomy” (ff. 1r–305r; see section 2.3 *infra*), *Data* (ff. 305r–372r) and Marinus *in Data* (ff. 372v–381r): the first scholium is *sch.* 1.88, related to *El.* 1.23, the last is *sch.* 7.40 (this manuscript does not contain *El.*).
- 5) Vat. gr. 204 (IXth century *in.*), ff. 199r–206v: annotations ranging from *sch.* 1.88 to 10.352 (the collection is incomplete both ways since the last scholium ends abruptly, in the middle of a sentence, with the last line of the page; this manuscript does not contain *El.*); title by the first hand σχόλια εἰς τὰ Εὐκλείδου στοιχεῖα βιβλίον α.

The scholia in 5) can also be found, written in the margins by the main copyists, in Vat. gr. 190, in Arethas’ *Dorvillianus*, partly in Laur. Plut. 28.3, in collections 3)–4) and, only for those related to book 10, in collection 1). The same pattern of coincidence can be recorded, as far as the stereometric books 11–13 are concerned, between collections 1), 3) and the first-hand scholia in Vat. gr. 190 and in the *Dorvillianus*. Collection 5) of Vat. gr. 204 is thus the common kernel of the constellation of scholia assembled in 1), 3), 4) and in the margins of the oldest three manuscripts of *El.*: 138 annotations in all¹². Heiberg concluded that these are the remains of a very old scholiastic *corpus*, mutilated at its beginning, which he called *scholia vaticana*.

Heiberg quite naturally surmised that the *scholia vaticana* are the result of the dismemberment of Late Antiquity commentaries. He first noted that the thirteen *scholia vaticana* related to *El.* 1 are well-conceived extracts from the commentary of Proclus (†17 April, 485), presenting a better text than the one provided by the direct tradition, and that the other scholia deal with similar themes: assumptions, aim of a proposition, textual issues, lemmas, converse proofs. He was in a position to add to Proclus *in El.* 1 the commentary of Pappus *in El.* 10, today available in a (heavily) revised Arabic translation¹³, but in the times of Heiberg only by the intermediation of an article written by F. Woepcke in 1856. Heiberg

¹² They are listed at Heiberg 1888, 233–234. Distribution of the scholia among the books of *El.*: 1: 13; 2: 9; 3: 11; 4: 3; 5: 9; 6: 2; 7: 9; 8: 1; 9: 3; 10: 40; 11: 24; 12: 10; 13: 4.

¹³ The edition of the Arabic text is in Junge/Thomson 1930.

assumed that the scholia which are not immediately identifiable as extracts from these two texts (for instance, those to books 2–9) must be assigned either to a lost commentary by Pappus on the whole of *El.*¹⁴, or to the alleged sequel of Proclus' in *El.* 1¹⁵. Heiberg decidedly favored the first alternative.

We must pause and recall why this conclusion was held by Heiberg to be of strategic significance. The main philological point of his edition of *El.* is that, contrary to all other manuscripts, Vat. gr. 190 contains a text not contaminated by the recension made by Theon of Alexandria in about the middle of the IVth century¹⁶ – and what is more, that the recension of the Vatican manuscript is not simply non-Theonine, but even pre-Theonine. Since Pappus precedes Theon by one generation, by definition he had access to a pre-Theonine text: by connecting the *scholia vaticana* with Pappus' commentary, Heiberg tried to corroborate his main result on the textual history of *El.* He noted to this effect that some *scholia vaticana* duplicate lemmas now contained in the *main text* of *El.*, both in Vat. gr. 190 and in the “Theonine” manuscripts: as a consequence, the lemmas at issue are spurious, and Heiberg maintained that both “authentic” scholia and spurious lemmas derive from Pappus' commentary. The problem with Heiberg's argument is that his analysis is conducted on the basis of what he knew of Pappus' commentary on *El.* 10 – namely, the extracts translated in Woepcke' article. Now, what is true (Vitrac 2003, 290–292), is that of the 481 scholia to *El.* 10, only 17 incontrovertibly depend on Pappus' commentary, of which only 7 are *scholia vaticana* (and, among them, *sch.* 10.1 mentions Theon). None of the lemmas interpolated in *El.* 10 is contained in Pappus' commentary in the form we read it. Furthermore, *sch.* (*vaticanum*) 10.352 summarizes the partition into hexads of *El.* 10.36–72 in a way that conforms with the transmitted text of *El.*, whereas *sch.* 10.340, by the first hand of Vat. gr. 190, and Pappus in his commentary, permute the hexads *El.*

¹⁴ The existence of Pappus' commentary can only be inferred: Proclus cites him three times in his own commentary on *El.* 1 (*in Eucl.* 189.11–191.4, 197.6–198.15, 249.20–250.19 Friedlein); Eutocius (*Archimedis opera omnia* 3.28.19–22) mentions a supplement to *El.* 12.1 that Pappus gave in his ὑπόμνημα τῶν στοιχείων (how to inscribe in a given circle a polygon similar to a polygon inscribed in another circle), a result whose proof we read as *sch.* (*vaticanum*) 12.2; a scholium to *Data* establishes a relation between the extensions of the notions of “given” and of “expressible” in the same way as done by Marinus in *Data* and by the redactor of *Def.* 136.35, but ascribes the idea to Pappus ἐν ἀρχῇ τοῦ εἰς τὸ ἰ τοῦ Εὐκλείδου (*Euclidis opera omnia* 6.262.1–7). In Pappus' commentary on *El.* 10 nothing on this issue can be found.

¹⁵ Proclus formulates this intent at *in Eucl.* 272.14–16 (how to divide a given angle into three or more equal parts: to be treated in book 3) and 398.18–19 (isoperimetric results, πρὸ πλεονέστερα ταῖς ὑποθέσεσι of book 2) Friedlein.

¹⁶ The ascription is contained in the inscriptions of any book of *El.* in the relevant manuscripts.

10.60–65 and *El.* 10.66–70. This shows that Heiberg’s assumptions about the role of Pappus’ commentary is no longer supported by the available evidence.

This notwithstanding, Heiberg’s bias towards Pappus is by and large harmless; all that is needed is to refocus his argument in order to tighten it up. First, we definitely read Pappus’ commentary on *El.* 10 in a *heavily reworked* translation; in particular, the first of the two books into which it is subdivided displays a (pseudo-)philosophical attitude carrying a decided Neoplatonic tinge (and consisting in fact of a series of Platonic commonplaces) that we read nowhere else in Pappus, and presents a number of technical notions that squarely contradict those expounded in the second book¹⁷: the two books cannot possibly have been written by the same author, and the first book alone gives the clear impression of being a second-hand patchwork. Moreover, the technical core of the commentary – namely, the second book – has the structure of a σύγγραμμα, in which all the material of *El.* 10 (117 propositions!) is reshaped and read in a unitary exegetic perspective. It comes as no surprise, then, that none of the lemmas interpolated in *El.* 10 is contained within it. In other words, we should have expected a different literary form from a “real” ὑπόμνημα on *El.* 10: a desultory collection of lemmas, alternative proofs, corrections, supplements, very much like those we read when Pappus himself, in *Coll.* 6 and 7, presents a huge amount of exegetic material related to the “little astronomy” and to the analytic *corpus*. This simply means that if Pappus really wrote a *stricto sensu* commentary on *El.* 10, we no longer have access to it. Third, it cannot be taken for granted that (with absolute certainty) Proclus and (possibly) Pappus were the only sources of the *scholia vaticana*. We know of many scholars who wrote *exegetica ad El.*, among whom Apollonius, Diodorus, Posidonius, Geminus, Menelaus, Hero, Ptolemy, Porphyry, and for one of them (Hero) there is positive evidence that arguments taken from his commentary have found their way into the scholiastic apparatus of *El.* (Heiberg 1903, 57–59)¹⁸.

These remarks show that finding scholarly sources of the *scholia vaticana* is by no means problematic. I will now argue that Heiberg’s proposal about the *origin* of this collection and of the residual scholia written by the main copyist of Vat. gr. 190 – namely, that they were composed within the circle of Isidorus of Miletus (early VIth century) – is highly plausible.

- a) A first point pertains to “kodikologische Stemmata”: the *scholia vaticana* are written by the hand of the main copyist of the relevant manuscripts and often

¹⁷ The inconsistencies go as far as describing the structure of *El.* 10 by means of incompatible orderings of its propositions.

¹⁸ But often through Proclus’ commentary: Acerbi/Vitrac 2014, *Introduction générale*, section 2.2.

marked out by a suitable *Auszeichnungsmajuskel*¹⁹. This feature strongly suggests that all these manuscripts simply reproduce the layout of their models; therefore, these models already contained the *scholia vaticana*.

- b) A second, and major, point, pertains to “mere” stemmatics, and is the gist of Heiberg’s philological argument: the *scholia vaticana* are contained in *independent* witnesses, dating to the (early) IXth or Xth century, of each of the two textual families of *El.*, and the early IXth-century Vat. gr. 204 presents these same scholia as a *non-marginal*, unitary collection²⁰. The former feature strongly suggests that the *scholia vaticana* in their present form were contained at least in the hyparchetypes of the two main branches of the tradition of *El.*, and not simply in the models of their best representatives. In turn, the resumption of the scholia in Vat. gr. 204 can only be explained by postulating some scholarly (or even authorial?) work on at least one such hyparchetype or on one of its ancestors²¹. Now, the two textual families of *El.* do not simply differ by normal variants of copy: they contain two different recensions of the Euclidean text, one of them certainly to be assigned, as seen above, to Theon of Alexandria. It is then quite natural to surmise that the *scholia vaticana* were attached to the said hyparchetypes within scholarly circles that had access to, and control over, both traditions.
- c) In order to identify such circles one must make do with the scanty information about centers of strong scientific interest in Late Antiquity or in the early Byzantine period. By far the best candidate is precisely Isidorus of Miletus’ school²², to which we almost certainly owe the layout of *El.* in fifteen books that the whole tradition has handed down to us. This layout makes up the original thirteen books of *El.* followed by the so-called “book 14”, a short tract on the comparison between dodecahedron and icosahedron written by Hypsicles during the IInd century BCE, and by the so-called “book 15”, a three-piece cento dealing again with properties of the regular solids, and in particular with the determination of “the angle of inclination of the faces containing

¹⁹ This happens in Bodl. Dorv. 301 and in Laur. Plut. 28.3. Vat. gr. 190 has no scholia in majuscule script.

²⁰ Vat. gr. 190 and Vat. gr. 204 are simply among the earliest known manuscripts in minuscule.

²¹ Collections 3) and 4) above, contained in manuscripts of the XIIIth century, are very likely the result of collations carried out in the medieval period.

²² Anthemius of Tralles and Isidorus were the architects entrusted by Justinian with reconstructing Hagia Sophia in 532 (Procopius, *De aedif.* 1.1.24; but note that a nephew of our Isidorus bore the same name and was an architect: see, e.g., *ibid.* 2.8.25). Anthemius wrote a tract dealing with burning mirrors, a fragment of which has been handed down to us by the first bifolium of Vat. gr. 218 (early Xth century).

any one of the five «regular» figures”. The redactor of this portion of the text²³ expressly assigns the authorship of it to Isidorus; the redactor was a pupil of Isidorus himself, who is qualified by the term διδάσκαλος²⁴. The school of Isidorus in Constantinople was also the reference circle of Eutocius (for whom see sections 2.2 and 3 below), a Neoplatonic philosopher with a strong mathematical bent based in Alexandria, who sent each book of his commentary on Apollonius’ *Conica* 1–4 to Anthemius of Tralles²⁵, and whose commentaries on some treatises by Archimedes were collected, proofread, and edited exactly by Isidorus and his school²⁶. An interpolated passage in Eutocius’ commentary on Archimedes’ *Sph. cyl.* 1 asserts that Isidorus invented a parabolic compass and that he provided a description of it in a (lost) commentary on Hero of Alexandria’s *Vaults*²⁷. In contrast, we do not know of any interest in *El.* of the Neoplatonic school of Alexandria, whereas the same school was involved in a series of scholarly activities concerning Apollonian and Archimedean writings, as we have just seen, and the *Almagest*, as we will see in the next section.

²³ *Euclidis Elementa* 5.1.29.17–38.16.

²⁴ At *Euclidis Elementa* 5.1.29.17–22: ἐξητήθη, πῶς ἐφ’ ἐκάστου τῶν πέντε στερεῶν σχημάτων ἐνὸς ἐπιπέδου τῶν περιεχόντων ὁποιοῦν δοθέντος εὐρίσκεται καὶ ἡ κλίσις ἐν ᾗ κέκλιται πρὸς ἄλληλα τὰ περιέχοντα ἐπίπεδα ἕκαστον τῶν σχημάτων. ἡ δὲ εὐρεσις, ὡς Ἰσιδώρος ὁ ἡμέτερος ὑφηγήσατο μέγας διδάσκαλος, ἔχει τὸν τρόπον τοῦτον One must recall that Isidorus operated in the age of Justinian, who severely persecuted high-level intellectual centers of pagan profession: it is therefore not surprising that abstract geometric subjects such as the theory of the regular solids were treated and taught by engineers and architects.

²⁵ See the liminar references to the addressee at *Apollonii Pergaei quae graece exstant* 2.168.5, 2.290.2–3, 2.314.2, 2.354.2 (forms ὦ φίλ[τατ]ε/ἐταῖρε/μοι Ἀνθέμιε), and the end of the prefatory letter to *in Conica* 4 *ibid.* 2.356.1–4: ἀνάγνωθι οὖν αὐτὰ ἐπιμελῶς, καὶ εἴ σοι καταθυμῶς γένηται καὶ τὰ λοιπὰ κατὰ τοῦτον τὸν τύπον ὑπ’ ἐμοῦ ἐκτεθῆναι, καὶ τοῦτο θεοῦ ἡγουμένου γενήσεται. Apparently, Athemius did not show himself keen on reading the edition of *Conica* 5–8 and the sequel of Eutocius’ commentary, since neither of them has been transmitted.

²⁶ This is borne out by the spurious pre-subscriptions of these commentaries, to be found at *Archimedis opera omnia* 3.48.28–31, 3.224.7–10, 3.260.10–12. As an example, let us read the first of these texts: Εὐτοκίου Ἀσκαλωνίτου ὑπόμνημα εἰς τὸ πρῶτον τῶν Ἀρχιμήδους περὶ σφαίρας καὶ κυλίνδρου ἐκδόσεως παραναγνωσθείσης τῷ Μιλησίῳ μηχανικῷ Ἰσιδώρῳ ἡμετέρῳ διδασκάλῳ. On these subscriptions, and in particular on the meaning of the verb παραναγιγνώσκω (= check a manuscript copy, proofread), see the surely wrong interpretation in Cameron 1990 and the reply in Jones 1999, 168–172 (this debate replicates, one century after, that between Heiberg and Tannery; see Heiberg 1880, 359; Tannery 1884, 119 of the reprint; and Heiberg’s recantation in *Archimedis opera omnia* 3.XCIII).

²⁷ *Archimedis opera omnia* 3.84.8–11: γράφεται δὲ ἡ παραβολὴ διὰ τοῦ εὐρεθέντος διαβήτου τῷ Μιλησίῳ μηχανικῷ Ἰσιδώρῳ τῷ ἡμετέρῳ διδασκάλῳ, γραφέντος δὲ ὑπ’ αὐτοῦ εἰς τὸ γενόμενον αὐτῷ ὑπόμνημα τῶν Ἡρωνος καμαρικῶν.

- d) If the fact that the *scholia vaticana* contain obvious extracts from Proclus' commentary on *El.* 1 sets a lower bound to their composition, some clues suggest that the upper bound cannot be set too close to the present. Proclus' philosophy, after the long eclipse triggered by Philoponus' *pamphlet*, was reintroduced in Byzantium in the XIIIth century, thanks to his *Hypotyposis* (Cacouros 2000); the direct tradition of his commentary on *El.* 1²⁸ presents a text that is worse than the one provided by the *scholia vaticana*. The redactor of the latter therefore had access to a direct tradition surely different and quite likely older than the one that has survived, although we cannot exclude that this better line of tradition was still open in early IXth-century Byzantium.
- e) The main copyists of Vat. gr. 190 and of the Vienna codex systematically back up the propositions of *El.* 1 with a set of condensed extracts from the relevant passages of Proclus' commentary. This running commentary *per excerpta*, again organized in the form of marginal annotations and hence doubling the less systematic *scholia vaticana*, would make them useless: therefore, the latter must precede the former (Vitrac 2003, 286–287), unless we suppose that the copyist of Vat. gr. 190 was urged to blindly collate the *excerpta* from another model.

It should be stressed that these remarks only corroborate (albeit quite strongly) the hypothesis that the *scholia vaticana* were composed in Late Antiquity, and in fact within the school of Isidorus of Miletus. One cannot require more than corroboration: no features of an apograph can unquestionably decide whether its direct model first displayed a specific layout (in our case, the apparatus of scholia) or simply reproduced that of one of its own models. In other words, if lower bounds to the composition of specific scholia can be deduced from their content (extracts from writings we can date with certainty, mention of known authorities), upper bounds are much more difficult, and often impossible, to establish. Assessing the issue is therefore a matter of degrees of plausibility: one can hypercritically doubt every step of the above reconstruction, since the possibility cannot be ruled out by the available evidence that a now-lost early IXth-century codex was the common model of the *scholia vaticana*²⁹ in several independent witnesses of *El.* and in Vat. gr. 204. I think that in proposing

²⁸ The oldest manuscript of Proclus' *in Eucl.* is Monac. gr. 427, a paper codex of the XIth century (Noack 1990).

²⁹ But not of *El.*, since there are two recensions; however, this codex must have contained either one or the other.

this hypothesis one should also accept to shoulder the burden of proof and, in particular, to provide a rationale for such hectic copying activity of *EL* in early IXth century (at least two branchings in the transmission)³⁰ and to identify a scholarly circle – in the same period – in which the enterprise of annotating the whole of *EL* by collating several exegetic resources could have been carried out.

The name of Leo the Mathematician naturally comes to mind³¹; it is therefore important to assess the testimonies of his scientific activity, in order to establish whether he was in a position to achieve a systematic annotation of *EL* to some extent analogous to the διόρθωσις of Plato's *Laws* 1–5 one celebrated scholium assigns to him³².

- The annotation at f. 263v *mg. ext.* of Vat. gr. 1594 τοῦ ἀστρονομικωτάτου Λέοντος ἡ βίβλος has been assigned at least to the XIIIth century by N. Wilson (1973, 223) and held by the same scholar to be a mere pen-trial.
- Four epigrams in the *Anthologia Palatina* ascribed to Leo mention technical writings or make them speak; the 2-lines epigrams 9.200 and 9.201 mention a βίβλος μηχανικῆ of Kyrinus and Marcellus (contemporaries of Libanius) and refer to an astrological treatise of Paul of Alexandria, respectively; epigram 9.202 credits Leo with having owned a book containing writings by Theon and Proclus³³; finally, epigram 9.578 makes a most generic geometric book speak: on the basis of the lemma accompanying the epigram itself, the book uses to be identified with Apollonius' *Conica*³⁴.
- The testimony of the inscription reproduced, after the subscription of Archimedes' *Quadratura parabolae*, by two of the Renaissance apographs of a

30 Remark b) above entails that this codex should even be earlier than the hyparchetypes of the two branches of tradition of *EL*.

31 All subsequent literature on Leo's mathematical interests depends in fact on Heiberg 1887 (see the conjunctive error pointed out in footnote 35 below).

32 The scholium can be read in Paris. gr. 1807, f. 200r *mg. ext.*: τέλος τῶν διορθωθέντων ὑπὸ τοῦ μεγάλου (φιλοσόφου) Vat. gr. 1, f. 48r) Λέοντος.

33 It is not said that the Theon mentioned in the epigram is Theon of Alexandria: half of the extant *Expositio rerum ad legendum Platonem utilium* of Theon of Smyrna deals with astronomic matters. Cf. Wilson 1983a (1996²), 83–84.

34 The lemma is written by the first hand of the mid Xth century codex Heidelb. Palat. gr. 23, p. 455: Λέοντος φιλοσόφου εἰς τὰ κωνικά Ἀπολλωνίου. It is useful also to read the lemmas of epigrams 9.201 and 9.202: τοῦ αὐτοῦ Λέοντος φιλοσόφου. εἰς τὴν βίβλον Παύλου ἀστρολόγου and τοῦ αὐτοῦ Λέοντος εἰς τὰς βίβλους Πρόκλου καὶ Θέωνος: τῆς μὲν Θέωνος ἀστρονομικῆς· τῆς δὲ Πρόκλου γεωμετρικῆς, respectively (p. 388 of the same codex, by a different, slightly later, hand). I am grateful to S. Martinelli Tempesta for precious indications on this point. On Leo's epigrams see also Baldwin 1990.

lost Archimedean codex owned by Giorgio Valla³⁵, must be assessed more carefully than it usually is. Irigoin's (2000) purportedly paleographic argument for assigning the lost codex to the middle of the IXth century is based on the script, apparently imitative of the model, of an apograph transcribed at the very end of the XVth century. Yet, his argument is subtly fallacious, since it hinges in a decisive way upon the piece of information coming from the inscription. The text of the inscription itself only proves that the lost Valla codex was in the hands of an acquaintance of Leo (maybe a pupil of his, or that otherwise unknown Theodorus whom Leo very likely appointed to the chair of geometry in the Magnaura school), not in his own hands.

- If it is true that manuscripts of scientific content were in Leo's hands, one must bear in mind that it is one thing to own manuscripts or to make copies of them, but quite another thing to provide the treatises therein contained with a rich and systematic apparatus of scholia. What is more, the mere fact that the earliest scientific manuscripts in minuscule (such as Vat. gr. 190 and Vat. gr. 204) happen to have been transcribed during Leo's lifespan proves nothing, simply because *all* the earliest manuscripts in minuscule were transcribed in the same period (after all, this is one of the principal manifestations of the "Byzantine renaissance"). On the contrary, if we are to believe the paleographers, such manuscripts as Vat. gr. 190 and Vat. gr. 204 were transcribed during Leo's youth, when he acted as a private teacher in Constantinople, and definitely before he became the director of (and held the chair of philosophy in) the Magnaura school.
- All in all, the only concrete sign of Leo's *mathematical activities* is limited to the *likely* ascription to him of a long post-liminar first-hand scholium to *El. 6*: it carries the title ὑπόμνημα σχόλιον εἰς τὰς τῶν λόγων σύνθεσιν τε καὶ ἀφαίρεσιν, Λέοντος and it is transcribed, at the end of the book and together with other exegetic material, at ff. 120–121 of Bodl. Dorv. 301³⁶. If the rather trivial content of the scholium and its non-marginal position have any implication, it is precisely that Leo did not embark on the enterprise of annotating the whole of the *Elements*. For a series of reasons, the scholium deserves a detailed analysis, which is contained in Supplement 1.

³⁵ Εὐτυχοῖης Λέον γεωμέτρα | πολλοὺς ἐς λυκάβαντας ἵοις πολὺ φίλτατε μούσαις, in Laur. Plut. 28.4, f. 120r (*perperam 120v cuncti viri docti*), et Paris. gr. 2360, f. 80r.

³⁶ The scholium is edited at *Euclidis Elementa* 5.2.341.9–345.7, within the *Appendix scholiorum III*.

In sum, the convergence of signs of full-fledged scientific activity on Leo the Mathematician is to a great extent a myth induced by the well-known scholarly habit of cumulating unassigned or uncertain data on the only available personality – in our case, a personality having an ideally suited, yet misleading, nickname³⁷.

Heiberg identified another collection of scholia, which he called *scholia vindobonensia*: 461 annotations (listed at Heiberg 1888, 244–248) transcribed in the margins by the main copyists of Paris. gr. 2344 and of Vindob. phil. gr. 31, f. 235r ff., to which he added, because of their presence in the later Laur. Plut. 28.2, the scholia transcribed by the hand responsible for the first part of the Vienna codex and by a second hand in the Paris manuscript. The main characters of this collection cannot be favorably appraised: excerpts from Proclus that are negligent and based on a text that is as bad as that of the direct tradition, borrowings from the *scholia vaticana*, presence of duplicates, explicit quotes of the texts being commented on, uncertain grammar and content often flawed by trivial errors, obscurities and blatant mistakes. Heiberg sets them in the XIth century, and submits Michael Psellus' name, to whom *sch.* 1.40 and 1.49 are ascribed in Magl. XI 53³⁸.

If one must *a priori* suspect that many non-authentic argumentative units in a mathematical text are former scholia that found their way into the text at some stage of copying, an interesting subset of these spurious passages consists of very old marginal annotations which, depending on the manuscript, followed different paths: integrated with the main text, transcribed as scholia, or simply omitted. Heiberg lists them (1888, 230–231), and the reader may follow their trajectories in his edition of *El*. They are common notion 5 *vulgo*, 6.def.5, the porisms to 3.31, 5.19, 6.8, 6.20 (porism 2), and 10.23, the supplements to 10.10, 10.36–40, and 13.1–5, the entire prop. 13.6. Only a handful of the over 1450 scholia edited by Heiberg (*sch.* 1.2, 68, 3.19, 6.46, 9.43, 10.177, 11.18, 12.94, *app. sch.* 2.8) allude to divergent texts; perhaps the most interesting indications are the two mentions, transcribed by the scholiast of the XIIth-century manuscript Paris. gr. 2466 (*sch.* 1.68 and 6.46), of better proofs to be found ἐν τῷ Σαρακηνικῷ ἀντιγράφῳ.

³⁷ Yet, Leo is awarded the epithet μαθηματικός only once: *Theophanes continuatus* 4.197.4. But recall that the term simply means “man of study”.

³⁸ The names of three other renowned Byzantine scholars surface in the scholia to *El*. They are Leo (the Mathematician?), as we have just seen, Maximus Planudes, in *sch.* 6.6 and 10.223 and in three further annotations in Laur. Plut. 28.2, and John Pothos Pediasimos, in two scholia again in Laur. Plut. 28.2 (Heiberg 1888, 272–275).

2.2 *Almagest*

The *scholia vetera* to the *Almagestum* (henceforth *Alm.*) have never been edited or studied as a collection³⁹. In this section I will try to give some elements useful for their study, with special focus on the scholiastic *corpus* of Vat. gr. 1594, a codex I have analysed thoroughly very recently.

Heiberg knew of 36 manuscripts of *Alm.*; he organized them into three families⁴⁰, whose best (and oldest) representatives are

- Vat. gr. 1594 [IXth century *p. m.*, *siglum* B, *Prolegomena ad Alm.* (henceforth *Prol.*), anonymous and incomplete, Ptolemy, *Alm.*, *Phaseis* (*Phas.*), *De iudicandi facultate et animi principatu* (*Judic.*), *De hypothesibus planetarum* (*Hyp.*), book 1] and Marc. gr. 313 [IXth century *ex.*–Xth century *in.*, *siglum* C, *Prol.*, *Alm.*];
- Paris. gr. 2389 (in majuscule, IXth century *in.*, *siglum* A, *Alm.*);
- Vat. gr. 180 (Xth century, *siglum* D, *Alm.*)⁴¹ and Vat. gr. 184 (XIIIth century *p. m.*, *siglum* G, *varia arithmetica et astronomica*, *Prol.*, *scholia miscellanea ad Alm.*, *Alm.*)⁴².

³⁹ In particular, no-one has so far redacted even a tool as simple as a concordance table of the scholia in the oldest manuscripts of *Alm.* See Mogenet 1962 and 1975, Tihon 1976, Pingree 1994, and Jones 2003 for editions limited to few *specimina*. There are just a handful of first-hand scholia to *Prolegomena ad Alm.*, nevertheless they provide us with one interesting piece of information: the true title of Pappus' *Collectio*. The text is ἰστέον ὅτι ὁ μέγας Πάππος ταῦτα ἐπέδειξεν ἔμμελῃ ἐν τῇ ἐ' βίβλῳ τῶν ἀνθιρῶν προβλημάτων (Marc. gr. 313, f. 3v, and Vat. gr. 1594, f. 5r, in minuscule, edited in Acerbi/Vinel/Vitrac 2010, 132.24 *app.*).

⁴⁰ In this order, partial *stemma* are given at *Ptolemaei opera omnia* 2.LIII, LXXVI, CXXXVI. One must recall that Vat. gr. 184 is employed by Heiberg only in tome 1.2 (= *Alm.* 7–13) and that it is incomplete (*des. ibid.* 1.2.589.7 ἀνωμαλίας).

⁴¹ On the structure of this codex, written by several copyists, see Orsini 2005, 317–322 and 340–342. The ff. 1r–2r and 280v, by a hand of the XIth century, contain excerpts from Theodoret's *Commentarius in Psalmos*.

⁴² Vat. gr. 184 (note by one of the copyists dated 1269/1270) is an apograph of Vat. gr. 1594 insofar as *Prol.* is concerned. This manuscript (see Bianconi 2004, 330–331, for its structure) contains annotations and corrections by John Pothos Pediasimos, John Catrarios, Nicolas Eudaimonoioannes [see in the first place Tihon 2003; Bianconi 2005b, 150–151, identified one of the hands singled out by Tihon with that of John Catrarios; the identification of Pediasimos (*olim* Turyn's R, to be found also in Bodl. Dorv. 301: B. Mondrain, unpublished – and in Vat. gr. 2326: Bianconi 2014) is in Pérez Martín 2010]. A select collection of scholia from Vat. gr. 1594 was transcribed in Vat. gr. 184, ff. 25r–80v, preceded by the title Θέωνος ἀλεξανδρέως· σχόλια πάνν χρησιμα εἰς τὴν μεγάλην σύνταξιν Πτολεμαίου; Mogenet (1975, 307) asserts that these are in all 121 annotations, of which 46 were originally written by the first hand of Vat. gr. 1594, 75 by a second hand (Mogenet does not qualify his statement, but there must be something wrong in his figures: there obviously are many more than 121 scholia in the collection of Vat. gr. 184).

The first two families, of which the said *codices* are also the prototypes, are linked by a series of conjunctive variants and thus give rise to a super-family. Heiberg notes that the tradition represented by the third family, although less correct and often interpolated, allows very old textual layers to be reached. Overall, the structure of the *stemma* proposed by Heiberg makes it possible to go very far back in the tradition of *Alm.*

Paris. gr. 2389 is a *de luxe* exemplar and has no *scholia vetera*, large quantities of which can, instead, be found in Vat. gr. 1594 and Marc. gr. 313. The sets of scholia of these two manuscripts are almost identical. We will presently see that we can also set an upper bound to their date of composition: the redaction of Theon's commentary in *Alm.*, about 360. We are thus presented with a situation fairly analogous to that encountered in the previous section with the *scholia vetera ad El.*: a collection of scholia assembled not before Late Antiquity and contained in independent (albeit belonging to the same family) witnesses of the main text. But the situation is even more favorable, since we can both lower the upper bound and increase the lower bound. In order to see this, let us consider first some of the main features of this *corpus* as we have it in Vat. gr. 1594, by far the best witness.

- 1) *First-hand scholia in majuscule.* First-hand scholia are either in a majuscule of small module or in a minuscule identical with that of the main text but of reduced module: over the same length of text, the scholia line up about $\frac{2}{3}$ of the signs of the text. Scholia in majuscule⁴³ can be found at the ff. 6r, 9r epigram (in *Auszeichnungsmajuskel*, of the same size as the titles of the chapters of *Alm.*), 12r (short schematic summary), 16r, 19r, 19v, 22v, 23r, 23v, 24r, 25r, 25v, 36r, 37v, 38v, 39r, 40r, 42r, 42v, 43r, 43v, 44r, 44v, 45r, 46v (schematic summary), 47r, 47v, 48r, 48v, 57v, 61v, 64v, 68v, 71r (short schematic summary), 75v, 81v–82r (annotations to the tables of the mean motions of the Moon), 92r, 97v, 100r, 102v, 106v, 110r, 116r, 118r, 120v, 122v, 123r, 123v, 125r (annotations to the tables of conjunctions), 126r, 127r, 128v, 132v, 133r, 138v, 140v, 141v, 148v, 154r, 155–164 (annotations to the star catalogue), 168r, 168v, 169r (schematic summary), 169v, 170r (schematic summary), 174v, 176r, 178r, 179v, 181r, 18v, 184r (annotations to the tables of the mean motions in longitude and anomaly of the five planets), 185v, 193r (data concerning the Moon and Mercury, in tabular form), 196r, 196v, 197r, 199r, 207r, 208r, 209v, 211v, 213r, 215v, 216v, 217r, 221r, 222r, 222v, 223v, 224r, 228v, 229r, 257v. Sche-

⁴³ These scholia are transcribed in Supplement 2 at the end of this article. Short numerical scholia are excluded.

matic scholia normally have the first categorization in majuscule (see item 3). Numerical tables normally are in majuscule (see item 4).

- 2) *First-hand scholia in minuscule*. These can be found on almost every page, and sometimes are of considerable extent; as regards their content, see *infra*. Starting from f. 113v (*Alm.* 5.4), a later hand marked these scholia selectively (the selection criterion appears to be related to length) by a slashed majuscule *gamma*. Starting from f. 140r (*Alm.* 6.10), the scholia are also numbered by a more recent hand [which at the beginning adds ση(μελωσα)] to the numeral letter], again selectively, and in fact over a subset of those receiving the first marking: numbers range from α' to γ' in book 6 (but including a β' and a β'+), from α' to ρβ' in books 8–9, from α' to κς' in book 10, from α' to ξβ' in books 11–12, from α' to ρ' in book 13: 274 scholia in all. Exactly the same numbering is apposed, only for book 13 and by the same XIVth century hand that transcribed the scholia, in Vat. gr. 180. Some scholia in minuscule have a “title” in majuscule. A small number of scholia are *figurata*, that is, they have the form of an object: ff. 10v (amphora), 18v (Latin cross), 24v (altar [?]), 26r (Latin cross having an amphora as basis, but only the final portion of the scholium, which begins in the upper margin), 36r (Latin cross), 36v (amphora with pointed basis), 38r (amphora), 68v (Latin cross having an amphora as basis), 205v (amphora having a Latin cross as basis). Even when they are not *figurata*, many first-hand scholia in minuscule have their last line(s) centered and showing progressively reduced length. Two long scholia at the end of *Alm.* 5.7 and 5.17 (ff. 106r and 117v) are set out, preceded and followed by decoration, as if they had a truly textual status, although they are still written with a script whose module is intermediate between that of the text and that of the marginal annotations.
- 3) *Schematic scholia*. These can be found at ff. 1v⁴⁴, 12r (entirely in majuscule), 12v, 24r, 46v (in majuscule), 47r, 71r (in majuscule), 119r, 145r, 169r (in majuscule), 170r (in majuscule), 260v. The schemes in majuscule are usually more condensed. All these schemes, except for the one at f. 145r, have portions in majuscule, normally the first row.
- 4) *First-hand tabular scholia*. Numerical tables (always without justification lines) can be found at ff. 27v, 37v, 38v, 42r, 44v, 45v, 48v, 59r, 62r, 70r, 74v, 75r, 75v, 76r, 76v, 78v, 79r, 81v, 82r, 86r, 86v, 87r, 88r, 89v, 92v, 93v, 95r, 95v (*mg. sup.*, these are data from Hipparchus), 99r, 100r, 101r, 101v, 111r, 113r, 113v, 114v, 115r, 115v, 122v, 123r, 126v, 127r, 127v, 128r, 128v, 129r, 129v, 130r, 132v, 133r, 133v, 143r, 143v, 174r, 176v, 182v, 184r, 186r, 192r, 193r, 201v, 209v

44 Edition in Acerbi/Vinel/Vitrac 2010, 78.3 *app.*

(comparison of the dates of observation reports by Dionysius and Ptolemy), 210r, 216v, 217r, 222v, 235r, 235v, 236r, 236v, 245v (incomplete), 261r. Tabular calculations (normally applications of simple proportional schemes required in interpolations or in applications of Menelaus' theorem) can be found at ff. 23v, 26r, 27r, 29v, 30r, 42v, 44v, 46r, 48v, 70r, 71r, 76r, 90r, 90v, 91r, 94v, 102r, 102v, 103r, 103v, 104r, 104v, 105v, 108r, 108v, 111r, 111v, 112r, 114r, 114v, 115, 116r, 116v, 117r, 121v.

- 5) *First-hand diagrams attached to scholia*. They can be found at ff. 45r, 64v, 65r, 68r, 68v, 75v, 76r, 79v, 87v, 98v, 99v, 103v, 119r, 120r, 127v, 128v, 129r, 131r, 134r, 135r, 172r, 188r, 255r. The systematic presence of these diagrams shows that they were traced at the same time as the scholia.
- 6) *Second-hand scholia and correctors*. These can be found at ff. 2r–5r (see *infra*), from f. 16v to f. 91r (*Alm.* 1.9–4.6), and at f. 112v (*Alm.* 5.14). Many of these annotations go back to the XIIth century, by a hand that also supplied ff. 66–67⁴⁵. Heiberg⁴⁶ identified four hands of correctors. The hand of the first corrector (end Xth–beginning XIth century), whose *ductus* is nervous and angular, strongly bent on the right, supplements short pericopes omitted, usually by *saut du même au même*, by copyist IIa at ff. 18r–v, 19r–v⁴⁷. By far the most frequent hand (and of an attentive reader: note the title at f. 169r), which also traces most of the diagrams omitted by the main copyist, relies for its interventions on a manuscript of the family of Vat. gr. 180 and 184. This hand coincides with the one that supplied ff. 66–67 and wrote down most of the later-hand scholia⁴⁸.

⁴⁵ Expertise of P. Canart *apud* Mogenet 1975, 303.

⁴⁶ *Ptolemaei opera omnia* 2.XXXII–XXXIII.

⁴⁷ The supplemented passages are at *Alm.* 1.10, *Ptolemaei opera omnia* 1.1.37.11–12, 37.15, 38.14, 39.16–18, 43.7, 43.13–16, 45.6–7. All these passages are also absent in Marc. gr. 313. Other interventions of this corrector are at *Ptolemaei opera omnia* 1.1.13.9 (*corr.* μείζοναι in χωρῆ), 15.17 (restoration of the order of three words by means of superposed apices), 19.21 (trivial correction), 38.18 (*add.* τε οὐκ *mg.* et ras.), 44.6.13 (correction of denotative letters). Therefore, this hand only checked for the text of *Alm.* 1.3–5 and 1.10. Vat. gr. 1594, formerly included in the “collection philosophique” (Ronconi 2013), was written by two copyists, called IIa (ff. 1r–277r) and IIc (ff. 278r–283r).

⁴⁸ The first scholium written by this hand is of the utmost importance: in the margins of *Prol.* at ff. 2r–5r, it provides us with crucial pieces of information on the relationships between Byzantine and Arabic astronomy. Redacted ca. 1032 and transcribed in Vat. gr. 1594 from unknown sources, this scholium was therefrom copied in the margins of Vat. gr. 2326, ff. 26r–28r, and of Paris. gr. 453 (Mogenet 1962).

Both first-hand and second-hand scholia to *Alm.* can be divided into three categories (Mogenet 1975):

- a) extracts from Theon's commentary *in Alm.*;
- b) extracts from the "same" commentary but containing additions (or presenting variants) to be found nowhere else⁴⁹;
- c) annotations referring to periods after Theon's times⁵⁰.

The first-hand scholia of categories a)–b) constitute almost the whole of the indirect tradition of Theon *in Alm.*, and Mogenet, in his article of 1975, had already set up comparisons to the detriment of the editorial practices of A. Rome. Now, while this work is partly made useless by the fact that books 1–4 and 6 are transmitted by the *vetustissimus* Laur. Plut. 28.18 (IXth century *in.*; these are the books edited in Rome 1931–1943, where the *scholia vetera* to *Alm.* are not collated), the only witness of Theon *in Alm.* 8–10 and 12–13⁵¹ not containing a Byzantine recension happens to be a portion, dated to the end of the XIIIth century, of Vat. gr. 1087⁵². For these books, then, the earliest indirect tradition of Theon *in Alm.*, represented by the first-hand scholia of Vat. gr. 1594, is over four centuries older than the direct tradition of the same work – only available in a form in which we have every reason to suspect interventions of the renowned Byzantine scholar Maximus Planudes⁵³.

⁴⁹ A tempting hypothesis (cf. Mogenet 1975, 307) on the origin of these extracts is that they come from Pappus' commentary *in Alm.*, in all evidence the (very close) model of Theon's (see Rome 1931–1943, LXXXIII–LXXXVI). Only books 5 and 6 of Pappus' *in Alm.* have survived, whereas Theon's equivalent commentary has been transmitted almost in its entirety (see *infra*).

⁵⁰ The sub-collection in Vat. gr. 184 gives the following figures (Mogenet 1975, 307): of the 46 first-hand scholia, 31 belong in one of categories a)–b), whereas only 8 of the later scholia have this origin.

⁵¹ Book 11 of Theon *in Alm.* is lost, book 7 can only be read in a Byzantine recension.

⁵² The relevant portion is at ff. 123–147. This manuscript must be completed (Rome 1927) with Paris. gr. 2396, which contains Theon *in Alm.* 1, 2, 4 and whose ff. 1–86 date back to the Planudean period and actually are in part (ff. 33v–76v) an autograph of Planudes himself: Mondrain 2002. Concerning the copyist of Paris. gr. 2396, ff. 77r–86v, and of the said folios of Vat. gr. 1087, who was an anonymous collaborator of Nicephorus Gregoras, see Bianconi 2006, 147–151. Both *codices* also contain annotations by Gregoras (Bianconi 2005a, 414–415 and 417). On Vat. gr. 1087, see in the first place Pérez Martín 1997, 83, and, most recently, Menchelli 2013.

⁵³ A proof of this is a calculation that Theon performs at *in Alm.* 13.3, first διὰ τῶν ἐκ τῶν γραμμικῶν ἐφόδων ἐπιλογισμῶν, then διὰ τῆς τῶν διοφαντείων ἀριθμῶν ἀγωγῆς. We read this passage as an unassigned extract at Vat. gr. 1594, f. 248v, and at Vat. gr. 180, f. 268r, written by a hand of the XIVth century (starting exactly from *Alm.* 13.3, the lower margin of each folio of Marc. gr. 313 has been cut off, but what remains bears no annotations; an edition of this text is published in Christianidis/Skoura 2013) – and obviously as a part of Theon's commentary at Vat.

As far as the first-hand scholia belonging to category c) are concerned, an analysis of three such scholia led D. Pingree to conjecture that they were the *membra disiecta* of a commentary redacted between 537 and 637, probably by a representative of the Nestorian community based in Nisibis, now Nusaybin in south-eastern Turkey⁵⁴. Pingree even ventured, “only in [his] imagination”, to propose a chain linking this unknown scholar with Theophilus of Edessa and his pupil Stephanus the Philosopher, who might have carried the model of Vat. gr. 1594 to Constantinople just before 775. As a matter of fact, Pingree’s argument rests on poor evidence: the first scholium, from which he draws the window between 537 and 637, appears to forge fictitious data for the sake of example; the second scholium is a précis of *Hyp.* 2, transmitted only in Arabic translation but well known in its original form by Proclus and Simplicius⁵⁵; the third scholium, of theological content, focuses on a point of doctrine (divine things are invisible to us only because of our weakness) that is not extremely specific – and Syria was not the only place where Nestorian ideas could be professed at the beginning of the VIth century.

Different suggestions as to the origin of the first-hand scholia in Vat. gr. 1594 come to the fore if we examine them more closely from a structural point of view. First of all, these scholia could not possibly have been composed or gathered by the copyist: as noted above, we find the same collection, with variations that would deserve to be studied in detail, also in Marc. gr. 313, belonging to the same textual family of *Prol.* and *Alm.* as the Vatican codex⁵⁶.

A second, and crucial, remark is that the copyist of *Prol.* and *Alm.* in Vat. gr. 1594 apparently found two different layers of scholia in his model, which he differentiated by means of the graphic dichotomy majuscule/minuscule⁵⁷. The most

gr. 1087, ff. 145r–v, where it is followed, in the main text, by a carefully arranged tabular set-up of the diophantine-style solution, identical in form to those displayed in Planudes’ commentary on Diophantus’ *Arithmetica*.

54 See Pingree 1994; the scholia can be read at Vat. gr. 1594, ff. 169r (*Alm.* 8.3), 174r (*Alm.* 9.1), and 10r (*Alm.* 1.1). Other manuscripts carrying annotations to *Alm.* can prove useful for reconstructing ancient writings. Mogenet (1975) has shown that those of Vat. gr. 1594 can assist in filling lacunas in book 3 of Theon in *Alm.* Tihon (1987) found book 5 of the same treatise in the margins of Vat. gr. 198 (XIVth century *p. m.*), after Rome (1953) had identified a long extract included in the main text (ff. 421v–424v).

55 Proclus, in *R.*, 2.230.14 Kroll, and in *Ti.*, 3.62.23 Diehl; Simplicius, in *Cael.*, 456.22 Heiberg. This list is printed in *Ptolemaei opera omnia* 2.110.

56 As for Vat. gr. 180, it contains a rich scholiastic apparatus, undoubtedly transcribed by collation from Vat. gr. 1594 by a hand of the end XIth–beginning XIIth century.

57 The evidence shows that the argument in Irigoien 1957, 9–10, concerning the presence of majuscule/minuscule script in the scholia as a dating criterion, could not be right, simply because

likely explanation is that the scholia he transcribes in majuscule could be identified as older in the model, the scholia he transcribed in minuscule being perceptibly more recent, and perhaps traced in a more informal hand⁵⁸. A first clue comes from the epigram transcribed in a quite formal majuscule script in Vat. gr. 1594, f. 9r *mg. inf.*, whereas Marc. gr. 313, f. 30v (in a very formal majuscule; it is not clear whether the copyist intended to have it in the text or to keep it in the margins, since it partly occupies both; the presence of a decoration between summary and epigram suggests that the former alternative holds), and Vat. gr. 180, f. 3r, have it in the main text, just after the summary of *Alm.* 1⁵⁹. It is quite clear that the epigram was present in the form of a scholium in the common model of Vat. gr. 1594 and Marc. gr. 313, and that the incertitudes as to its placement in the latter codex must come from the fact that its copyist shifted the format from two columns to full page. Now, the epigram is also attested in Synesius, *De dono* 5 (no ascription; it is qualified as ἀρχαῖον), as *Anthologia Palatina* 9.577 (Heidelb. Palat. gr. 23, p. 455, lemma Πτολεμαίου εἰς ἑαυτόν), in Vat. gr. 184, f. 82r (minuscule script, in the intercolumnar space, no ascription and after an indication ἐπίγραμμα), in Leid. B.P.G. 78, f. 145r (Ptolemy, *Tabulae manuales*), where the epigram, written by the main copyist in an early IXth century majuscule, is included in the last table (!) of the catalogue of the fixed stars, preceded by the title ἐπίγραμμα ὃ εἶπεν Πτολεμαῖος εἰς ἑαυτόν. All these testimonies had only access to a debased text, marred by three conspicuous *lectiones faciliores*. Thus, the best version of the epigram has only been transmitted by the model of Vat. gr. 1594, the debased version being attested in as early as Synesius. This suggests that the epigram was already contained as a scholium in an ancestor of the model itself: the formal *Auszeichnungsmajuskel* adopted in the surviving apographs of this codex can be taken to reflect this fact. A second clue is that the scholia to *Prol.*, which was redacted not before the end of the Vth century as we will see, are all in minuscule, including the highly symmetric schematic summary on f. 1v. A third clue, corroborated by what we will argue about the origin of the hyparchetype of the textual family led by Vat. gr. 1594, is that the scholia in minuscule have the structure of a running commentary, made up of extracts from

it was based on too reduced a sample (for instance, Irigoin does not mention Vat. gr. 190, whose scholia are all in minuscule).

⁵⁸ In particular, some schematic summaries could be older than others, the copyist having kept the majuscule only for the first line of the most recent ones. To the scholia in majuscule to *Alm.* should be added four annotations in majuscule to *Judic.*

⁵⁹ But in Vat. gr. 180 the epigram is transcribed by the same hand of the end XIth–beginning XIIth century that collated the scholia of Vat. gr. 1594. The epigram is edited in *Ptolemaei opera omnia* 1.14.5 *app.* and, for the variant readings of the *recentiores*, *ibid.* 2.CXLVII–CXLVIII; an edition taking into account the entire tradition is in Boll 1921.

other commentaries: it is a specialist's job, finding its natural *milieu* in well-organised scholarly circles, most notably from the point of view of access to sources. A fourth clue suggesting the ancient origin of all first-hand scholia in Vat. gr 1594 is the notational practice of the signs representing sexagesimal numeric entities: on the one side is the evidence of *Prol.*: apices; on the other stands the evidence of the main text of *Alm.* and of the scholia thereon in *all* the oldest manuscripts: bars. It seems as if our documents testify to a notational change that took place in the period between Theon (IVth century *p. m.*), whose *in Alm.* was the basis of the excerpted scholia, and the circles in which *Prol.* was redacted (VIth century *in.*), and the change may indeed have been triggered by these very circles. What is paradoxical is that in the same codex (Vat. gr. 1594) one finds two different notations for the sexagesimal numeric entities, and that one (apices) is systematically adopted in a work (*Prol.*) that was intended as a technical primer for the algorithmic practice of the treatise (*Alm.*) where the other (bars) is adopted (Acerbi 2013b).

The strongest argument in favor of assigning the model of Vat. gr. 1594 to the Alexandrine Neoplatonic school of the late Vth–early VIIth centuries, is what we may call “preliminary material” (*scil.* to *Alm.*). This resource is made up of four texts, given in the following order: *Prol.*, the *Inscriptio Canobi* (a work by Ptolemy!), a list of seven observation reports of astronomic phenomena, the *Septem astrorum epitheta* of Dorotheus of Sidon (1st century CE). Now, only 1/3 of *Prol.* remains in Vat. gr. 1594, but the original presence there of the preliminary material in its entirety is beyond doubt: two quires after the first quaternion have surely been lost in Vat. gr. 1594, and we find the same material in its complete form, and immediately followed by *Alm.*, in direct apographs of the Vatican codex such as Paris. gr. 2390 and Vat. gr. 2326; what is more, we also find it in Marc. gr. 313, an independent copy of the same model as Vat. gr. 1594.

Now, six of the observation reports contain the name of the observer: it is Heliodorus, son of Hermias and brother of Ammonius⁶⁰, the Neoplatonic philosopher who held the chair of the School of Alexandria and was still living in 517⁶¹. To these six observations, expressly dated between 498 and 510, another was added, made

⁶⁰ See Zintzen 1967, 100.7–8, 101.2, 109.7–11 (= Phot., *Bibl.* 242, 341a 7–9, and *Suda* ε 3035, 2.412.22, and α 79, 2.162.13–17 Adler, respectively).

⁶¹ Editions in *Ptolemaei opera omnia* 2.XXXV–XXXVII, Jones 2005. Analysis of the astronomic content in Neugebauer 1975, 1038–1041. The observations are: 1st May 498, conjunction Mars-Jupiter; 21 February 503, lunar occultation of Saturn; 18 November 475, lunar occultation of Venus; 27 September 508, conjunction Jupiter-Regulus (= α Leonis); 11 March 509, lunar occultation of the “bright «star» of the Hyades” (= α Tauri); 13 June 509, conjunction Mars-Jupiter; 20–21 August 510 (date not specified in the text), missed conjunction Venus-Jupiter.

in 475 in Athens, preceded and followed by the indication τοῦ θεοῦ τήρησις⁶². The reports are worded in the first person and begin with εἶδον Ἡλιόδωρος. In one of them, made on 21 February 503, it is specified that “the beloved brother” of Heliodorus was also present (ἐγὼ τε καὶ ὁ φιλότατος ἀδελφός) – that is, Ammonius.

Heliodorus’ observations provide us with one crucial piece of information about the history of the text. In fact, the *incipit* of this short tract is ταῦτα ἀπὸ τοῦ ἀντιγράφου τοῦ φιλοσόφου ἔγραψα: it is the remark of a copyist, and the fact that, both in Marc. gr. 313 and in the apographs of Vat. gr. 1594, we find these words in isolation at the beginning of the text (still not identified as a title by some *Auszeichnungsschrift*) shows that they were contained in the common ancestor of the Vatican and Venetian *codices*. The rhetorical device of antonomasia and the fact that the epithet φιλόσοφος was exclusive to the chairholder of the Neoplatonic school make it almost certain that this unnamed “philosopher” is Ammonius or one of his immediate successors. Moreover, it goes without saying that the “exemplar of the philosopher” was a copy of *Alm.*: one is thus led to conclude that Heliodorus and Ammonius were an active part in the revision that has consigned to us a whole branch of the manuscript tradition of Ptolemy’s *magnum opus*, enriched with the preliminary material. In this perspective, it is likely that the common model of Vat. gr. 1594 and of Marc. gr. 313 was closely linked with the “exemplar of the philosopher”. It should also be recalled that no more than 350 years passed between Heliodorus and the creation of Vat. gr. 1594, and that a copy of *Alm.* was extremely expensive⁶³. Consequently, Heiberg puts the hyparchetype of this branch of the tradition directly in the VIth century, arguing that this codex coincides with the exemplar of Heliodorus/Ammonius or – though he sees this as less likely – with an immediately subsequent copy⁶⁴.

That *Prol.* was also produced in Neoplatonic circles is beyond doubt: it presents *Alm.* according to the isagogic schemes developed by late Neoplatonism⁶⁵, it

⁶² Heiberg (*Ptolemaei opera omnia* 2.XXXVII) surmised that that “divine” was Proclus; Westerink (1971, 20 n. 27) recalls that in Late Antiquity θεῖος may simply mean “uncle” (this is the origin of the Italian word “zio”). From different sources (but they all can be traced back to Damascius’ *Vita Isidori*), we know that the name of Hermias’ brother was Gregorius: see Zintzen 1967, 104.5 and 105.7 (= Phot., *Bibl.* 242, 341a 33, and *Suda* γ 453, 1.543.8 Adler, respectively).

⁶³ For the cost of copy in the times of Arethas see Follieri 1973–1974.

⁶⁴ See *Ptolemaei opera omnia* 2.XXXIV–XXXVII, and the *stemma*, LIII.

⁶⁵ For a first orientation on this exegetic format, best exemplified by Simplicius’ introduction to his *Cat.* 8.9–20.12 Kalbfleish, see Hadot 1990, 21–47 and 138–160, and the synthesis in Hoffmann 2006. A treatise was presented by clarifying in succession its goal, usefulness, position in the canonical sequence of readings, title, authenticity, division into “chapters”, and assignment to a specific branch of Aristotelian philosophy.

attaches the epithet “divine” to some of the authorities it names⁶⁶. A *terminus post quem* is set by the ascription to Syrianus (†ca. 437) of a specific computational algorithm: λέγεται δὲ ἡ εὗρεσις Συριανοῦ τοῦ μεγάλου φιλοσόφου. The dubitative shade of meaning suggests that there was no strict doctrinal continuity between Syrianus’ discovery and its mention in *Prol.*: it is therefore reasonable to shift our gaze from Athens to Alexandria and let a couple of generations pass. The text of *Prol.*, which – given the syntactic evidence and the types of arguments adduced – was in all probability based on lecture notes taken from oral teaching (redaction ἀπὸ φωνῆς) that were never the object of a final redaction in view of their ἔκδοσις, was thus composed in the Alexandrine Neoplatonic circles in order to serve as an introduction and a technical primer for the algorithmic practice of the recension of *Alm.* that circulated among Ammonius’ pupils.

To sum up, the model of the model of Vat. gr. 1594 can probably be identified with the ἀντίγραφος τοῦ φιλοσόφου (Heliodorus’ observation reports), which must have been a relatively clean exemplar (sparse first-hand scholia in majuscule). The model itself was at the same time the working exemplar of a top-level scholar (abundant and technically refined first-hand scholia in minuscule)⁶⁷ and an official copy, intended to assist teaching in the Alexandrian Neoplatonic school (preliminary material and recension of *Alm.*) but without the features of a *de luxe* exemplar (unfinalized state of *Prol.*⁶⁸). Some factual data suggest that Vat. gr. 1594 is a (partially) conformal – and therefore direct – copy of this model (unlike Marc. gr. 313, in which all these characters disappear): the *mise en page* on two columns, the presence of a *tabula ansata* at f. 20v, the differentiation of the layers of scholia by means of the graphic dichotomy majuscule/minuscule⁶⁹.

⁶⁶ Eudoxus and Archimedes: οἱ θεῖοι ἄνδρες ἐκεῖνοι; Ptolemy: τοῦ θεοῦ Πτολεμαίου and τοῦ μεγάλου Πτολεμαίου. We may add the epithet of Syrianus as τοῦ μεγάλου φιλοσόφου and that of Theon as τοῦ φιλοσόφου.

⁶⁷ A further indication of this is that these scholia are seldom accompanied by signs directing to the portion of text they are intended to clarify. As a consequence, only the circle of scholars who made a unitary collection of these annotations could profitably use a manuscript containing them. Accordingly, the scholia were eliminated from all apographs of Vat. gr. 1594, while being copied selectively, surely on the initiative of scholars well acquainted with *Alm.*, in Vat. gr. 180, a manuscript belonging to another branch of the tradition.

⁶⁸ But the scholia to *Prol.* were composed within well-informed circles, and *Prol.* itself contains a version of Zenodorus’ treatise on isoperimetric figures that is different from those we read in Pappus, *Coll.* 5, and Theon, in *Alm.* 1.10.

⁶⁹ For such arguments of “kodikologische Stemmata”, see in the first place Kresten 1969, and the considerations in Cavallo 1999. A. Stramaglia pointed out to me the importance of the *tabula ansata*.

It goes without saying that this reconstruction, very much as in the case of *El.*, entails that the collection of first-hand scholia in Vat. gr. 1594 was composed in Late Antiquity, not in the early Byzantine period. The impression one draws from a careful study of this manuscript is in fact that its content must be taken as a well-thought-out whole: *Prol.* and the rest of the “preliminary material”, recension of *Alm.*, scholia to *Alm.*, all belong to a unitary exegetic enterprise, performed by a skilled and well-documented (circle of) scholars. The above discussion strongly suggests that this project was carried out to assist the teaching activities within the Neoplatonic school of Alexandria.

Again, as in the case of the scholia to *El.*, assessing the origin of the collection of first-hand annotations to *Alm.* contained in Vat. gr. 1594 cannot but be a matter of mere plausibility: as pointed out in the previous section, no feature of an apograph can unquestionably decide whether its direct model first displayed a specific layout (in our case, the apparatus of scholia) or simply reproduced that of one of its own exemplars, nor, given the inherently disconnected character of a set of specific annotations, can indications coming from specific scholia be uncontroversially generalized to the entire set⁷⁰. As a matter of fact, the two case-studies of *El.* and *Alm.* corroborate each other since they share a key characteristic: the relevant collections of first-hand scholia are contained in manuscripts featuring among the earliest transcriptions in minuscule. That in either case, and *a fortiori* in both cases, an unknown Byzantine *Gelehrter*⁷¹ had produced a now-lost early IXth-century codex that was the common model of the several independent witnesses *only* for the scholia, is in my view utterly unrealistic.

We may proceed a step further in this argument and, in order to achieve a more exact indication of the date of redaction of *Prol.*, discuss the pieces of information concerning the astronomic inclinations of the main scholars of the Neoplatonic

⁷⁰ For instance, among the first-hand scholia of Vat. gr. 1594, f. 25v, is one coinciding with the entire general part of the short tract on removal of ratios ascribed to Domninus of Larissa, a pupil of Syrianus and fellow-student of Proclus; this text expounds a procedure different from that set forth in *Prol.* We read the same annotation in Marc. gr. 313, f. 52r, in Vat. gr. 180, f. 23v, and, assisted by a peculiar *mise en page*, in Vat. gr. 184, ff. 91v–92r – that is, in all branches of the tradition of *Alm.* containing scholarly material. Now, an analysis of the scholium shows that it was the source, after the addition of a complete set of examples, of what we now read as a self-contained text. But even in this case, dating this scholium does not amount to dating the entire collection in Vat. gr. 1594 (the same must be said of the scholia discussed by Pingree). The definitive edition of all writings ascribed to Domninus is in Riedlberger 2013, the scholium is edited and discussed in Acerbi/Riedlberger 2014.

⁷¹ By this term Westerink 1990, 122, designates the personality responsible for shaping the “collection philosophique”.

school of Alexandria⁷². As we have seen, the “exemplar of the philosopher” was most likely the working copy of an Alexandrian *diadochus*, and by implication of someone giving official classes. We are thus left, in order of διαδοχία, with Ammonius, Eutocius⁷³, Olympiodorus and Stephanus of Alexandria.

Damascius asserts that he was taught by Ammonius “the composition of the astronomic books of Ptolemy”⁷⁴, and a passage in Simplicius depicts Ammonius who, in the presence of Simplicius himself, observes Arcturus with an armillary sphere, in order to determine the longitude of the star and thereby confirm the constant of precession given by Ptolemy⁷⁵. A passage from a τέχνη μαθηματική of some Stephanus (who quotes Simeon Seth and is therefore later than the mid XIth century) mentions a “table” by Ammonius which, like those of Theon and Heraclius, employed the era of Philip and the Egyptian months. It may be that the text refers to a commentary by Ammonius *in Can.*⁷⁶. Finally, John Philoponus mentions, at the very beginning of his own treatise on the subject⁷⁷, a work on the astrolabe redacted by Ammonius – and we have every reason to think that as in many other cases, Philoponus simply took up and reformulated lecture notes taken during a course held by Ammonius.

⁷² Analysis of the technical aspects in Neugebauer 1975, 1037–1051.

⁷³ That Eutocius was the successor of Ammonius is suggested by the fact that, according to Elias, he gave classes on Porphyry’s εισαγωγή: εἰ μέρος ἢ ὄργανον ἢ λογικὴ φιλοσοφίας, Εὐτόκιος μὲν ζητεῖ τῆς εισαγωγῆς ἀρχόμενος, in Westerink 1961, 134.4–5, within a fragment of a commentary of Elias on Aristotle’s *APr.*, contained in the composite manuscript Paris. suppl. gr. 678, ff. 131–138 (XIIIth century this quire).

⁷⁴ Phot., *Bibl.* 181, 127a 8–10 (= Zintzen 1967, 199.5–6): τοῦτον [*scil.* Ammonius] καὶ τῶν Πλατωνικῶν ἐξηγητὴν αὐτῷ γεγενῆσθαι Δαμάσκιος ἀναγράφει, καὶ τῆς συντάξεως τῶν ἀστρονομικῶν Πτολεμαίου βιβλίων.

⁷⁵ *In Cael.*, 462.20–30 Heiberg: ἐπειδὴ δὲ καὶ ὁ ἡμέτερος καθηγμένων Ἀμμωνίου ἐμοῦ παρόντος ἐν τῇ Ἀλεξανδρείᾳ τηρήσας διὰ τοῦ στερεοῦ ἀστρολάβου τὸν Ἀρκτοῦρον ἡῦρε πρὸς τὴν κατὰ Πτολεμαῖον ἐποχὴν αὐτοῦ τοσοῦτον ἐπικινηθέντα, ὅσον ἐχρῆν κατὰ ἑκατὸν ἔτη μίαν μοῖραν ἀντικινούμενον.

⁷⁶ ἐπεὶ δὲ τὸ τοῦ Πτολομαίου (*sic*) κανόνιον καὶ τὸ τοῦ Ἀμμωνίου καὶ τῶν λοιπῶν παλαιῶν ... ὃ τε γὰρ Πτολομαῖος τοῖς ἀπὸ τοῦ Ναβουχοδόνοσορ ἔτεσιν ἐχρήσατο καὶ μισὶν Αἰγυπτιακοῖς ὁ δὲ γε Θέων καὶ Ἡράκλειος [*immo* Stephanus, see *infra*] καὶ ὁ Ἀμμωνίος τοῖς τοῦ Φιλίππου καὶ μισὶν Αἰγυπτιακοῖς οἱ δὲ νεώτεροι τοῖς τῶν Περσικῶν ἡγεμόνων καὶ τοῖς Σαρακηνικοῖς ἔτεσι. Edition (by F. Cumont) of the passage in Kroll/Olivieri 1900, 182.12–20, discussion in Tihon 1976, 178–179.

⁷⁷ *De usu astrolabii*, in Hase 1839, 129.5–11: τὴν ἐν τῷ ἀστρολάβῳ τῆς ἐπιφανείας τῆς σφαίρας ἐξάπλωσιν, καὶ τῶν ἐν αὐτῷ καταγεγραμμένων τὰς αἰτίας, τὴν τε χρεῖαν αὐτοῦ εἰς πόσα τε καὶ ποῖα καθέστηκε χρῆσιμος, ὥς ἂν οἷός τε ὡ σαφῶς ἐκθεῖναι πειράσσομαι, ἥδη μὲν ἱκανῶς Ἀμμωνίῳ φιλοσόφῳ, τῷ ἡμῶν διδασκάλῳ, ἐσπουδασμένην, πλείονος δὲ ὅμως δεομένην σαφηνείας, ὥς ἂν καὶ τοῖς μὴ ταῦτα πεπαιδευμένοις εὐληπτος γένοιτο.

Eutocius shows himself well at home with *Alm.* and its commentaries⁷⁸; most notably, he mentions, in his commentary in *Conica*, his own non-inductive treatment of the theory of compound ratios, developed in σχόλια to *Alm.* 179.

Between May and August 564, Olympiodorus held classes on Paul of Alexandria's εἰσαγωγή; we read a redaction of these lecture notes in incomplete form⁸⁰. Other passages in Olympiodorus' Aristotelian commentaries show that he had remarkable astronomic skills⁸¹.

Stephanus of Alexandria, if we accept to identify him with a number of other homonymous scholars circulating between the end of the VIth and beginning of the VIIth century (Wolska-Conus 1989), wrote ca. 619, in Constantinople, a commentary in *Can.*⁸² duplicating Theon's "Little Commentary" but adapting it to the Byzantine world⁸³. He also gave classes on several Aristotelian treatises (*Int.*, *de An.* 3, the redactions of which are extant, *Cat.*, and *Apr.*); he may have written a tract on arithmetical matters⁸⁴ and, again if the identification is reliable, commentaries on Hippocrates and Galen. He taught first in Alexandria and then moved to Constantinople, where he became οἰκουμενικὸς διδάσκαλος, perhaps under the emperor Heraclius (regn. 610–641) – whose name is also attached to Stephanus' in *Can.* – and definitely before 617 (Alexandria seized by the Persians).

The issue of the exact scholarly circles in which *Prol.* was redacted is not settled by this quite scanty evidence, but I would surmise that in *Prol.* we read the beginning of Ammonius' lecture notes on *Alm.* If we accept this, and the recon-

78 *Archimedis opera omnia* 3.260.1–5 (εἰ δέ τις ὅλως ἐβούλετο εἰς ἕλαττον αὐτὸ καταγαγεῖν, ἔχρην τοῖς ἐν τῇ μαθηματικῇ συντάξει Κλαυδίου Πτολεμαίου εἰρημένους ἀκολουθοῦντα διὰ τῶν μοιρῶν καὶ λεπτῶν καὶ τῶν ἐν τῷ κύκλῳ εὐθειῶν τοῦτο ποιεῖν, καὶ πεποιήκειν ἂν ἐγὼ τοῦτο) and 3.232.13–17 (ὅπως δὲ δεῖ σύνεγγυς τὴν δυναμένην πλευρὰν τὸν δοθέντα ἀριθμὸν εὑρεῖν, εἴρηται μὲν Ἡρωνι ἐν τοῖς μετρικοῖς, εἴρηται δὲ Πάππῳ καὶ Θέωνι καὶ ἑτέροις πλείοσιν ἐξηγουμένοις τὴν μεγάλην σύνταξιν τοῦ Κλαυδίου Πτολεμαίου).

79 *Apollonii Pergaei quae graece exstant* 2.218.6–12: ἐπεὶ δὲ ἐπακτικώτερον μᾶλλον καὶ οὐ κατὰ τὸν ἀναγκαῖον τρόπον ὑπὸ τῶν ὑπομνηματιστῶν ἐλέγετο, ἐζητήσαμεν αὐτὸ καὶ γέγραπται ἐν τοῖς ἐκδεδομένοις ἡμῖν εἰς τὸ τέταρτον θεώρημα τοῦ δευτέρου βιβλίου τῶν Ἀρχιμήδους περὶ σφαίρας καὶ κυλίνδρου καὶ ἐν τοῖς σχολίοις τοῦ πρώτου βιβλίου τῆς Πτολεμαίου συντάξεως.

80 Edition in Boer 1962, attribution and discussion in Westerink 1971.

81 See for instance in *Mete.* 19.20–20.3, 52.24–53.2, 68.20–27, 72.14–16, 188.34–189.10, 261.34–262.13 Stīve. This commentary was redacted after 565.

82 See Lempire 2011 (analytic study and discussion of the attribution issues, with overview of the other writings ascribed to Stephanus) and 2014 (edition of the text). Stephanus' text contains some additions (chapters 1 and 28–30), whose author is the emperor Heraclius.

83 That is, by changing latitude (the tables were recalculated for the latitude of Byzantium, taken as the arithmetic mean of the 5th and of the 6th *klima*) and by resorting to Julian months.

84 [Philoponus] (*immo* Stephanus of Alexandria) in *de An.* 3.1457.24–25 Hayduck: οὐδὲ γάρ ἐστιν ἡ μονὰς ἀριθμός, ὡς ἀποδέδεικται ἐν τοῖς ἀριθμητικοῖς λόγοις.

struction of the ancestors of Vat. gr. 1594 given above, the model of Vat. gr. 1594 must have passed from Alexandria to Constantinople between the end of the VIth century and the mid IXth century, and we cannot help thinking of Stephanus of Alexandria as the likely vector⁸⁵. This model was available for some decades after its arrival in Constantinople (copying of Marc. gr. 313).

2.3 The so-called “little astronomy”

The “little astronomy” is a set of nine short treatises of astronomical content transmitted and studied as a collection at least since the late Roman period. It was intended as an introductory resource to the highly refined mathematical astronomy in *Alm.*, and the denomination μικρὸς ἀστρονομούμενος τόπος⁸⁶ may well have been created in Late Antiquity in opposition to the parallel denomination of Ptolemy’s *magnum opus*⁸⁷. As for the transmission, the best witness of

⁸⁵ See Rashed 2002, 717, for the same hypothesis applied to Marc. gr. 226.

⁸⁶ One occurrence of this designation can be read in the subscription of *Coll.* 6 [Vat. gr. 218, f. 118r, by the first hand (Xth century *in.*), in majuscule]: Πάππου ἀλεξανδρέως συναγωγῆς ζ’ περιέχει δὲ τῶν ἐν τῷ μικρῷ ἀστρονομούμενῳ θεωρημάτων ἀπόρων λύσεις; it is preliminarily introduced as a first-hand scholium in majuscule at f. 87v: περιέχει τὸ ζ’ τῶν Πάππου ἀποριῶν λύσεις τῶν ἐν τῷ μικρῷ ἀστρονομούμενῳ; we will read *infra* two other occurrences of this denomination: one in Pappus, *Coll.* 6.1, and one in *Prol.*

⁸⁷ *Magnum <opus>* is exactly what *Almagest* means, by intermediation of the Latin transliteration of the Arabic transliteration and nominalization *al-mğsfi*, coming in its turn from ἡ μεγίστη <σύνταξις> (Kunitzsch 1974, 115–125), a designation attested in Greek only in Simeon Seth (second half of the XIth century), *Util. corp.* 2.110. Even the positive-degree qualification μεγάλη appears to be a late addition to the title. One repeatedly finds it in *Prol.*, written as we have seen in Neoplatonic circles no earlier than the VIth century, and in Eutocius (*Archimedis opera omnia* 3.232.16–17), who also mentions the title without the adjective (μαθηματικὴ σύνταξις *ibid.* 260.2). The only occurrences in Aristotelian commentators are in Asclepius, in *Metaph.* 359.32 Hayduck, and Michael of Ephesus, in *EN*, 582.9 Heylbut. In its entry on Ptolemy, the *Suda* calls the *Almagest* μέγας ἀστρονόμος ἥτοι σύνταξις but, in the entry on Pappus, mentions his commentary on the μεγάλη σύνταξις (π 3033, 4.254.7–8, and π 265, 4.26.6 Adler, respectively). Before these very late sources, neither Pappus nor Theon nor, before them, a fragment of an anonymous commentary in *Alm.* written *ca.* 213 (Jones 1990), nor, after them, Proclus, either in the *Hypotyposis* or elsewhere, add the adjective. In these authors, the most frequent title is simply σύνταξις. On the basis of the self-citations within *Alm.*, of the titles and subscriptions in the manuscripts and of two citations in Pappus, *Coll.* 8.18 and 8.46 (Hultsch 1876–1878, 1058.13–14 and 1106.14, respectively), Heiberg argues that the primary denomination was μαθηματικά, to which Ptolemy himself adds σύνταξις in order to identify the genre of literary product of which *Alm.* is a species: the result is μαθηματικὴ σύνταξις, which in fact simply means “mathematical work” [*Ptolemaei opera omnia* 2.CXL–CXLI. The inscriptions mentioning only the μαθηματικά are, with indication of the com-

this collection is Vat. gr. 204, in which it is presented in the form of a well-ordered sylloge: the ordering principle is that of decreasing degree of abstraction. Thus the manuscript contains⁸⁸:

- 1) (ff. 1r–37v) Theodosius, *Sphaerica* 1–3 (henceforth *Sph.*) with scholia.
- 2) (ff. 38r–43v) Autolycus, *De sphaera mota* (*Sph. mota*) with scholia.
- 3) (ff. 43v–59r) Euclid, *Optica* (*Opt.*) recension B with scholia.
- 4) (ff. 59r–77v) Euclid, *Phaenomena* (*Phaen.*) recension b with scholia⁸⁹.
- 5) (ff. 77v–83v) Theodosius, *De habitationibus* (*Hab.*) with scholia.
- 6) (ff. 84r–109v) Theodosius, *De diebus et noctibus* 1–2 (*Dieb.*) with scholia.
- 7) (ff. 109v–118v) Aristarchus, *De magnitudinibus et distantis solis et lunae* (*Magn.*) with scholia.
- 8) (ff. 119r–133r) Autolycus, *De ortibus et occasibus* 1–2 (*Ort.*) with scholia.
- 9) (ff. 133v–135v) Hypsicles, *Anaphoricus* (*Anaph.*) with scholia.
- 10) (ff. 136r–145r) Euclid, *Catoptrica* (*Catoptr.*) with scholia; f. 145v is left blank; from f. 145r on, the main copyist starts a fresh numbering of the quires (from α' to ζ').
- 11) (ff. 146r–173r) Eutocius, *in Conica*.
- 12) (ff. 173v–194v) Euclid, *Data* with scholia; it is followed by a collection of scholia to *Data* (ff. 194v–195v).
- 13) (ff. 196r–198r) Marinus, *Prolegomena in Data*; f. 198v is blank; the 25th quire, a ternion, ends here; this is the only quire of the codex that is not a quaternion.
- 14) (ff. 199r–206v) *Scholia in El.*: it is collection 5) of section 2.1 *supra*.

binations of manuscripts containing them, at *Ptolemaei opera omnia* 1.1.85.19, 190.15 (ABCG); 1.1.459.5, 1.2.105.21, 204.15, 358.17, 448.9 (ACDG); 1.2.294.17 (CDG); 1.2.522.16 (ADG); 1.2.106.2 (AG); 1.1.546.20, 1.2.1.1 (CG); 1.1.86.1, 189.6 (D); 1.1.263.21, 264.1, 348.6, 1.2.295.1 (DG). To this list should be added the titles of the two extant books of Pappus in *Alm.*: εἰς τὸ πέμπτον (ζ') τῶν Κλαυδίου Πτολεμαίου μαθηματικῶν σχόλιον; again Pappus begins his exposition by referring τῷ τετάρτῳ (ε') βιβλίῳ τῶν μαθηματικῶν (Rome 1931–1943, 1.2–3 and 171.2–3)]. Starting from this denomination, the passage to σύνταξις would have been the natural outcome of the action of metonymy and antonomasia (“qui deinde in sermone neglegentiore scholae Alexandrinae detruncatus in Σύνταξις abiit” writes Heiberg), and after that a further step would have led to μεγίστη (μεγάλη) σύνταξις. Since the dialectic in the denominations “little astronomy” and “*Almagest*” appears to begin with *Prol.* (the subscription of *Coll.* 6 cannot be authentic with Pappus), I would surmise that it was introduced in Neoplatonic circles, as a parallel to the grading between the “little” and the “great” mysteries of philosophy (= Plato and Aristotle, respectively).

⁸⁸ On Vat. gr. 204 see most recently Acerbi 2012.

⁸⁹ As we have seen in section 2.1 *supra*, the main witness of recensions A and a of these Euclidean writings is Vindob. phil. gr. 31.

It is quite obvious that in this codex there is more material than can reasonably be called “little astronomy”; the problem resides in where to put the cut-off. Only with regard to the presence of *Catoptr.* do the codicological and technical answers not coincide; I will exclude it and not pursue the point any further, but note that the latest-dated author involved is Theodosius, to be dated to the early Ist century BCE. The other main witnesses of the collection, usually (that is, for each treatise involved) independent of Vat. gr. 204, are Vat. gr. 191, 202, 203⁹⁰, and Paris. gr. 2364⁹¹, 2390⁹², and 2448⁹³. If in Vat. gr. 204 the ordering principle is that of decreasing degree of abstraction, these manuscripts adopt disparate criteria. Vat. gr. 191 has all the treatises but the order is (approximately) by author: Euclid, Theodosius, Aristarchus, Autolycus *Ort.*, Hypsicles, Autolycus *Sph. mota*. Vat. gr. 202 adopts the same ordering as Vat. gr. 204 but omits *Catoptr.* Vat. gr. 203 omits the Euclidean writings and presents what remains by author: Theodosius, Autolycus, Hypsicles, Aristarchus; Paris. gr. 2364 does the same but permutes Aristarchus and Hypsicles.

The “little astronomy” was constituted as a resource for the study of astronomy as early as the Roman period. Two main pieces of evidence corroborate this view. The first is contained in a commentary by Galen on the Hippocratean *Air waters and places* transmitted in an Arabic translation only⁹⁴. In the text, Galen

90 These three *codices* can be assigned to the XIIIth century *ex*. On the first, a huge collection written by 16 copyists between 1296 and 1298, see now Bianconi 2004, 324–333; to one of these copyists we also owe the second part (ff. 56–98) of Vat. gr. 203.

91 This manuscript of the XVth century *ex*–XVIth century *in*. contains, in this order, *Sph.*, *Hab.*, *Dieb.*, *Sph. mota*, *Ort.*, *Magn.*, *Anaph.* It bears a possession note, dated 1508, of Andreas Coner. See Mogenet 1950, 86–88, Noack 1992, 277–288 and 298–303, Czinczenheim 2000, 236–237, 519–530.

92 This manuscript of the XIIIth century *ex*. contains *Prol.*, *Alm.*, Ptolemy, *Pseph.*, *excerpta ex Theone in Can.*, *Hyp.* 1, *Phas.*, *Judic.*, Theon, *in Alm.* 1–2, *Sph.*, *Sph. mota*, *Opt.* B. Vat. gr. 191, 202, 203, and Paris. gr. 2390 usually admit a common model.

93 Paris. gr. 2448 (XIVth century *in*.) is an interesting manuscript, still in need of a detailed study (but see Mogenet 1950, 65–67, Czinczenheim 2000, 239–241, and Riedlberger 2013, 101–102): the peculiar choice of writings there included [(pseudo-)Michael Psellus, *varia*, *Data*, Archimedes, *Problema bovinum*, *Catoptr.*, Diophanes and other metrological material (= *Geom.* 22), Domninus, *Ratio*, *Sph. mota*, *Sph.*, *scholia in Data*] is made even more peculiar by the fact that most of them are presented in Byzantine (?) recensions not attested elsewhere (the variants to *Data*, *Catoptr.*, *Ratio*, *Sph. mota*, *Sph.* are listed at *Euclidis opera omnia* 6.XXVI–XXX, 7.XLVI–XLVIII, Riedlberger 2013, *app.*, Mogenet 1950, *app.* and 283–284, Czinczenheim 2000, 241–258 and *app.*).

94 To this should be added a far less explicit passage in Galen's *De animi cuiuslibet peccatorum dignotione et medela*: ἐπιστήμη γοῦν ἐστὶ τοῦ γεωμετρικοῦ τοιαύτη περὶ τὰ δεδιδαγμένα διὰ τῶν στοιχείων, ὅποια τῶν πολλῶν ἐστὶ τοῦ τὰ δις δύο τέτταρα εἶναι. τὴν δ' αὐτὴν ἐπιστήμην ἔχει καὶ περὶ τῶν ἐφεξῆς τοῦτοις διδασκομένων σφαιρικῶν θεωρημάτων, ὥσπερ γε καὶ τῶν κατ' αὐτὰ ἀναλυομένων ἀπάντων, ἔτι τε τῶν κωνικῶν καὶ τῶν γνῳμονικῶν (5.59.12–60.3 Kühn).

attacks the Roman astrologers on account of their unsatisfactory technical background:

As for geometry, most of [them] have learned it and know it ... only in abridgment. ... †Some of them have learned only the thirteen *Elements* which Euclid composed ... analytics for geometry, and it is the division of number ... and that book is called “*Dedomena*”, and it is the *Data*.† Some of them have learned the science of the motion of the sphere and the science of the appearances of the stars and the science of the inhabited earth and the science of night and day. But few of them know the science of geometry in its entirety, and few of them have studied the figures of ellipse and cone. (Toomer 1985, 199)

There is no doubt that the astronomical treatises alluded to by Galen are *Sph. mota*, *Phaen.*, *Hab.* and *Dieb.* One must conclude that they formed a part, in Rome and in the second half of the IInd century, of a middle-to-high level technical curriculum.

The second piece of evidence is the entire book 6 of Pappus’ *Collectio*. This amounts to a series of lemmas, alternative proofs, corrections, supplements to some of the treatises of the “little astronomy”, according to the following progression: *Sph.* (*Coll.* 6.2–32), *Sph. mota* (6.33–47), *Dieb.* (6.48–68), *Magn.* (6.69–79), *Opt.* (6.80–103), *Phaen.* (6.104–130). In his introduction to the *corpus*, Pappus states that this formed part of teaching activity and that the exegetic material he is about to present will be developed in opposition to a firmly established tradition⁹⁵.

⁹⁵ Read *Coll.* 6.1: πολλοὶ τῶν τὸν ἀστρονομούμενον τόπον διδασκόντων ἀμελέστερον τῶν προτάσεων ἀκούοντες τὰ μὲν προστιθέασιν ὡς ἀναγκαῖα, τὰ δὲ παραλείπουσιν ὡς οὐκ ἀναγκαῖα ... ὧν ἕκαστον ἐπιδείξομεν ἡμεῖς. Pappus’ exegesis is in fact highly selective. After a long series of preliminary results, only two theorems of *Sph.* are discussed, namely, 3.5 and 3.6 (in *Coll.* 6.2–12 and 13–32, respectively). With *Sph. mota* Pappus adopts another strategy: he states a general exegetic principle (to determine the position of the great circles studied in each theorem) and lists, summarily and in this perspective – but mentioning one by one all propositions – the content of the treatise (6.33–44); he then passes on to prove what is omitted in prop. 1 (6.45–47). As for *Dieb.*, Pappus has a polemical target: to show that all preceding interpreters were mistaken when proposing an extension of the result of prop. 1.4. Pappus aptly qualifies his own extension (in fact a correct one) as being ἀστρονομικότατα (6.49), and seizes the opportunity for a digression on correlated magnitudes that increase or decrease without limits (6.57–61). Aristarchus’ treatise is mentioned only in connection with arguments involving authorities like Hipparchus and Ptolemy, that focus on the six preliminary “hypotheses” (6.69–73); a lemma follows, chosen among those handed down by the exegetic tradition, to prop. 4. *Opt.* deserves a specific treatment. In 6.80–97 Pappus rewrites (or writes) the proof of what we now read as *Opt.* 34–36 A = 34–37 B. In the same way, Pappus regarded as unclear the status of the enunciation opening *Coll.* 6.80, which coincides with a part of the enunciation of *Opt.* 35 A = 36 B. Therefore, Pappus’

A third piece of evidence opens further perspectives. In the middle of the long exposition on isoperimetric figures contained in *Prol.*, of a crucial lemma it is said that δέδεικται μὲν Θέωνι ἐν τῷ ὑπομνήματι τοῦ μικροῦ ἀστρονόμου⁹⁶. This lemma has been transmitted by several sources⁹⁷: *Opt.* 8 A; *Opt.* 8 B; Theon, in *Alm.* 1.3; scholium to *Sph.* 3.11 (*sch.* 450, see *infra*); a scholium to Pappus, *Coll.* 5.4. Contrary to the author of *Prol.* and Theon, Pappus did not prove the lemma, but included a mention of it followed by the clause τοῦτο γὰρ ἐν τοῖς εἰς τὰ σφαιρικά λήμμασιν δέδεικται (Hultsch 1876–1878, 310.5–6). This prompted the need to supply the proof in a scholium. Insofar as Theon’s proof is concerned, it might coincide with the scholium to *Sph.*, extracted from his ὑπόμνημα.

We may go a step further in this argument, and suppose that Theon’s ὑπόμνημα, whose existence is attested only in the above clause of *Prol.*, was not a text with a discursive approach as his in *Alm.*, but rather the passive receptacle of a long exegetic tradition (cf. Pappus’ statement about a supply of “lemmas to the *Spherics*”⁹⁸). The content of such a “commentary” could have ranged from precise remarks to lemmatic material to more structured digressions, very much in the style of Pappus’ *Coll.* 6 and 7. The formation of the “little astronomy” as a self-contained codicological unit, transmitted in a well-structured form in Vat. gr. 204 (a factual datum often neglected in the discussions on the argument: whoever placed *Sph.* at the beginning must have noticed the results of spherical geometry “presupposed” in Autolycus or in *Phaen.*), may have represented an opportunity for “distributing” Theon’s ὑπόμνημα, either in the margins of or within the main text, in one or more of a number of different ways:

- 1) as specific scholia, by the same mechanism seen at work in section 2.2 *supra* in the case of Theon in *Alm.* (these scholia have a more complex structure in *Opt.* B and *Phaen.* b than in the recensions attested in Vindob. phil. gr. 31, which does not contain the “little astronomy”);

exegesis has heavily interfered with the text of both recensions of *Opt.* In *Coll.* 6.98–103 Pappus finally proves a result that is a supplement to the Euclidean exposition. Similarly, in the case of *Phaen.*, and in fact to a greater extent, Pappus’ exegesis has heavily interfered with the text of both recensions, particularly in the case of props. 2, 12, and 13.

⁹⁶ See Acerbi/Vinel/Vitrac 2010, 121.19; the text of the lemma is *ibid.* 121.18–122.5; a comparative tabular set-up of all versions is provided *ibid.* 177–179; the lemma was first discussed in Knorr 1985.

⁹⁷ These texts are edited in *Euclidis opera omnia* 7.14.1–16.5 and 7.164.1–166.2; Rome 1931–1943, 358.1–11; Heiberg 1927a, 195.21–196.22 = Zinzendorf 2000, 435.1–20; Hultsch 1876–1878, 1167.5–23, respectively.

⁹⁸ This might well be a generic designation of all geometric material pertaining to spherical astronomy.

- 2) as short prefaces aimed at justifying some of the assumptions or focusing on lexical issues (*Opt. B*, *Phaen.*, both recensions)⁹⁹;
- 3) as adjustments in the definitions: all “abstract” definitions pertaining to the geometry of a sphere are given at the beginning of *Sph.*; they are never repeated in the sequel, even if some of the treatises, when taken in isolation, had required them¹⁰⁰; the definitions of κόσμου περιστροφῆς χρόνος and of ἐξαλλαγή φανεροῦ ἡμισφαιρίου can be found as scholia to *Phaen.* 14 and 15 b (and, by collation, in the main text in a) but among the definitions in *Dieb.* 1; a scholium supplies the crucial definition of οἰκήσις in *Hab.*;
- 4) as alternative proofs (*Sph. mota* 2¹⁰¹, *Phaen.* 6, 12, 14, 15 b, recension a carrying no alternative proofs¹⁰²);
- 5) as a rewriting of some propositions (*Opt. B*, *Phaen.* b¹⁰³);

⁹⁹ The two prefaces are edited in *Euclidis opera omnia* 7.144.1–154.2 and 8.2.1–10.10, respectively.

¹⁰⁰ Paris. gr. 2448 (which does not contain the entire “little astronomy”) and the Arabo-Latin tradition of *Sph. mota* have this treatise preceded by the definitions of “axis” and “poles” of a sphere, which are also to be found with identical wording (and taking into account an obvious scribal omission) at the beginning of *Sph.*

¹⁰¹ But it appears that the order of composition must be inverted: the first proof was intended to replace the flawed alternative proof.

¹⁰² The proof of prop. 12 b *aliter* is almost identical with the proof of 12 a (some additions excluded); that of 14 b *aliter* is only partly so. The sets of scholia attached to the two recensions are almost disjoint, even though the Vienna codex, whose text ends abruptly at the beginning of prop. 16 (the treatise has 18 propositions), was collated with Vat. gr. 204 from prop. 9 onwards, exactly where the two recensions start to diverge. The diagrams of the two recensions are often different and those of the Vienna codex are particularly flawed. Lemma 13/14 can be found in the main text in a but as a scholium (*sch.* 107) in b; on the other hand, Vat. gr. 204 has four scholia in the text, to props. 12 (*sch.* 102, preceded by the indication ἐκ περισσοῦ, of the first hand and in *Auszeichnungsmajuskel*) and 14 *aliter* (*sch.* 127–129, again accompanied by the indication ἐκ περισσοῦ; the order in Vat. gr. 204 is props. 12, *sch.* 102, 12 *aliter*, 13, 14, 15, *sch.* 127–129, 14 *aliter*, 15 *aliter*), that do not feature in a, either in the text or among the scholia. As for *Opt.*, the opposite phenomenon occurs: *Opt. A* contains alternative proofs to props. 22 (*bis*), 28, 42, 44, 54 (*bis*), all almost identical with the corresponding propositions in recension B, *Opt. B* has none: one must conclude that recension A was collated with recension B.

¹⁰³ See the preceding footnote. It has been suggested that *Ort.* 2 was conceivably a rewriting of *Ort.* 1 (Neugebauer 1975, 751 and references therein), but we have no reason to think that this (supposed) second version was one of the outcomes of the scholarly activity that eventually resulted in the formation of the “little astronomy”.

The scholia to the treatises of the “little astronomy” have been edited in modern times along with the main texts¹⁰⁴. The task of analysing them is arduous, since these editions list all scholia propositionwise without partitioning them between manuscripts and hands therein: therefore, the critical apparatus has to be checked every time in order to retrieve such pieces of information. What is more, and in contrast to *Alm.*, it may well be that we read what was in origin a single scholiastic *corpus* scattered as manifold *subcorpora* among the several independent witnesses of the “little astronomy” (as evidence that this phenomenon is likely to occur, suffice it to recall the numbered scholia in Vat. gr. 1594 and the selective collection in Vat. gr. 184). With this proviso, let us nevertheless take a preliminary look at the scholia to the several treatises of the “little astronomy”, focusing on explicit metadiscursive marks of scholarly activity. I will retain only the scholia written by the main copyist in any of the manuscripts listed at the beginning of this section and organize them in the following typology, where the numbers (possibly preceded by *sch.*) coincide with those assigned to the scholia in the editions mentioned in the previous footnote¹⁰⁵.

- Mentions of exegetic authorities: *Sph.* 2 (Theon), *Sph. mota* /, *Opt.* B 65 (Hero)¹⁰⁶, *Phaen.* b /, *Hab.* /, *Dieb.* /, *Magn.* /, *Ort.* /, *Anaph.* /.
- Mentions of exegetic enterprises: *Sph.* 348 (reference, worded in the first person, to a proof given in 2.11 διὰ τοῦ προλημματίου), 416 (referred to by Pappus and Eutocius)¹⁰⁷, 450 (see above), *Sph. mota* 36, *Opt.* B 84, *Phaen.* b /, *Hab.* 29, 33, 56, *Dieb.* 19, 81, 83, *Magn.* 55 (βέλτιον ὥς ἐν τῷ ὑπομνήματι αὐτῷ γὰρ καὶ ὁ Πτολεμαῖος ἐχρήσατο), *Ort.* 134, *Anaph.* /.

104 Czinczenheim 2000, 384–439 (*Sph.*; see also Heiberg 1927a, 166–199), Mogenet 1950, 259–282 (*Sph. mota*, *Ort.*), *Euclidis opera omnia* 7.125–141, 7.251–284, and 8.134–156 (*Opt.* A, B, and *Phaen.*, respectively), Fecht 1927, 44–52 and 156–176 (*Hab.* and *Dieb.*), Fortia d’Urban 1810, 90–198 (who, however, only resorted to manuscripts in Paris, with special attention to Paris. gr. 2342 and 2488), and Noack 1992, 67–82 and 345–380, who redacted a detailed check-list of the scholia edited by Fortia d’Urban keyed to *all* manuscripts, and edited those left out by d’Urban, while giving an advance overview for *Magn.* (on 346–351) of a part of the task I am about to undertake for the entire “little astronomy” (both *Magn.*), De Falco/Krause 1966, 41–45 (*Anaph.*).

105 The numbering of the scholia to *Magn.* is that established in Noack 1992, 72–79.

106 The scholium asserts that Hero addressed in a well-structured discursive form (verbal form διαρθροῖ) the issue of the stability of inequality of ratios under the standard operations on ratios (*alternando*, *componendo*, *dividendo*, etc.; the stability of identity of ratios under the same manipulations is the gist of *El.* 5); this subject is touched on in Pappus, *Coll.* 3.15–18 and 7.45–53.

107 Pappus, *Coll.* 5.12 (Hultsch 1876–1878, 338.13: λήμμα σφαιρικῶν) and in *Alm.* 6 (Rome 1931–1943, 257.16: λήμμα σφαιρικόν); Eutocius, in *Aequil.* (*Archimedis opera omnia* 3.270.25–28: διὰ τῶν ἐν τῇ ἀρχῇ τοῦ δεκάτου τῆς στοιχειώσεως Εὐκλείδου εἰρημένων καὶ ἐν τῷ τρίτῳ τῶν Θεωδοσίου σφαιρικῶν).

- References to canonical texts: *Sph.*, 53 items to *El.*¹⁰⁸, *Sph. mota* 17, 38 (*El.* 11.14, 11.19, respectively), *Opt.* B 68 (1.4 and 1.18 of Euclid's στερεά = *El.* 11.4 and 11.18), 69 (enunciation of a theorem found ἐν τοῖς στερεοῖς, not attested in *El.*), 83 (3.34 of Euclid's ἐπίπεδον = *El.* 3.34)¹⁰⁹, *Phaen.* b /, *Hab.* 27 (1.19 of Euclid's στερεά = *El.* 11.19), *Dieb.* /, *Magn.* 3 (generic to *Opt.*, *immo Opt.* 22), 3 (*Alm.* 5.#, *immo 5.14*), 8, 11, 12 (*El.* 3.16 porism, 3.17, 3.18, respectively), 20 (3.# of Euclid's ἐπίπεδον, *immo El.* 3.7), 21 (τὸ παρατέλευτον τοῦ γ' τῶν ἐπιπέδων, *immo El.* 3.36), 22 (*El.* 3.8), 44 (converse of a definition of Euclid, *immo El.* 1.def.15), 45 (generic to *Alm.*, *immo Alm.* 5.16), 48 (*El.* 6.#, *immo 6.1*), 55 (generic to Ptolemy, *immo Alm.* 1.10), 60 (generic to *Alm.*, *immo Alm.* 5.16), 62 (8.# of Euclid's ἀριθμητικά, *immo El.* 8.12), 63 (among the definitions of Euclid's ἐπίπεδον, *immo El.* 5.def.10), 64 (the last proposition of book 2 of Euclid's στερεά, *immo El.* 12.18), *Ort.* /, *Anaph.* /.
- References (mostly παραγραφαί) to other (in fact only previous) treatises in the “little astronomy”: *Sph.* /, *Sph. mota* 1, 3, 4, 6, 8, 43, 44, 47, 51, 52, 59 (*Sph.* 1.1 and 1.6, 1.8, 2.2, 2.10, 2.10, 2.13, 2.2, 2.20, 2.5, 3.3, 1.7, respectively), *Opt.* B 20, 39 (*Sph.* 3.4 and 1.1, respectively), *Phaen.* b 18 (*Sph. mota* 12), 21 (by the definition of *Opt.*), 33 (*Sph. mota* 10), 37, 41, 43, 57, 61, 82, 83 (*Sph.* 2.9, 2.5, 2.#, 2.13, 2.13, 2.17, 2.18, respectively)¹¹⁰, *Hab.* 6 (beginning of the enunciation of *Sph.* 2.5), 9 (*Sph. mota* 4), 10 (*Sph. mota* 5), 22 (*Sph.* 2.3), 23 (*Sph. mota* 8), 31 (*Sph.* 2.13), *Dieb.* 5 (*Phaen.* 18), 10 (*Sph.* 2.12), 13 (*Sph.* 2.9), 37, 38, 39, 53, 55, 59, 60 (*Phaen.* 18, 15, τὸ τελευταῖον ἐν τοῖς φαινόμενοις *immo 18*, generic to *Phaen. immo 12*, 12, 17, 17, respectively), 61 (*Sph.* 2.13), 63 (*Sph.* 2.20), 89 (διὰ τὸ Εὐκλείδου, *immo Phaen.* 14), *Magn.* 7, 42 (*Sph.* 1.1 and 1.7, respectively), *Ort.* 85, 86, 113, 138 (all *Sph. mota* 9), 141 (*Phaen.* 4), 142 (*Sph. mota* 9), 153, 155 (*Phaen.* 13 and 12, respectively), *Anaph.* 19, 21, 21a, 28, 29 (*Phaen.* 11, 13, 11, 12 πρὸς τῷ τέλει, 11, respectively).

108 Namely, *sch.* 3, 5, 9, 10, 15, 16, 17, 18, 20, 21, 22, 25, 26, 27, 37, 47, 65, 70, 74, 77, 80, 90, 97, 103, 111, 125, 131 (*ad sch.* 130), 137, 143, 145, 157, 176, 178, 180, 181, 186 (attested elsewhere as *El.* 11.38 *vulgo*), 241 (11.16 of Euclid's στερεά), 267, 269 (definition of the κλίσις of two planes = *El.* 11.def.6), 270 (definitions of Euclid's στερεά), 300, 301, 316, 319, 340, 351, 374, 382 (*ad sch.* 381), 422, 440, 442, 454.

109 To these should be added the following first-hand παραγραφαί in Vat. gr. 204, which Heiberg did not edit among the scholia: to (the converse) of 11.def.# and to *El.* 6.7 (both f. 53r; the former also f. 54v), to the porism of 3.34 of Euclid's ἐπίπεδον (f. 57r).

110 To these should be added a number of first-hand παραγραφαί in Vat. gr. 204 that Menge did not edit among the scholia (note also that Menge misassigned many scholia): to *Sph.* 2.19 (just after *sch.* 37), to *Sph. mota* 1, 7, 11 [ff. 62r (*bis*), 64r], to *Sph.* 2.5 and 2.9 (f. 64v, as scholia to *sch.* 76), 3.7, 2.20, 2.13 and 3.8 (within the same clause), 2.17, 2.18, 3.3, 3.8, 2.17, 2.18, 3.3, 2.17, 2.19, [ff. 65r, 66r, 67v(*bis*), 68r (*ter*), 70r, 70v(*ter*), 76r(*bis*)].

- References (mostly παραγραφαί) internal to a treatise: *Sph.*, 117 items¹¹¹, *Sph. mota* /, *Opt.* B 30, 31, 32, 49, 51, 85¹¹², *Phaen.* b 87, 115, 117¹¹³, *Hab.* 45, 53, 54, *Dieb.* 22, 33, 34, 73, 77, 100 (to lemma 2.9/10, which this scholium shows to be spurious), *Magn.* 24, 39, 41, 43, 61, 101, 108, 109, 111, 115, 118, 121, 130, 132, 133, *Ort.* 76, 110, 111, 124, 126, 127, 131, 158, 191, 193¹¹⁴, 194, 202, 203, 210¹¹⁵, 2, *Anaph.* 18, 21b, 24, 27.
- References to scholia to other (previous) treatises in the “little astronomy”: *Sph.* διὰ τὸ σχόλιον τοῦ ζ and ἀπὸ τοῦ σχολίου τοῦ ἐν τῷ ζ (f. 75r), *Sph. mota* /, *Opt.* B 22 (ἐν τῷ ια' θεωρήματι τοῦ γ' βιβλίου τῶν σφαιρικῶν εὐρήσεις ἔξωθεν σχόλιον ὃ συμβαλεῖται σοι εἰς τὴν παροῦσαν δεῖξιν), *Phaen.* b /, *Hab.* /, *Dieb.* 12, 23 (both to a scholium to *Phaen.* 7, *immo sch.* 76), *Magn.* /, *Ort.* /, *Anaph.* /.
- References to other scholia to the same treatise: *Sph.* /, *Sph. mota* /, *Opt.* B /, *Phaen.* b /, *Hab.* 41, *Dieb.* 90, 97, *Magn.*, 27 (a scholium in majuscule to a far longer scholium in minuscule, namely, *sch.* 36), 54 (to *sch.* 32), 66 (to *sch.* 25), 70 [from a porism παρακείμενον to a lemma (*immo sch.* 55) to theorem 5 (*immo* 7)], 88 (to *sch.* 89), 96 (to *sch.* 92), 105, 110 (both to *sch.* 96), 114 (to *sch.* 106), 117 (to *sch.* 96), 118 (to *sch.* 117), 122 (to *sch.* 96), 123 (to *sch.* 126), *Ort.* /, *Anaph.* 2, 6, 7, 11.
- References to the state of the text: *Sph.* 121 (*Sph.* 1.22–23 are absent in some manuscripts), 127 (some interchange 2.1 and 2.2), 314 (appropriate location of 3.1 and 3.2), *Sph. mota* /, *Opt.* B 21 [on an alternative form of prop. 7 (*immo Opt.* 7 A) to be found ἐν τισι τῶν ἀντιγράφων], 28 (τὸ ι' ἐν ἄλλω οὕτως), 84 (alternative proof of prop. 50), 85 (alternative proof of prop. 52), *Phaen.* b 89,

111 Namely, *sch.* 8, 24, 56, 58, 66, 67, 69, 71, 72, 73, 75, 76, 79, 84, 99, 106, 108, 117, 132 (*ad sch.* 130), 133 (*ad sch.* 130), 135, 136, 142, 144, 148, 150, 151, 154, 155, 156, 158, 160, 163, 166, 168, 170, 172, 173, 175, 177, 179, 195, 199, 200, 203, 205, 208, 209, 212, 213, 215, 216, 221, 223, 228, 231, 233, 234, 238, 240, 246, 248, 257, 258, 261, 266, 272, 275, 280, 281, 282, 283, 284, 293, 298, 302, 306, 312, 363, 365, 372, 373, 383 (*ad sch.* 381), 384, 385, 386, 390, 391, 392, 395, 396, 397, 402, 409, 410, 411, 413, 417 (reference to a theorem case by means of the term καταγραφή), 420, 424 (as in *sch.* 417), 426, 431 (as in *sch.* 417), 434, 438, 439, 457, 462, 464, 465, 466, 467, 469, 470, 471, 473, 475.

112 To these should be added the following first-hand παραγραφαί in Vat. gr. 204, which Heiberg did not edit among the scholia: to prop. 31 (f. 52r), to (the converse of) the definition (f. 53r).

113 To these should be added a number of first-hand παραγραφαί in Vat. gr. 204 that Menge did not edit among the scholia: to props. 12 (f. 71r), 14 *aliter* (f. 75r), 1 and 12 (f. 75r, scholia to lemma 13/14, that Vat. gr. 204 has in the margins), 11 (f. 76r), 14 (f. 76v).

114 In *sch.* 191 and 193, *Ort.* itself is referred to “from outside”, by mention of the title (the scholia are in book 2 but refer to prop. 1.10).

115 I transcribe this funny scholium, apposed in Vat. gr. 202: ὅρα ὁ ἀναγινώσκων τὰ σχόλια ὡς σαφώτατα καὶ συνεργὰ εἰς τὴν γνῶσιν τοῦ θεωρήματος.

102¹¹⁶, 104¹¹⁷, 106, 113, 114¹¹⁸, 121¹¹⁹, 127, 128, 129¹²⁰, *Hab.* /, *Dieb.* /, *Magn.* /, *Ort.* /, *Anaph.* /.

- Indication of mistakes in the text or in the diagram: *Sph.* 294, 315, 366 (text, all)¹²¹, *Sph. mota* /, *Opt.* B /, *Phaen.* b /, *Hab.* /, *Dieb.* /, *Magn.* 83 (diagram), *Ort.* 83, 146 (text, both), *Anaph.* 17 (diagram), 22 (text).

As for the scholia to some of the treatises, we may single out the following notable features. In *Sph. mota* 36, reference to results that προδέδεικται τοῖς ἐφιστῶσι καὶ ἐν τῇ ε' θέσει τοῦ παρόντος βιβλίου. In *Opt.* B 84, it is said that a theorem (a quadrilateral whose opposite angles make two right angles is inscribed in a circle) δέδεικται ἐν τῷ ὑπομνήματι. In *Hab.*, *sch.* 1 supplies the crucial definition of οἰκήσις; *sch.* 29, 33, 56 refer to proofs to be found in a commentary: ὡς ἐν τῷ ὑπομνήματι δεικνύται. In *Dieb.*, *sch.* 19 refers to a better proof to be found in a commentary: βελτίων ἢ ἐν τῷ ὑπομνήματι δείξις; *sch.* 81, 83 refer to proofs to be found in commentaries to *Dieb.* and *Phaen.*: ἐν τῷ εἰς τὸ β' θεώρημα τοῦ πρώτου βιβλίου τοῦ περὶ νυκτῶν καὶ ἡμερῶν ἐν τῷ ὑπομνήματι / ἐν τῷ ιδ' τῶν φαινομένων ἐν τῷ ὑπομνήματι; *sch.* 90, 97 refer to proofs lying or redacted in the “prominences”, that is, in the margins¹²²: ἐν τῷ ἐξοχίῳ / ἐν τοῖς τελευταίοις ἐξοχίοις. In *Ort.*, *sch.* 134 (which all manuscripts have in the text) refers to a result already employed in *Hab.*: τοῦτ' γὰρ ἐχρησάμεθα καὶ ἐν τῷ περὶ οἰκίσεων. The annotations to the theorems of the arithmetic part of *Anaph.* provide numeric instantiations of

116 As seen above, *sch.* 102, 127–129 are preceded by the indication ἐκ περισσοῦ, which also precedes, again in *Auszeichnungsmajuskel*, prop. 15 *aliter*.

117 *Sch.* 89 and 104 read: σαφεστέρα ἢ β' ἔκδοσις (ἐστίν) ἥτις κεῖται μετὰ γ (ἡμισυ) φύλλα.

118 Both *sch.* 106 and 114 contain the definition of ἐξαλλαγή φανεροῦ ἡμισφαρίου, that recension a has at the end of the introduction.

119 This scholium to prop. 12 *aliter* contains the following clause: δέδεικται μὲν ἐν τῇ ἄλλῃ ἐκδόσει τοῦ θεωρήματος ἐν τῇ πρό ταύτης καταγραφῇ.

120 To these should be added the following indications, which Menge did not edit among the scholia although most of them are written in *Auszeichnungsmajuskel*: ἀρχὴ ἀστρονομίας | τὰ φαινόμενα (in the outer margin of f. 59r, alongside the very first line of the treatise); αὕτη δέ ἐστιν ἡ σαφεστέρα ἔκδοσις (*Euclidis opera omnia* 8.116.4; the same should be replaced for what we read *ibid.* 8.122.14), which precedes props. 12 *aliter* and 14 *aliter*, respectively; σαφεστέρα αὕτη (to the second diagram of *sch.* 76); σαφεστέρα καταγραφῇ, ἀρχαιότερα ἢ καταγραφῇ and σαφεστέρα αὕτη ἢ καταγραφῇ [to the double diagrams of props. 14 (part II, *immo* 15 in Vat. gr. 204, which entails a shift in the numbering of the subsequent propositions), 14 *aliter*, respectively].

121 *Sch.* 366 triggered the reaction of the annotator of *sch.* 367, who addressed the other scholiast as σοφώτατε ἄνερ ὁ γράψας τὸ σχόλιον.

122 At least, this is my guess: the noun is not recorded in the LSJ, nor are occurrences of it to be found in the TLG. In *sch.* 174 *ad Data* (see the beginning of section 4 *infra*), the alternative form ἐξωχίη is found.

their enunciations, always given in quasi-general terms, and worked-out specific examples; *sch.* 4 contains a self-reference in the first person ὡς ἐξῆς δεῖξω¹²³.

In sum, the scholia to the “little astronomy” show that this technical resource was annotated as a whole in Late Antiquity or in the early Byzantine period, but further investigations (in particular on the several comment scholia there included) are needed to confirm or to disprove the hypothesis that this set of annotations derives from an exegetic project as unitary and sustained as the one we perceive behind the scholiastic collections of *El.* and, most obviously, *Alm.*

3 A commentary in the form of scholia: Eutocius on Apollonius’ *Conica*

Apollonius sent off the books of his *Conica* (henceforth *Con.*) separately and in succession: books 1–3 to Eudemus of Pergamum, books 4–7 to Attalus; therefore, each book was originally circulated as a single exemplar, sent to its addressee. In the preface to book 2 Apollonius instructs Eudemus thus: “communicate it to those who are worthy to take part in such things; and Philonides the geometer, whom I introduced to you in Ephesus, should he ever visit Pergamum, communicate it to him”. In the preface to book 1 we learn more: Apollonius affirms that he redacted two versions of *Con.* The first he had communicated, “in a hurry” and “putting down all that occurred to [him], with the intention of returning to it later”, to Naucrates the geometer, at the request of whom he undertook the investigation, when the latter was on the point of sailing from Alexandria¹²⁴. The first two books, still uncorrected, also circulated among Apollonius’ acquaintances. The second redaction is the one he was about to send, after correction, to Eudemus, with the following warning: “don’t be surprised if you come upon them in a different form”¹²⁵.

Seven centuries after this double ἔκδοσις, the Neoplatonic philosopher Eutocius undertook the task of introducing some order into the resulting tradition and

¹²³ Noack detects this kind of metadiscursive markers (which she calls “rhetorische Elemente”) in *sch.* 13, 21, 32, 50, 52, 84, 99, 104, 117, 123, 126, 134 (but the φιλόσοφος here mentioned is obviously Aristarchus) to *Magn.*

¹²⁴ Even if the story about Naucrates might well be nothing but the application of a literary *topos* in order to forestall the deficiencies of an unsatisfactory first redaction, it is clear that we are here faced with a προέκδοσις with limited circulation (Dorandi 2007, 65–81), over which Apollonius quickly and obviously lost control.

¹²⁵ *Apollonii Pergaei quae graece exstant* 1.192.8–11 and 1.2.9–22, respectively.

of commenting on the text he thereby obtained. Commenting on mathematical texts was not new to Eutocius: his career had begun, when he was a pupil of Ammonius, with three Archimedean treatises, *Sph. cyl.* 1–2, *Circ.*, and *Aequil.* 1–2. But commenting on *Con.* was quite definitely a more arduous task; in particular, Eutocius must have soon realized that this could not be done without establishing a reliable text of Apollonius' treatise. Eutocius explains his editorial and exegetic strategy in the prefatory epistles to his commentary in *Con.* 1, 3 and 4, addressed to Isidorus of Miletus' colleague Anthemius of Tralles; these texts are an *unicum* in the ancient scholarly tradition and deserve to be read in their entirety. The first passage closes the first epistle, the second passage coincides with the entire second epistle, the third passage is the *incipit* of the third epistle. Technical terms to be discussed are underlined¹²⁶.

T1 ... πλειόνων δὲ οὐσῶν ἐκδόσεων, ὥς καὶ αὐτός φησιν ἐν τῇ ἐπιστολῇ, ἄμεινον ἡγησάμην συναγαγεῖν αὐτὰς ἐκ τῶν ἐμπιπτόντων τὰ σαφέστερα παρατιθέμενος ἐν τῷ ῥήτῳ διὰ τὴν τῶν εἰσαγομένων εὐμάρειαν, ἔξωθεν δὲ ἐν τοῖς συντεταγμένοις σχολίοις ἐπισημαίνεσθαι τοὺς διαφορούς ὡς εἰκὸς τρόπους τῶν ἀποδείξεων.

T2 τὸ τρίτον τῶν κωνικῶν, ὃ φίλτατέ μοι Ἀνθέμιε, πολλῆς μὲν φροντίδος ὑπὸ τῶν παλαιῶν ἡξίωται, ὥς αἱ πολύτροποι αὐτοῦ ἐκδόσεις δηλοῦσιν, οὔτε δὲ ἐπιστολὴν ἔχει προγεγραμμένην, καθάπερ τὰ ἄλλα, οὐδὲ σχόλια εἰς αὐτὸ ἄξια λόγου τῶν πρὸ ἡμῶν εὐρίσκεται, καίτοι τῶν ἐν αὐτῷ ἀξίων ὄντων θεωρίας, ὥς καὶ αὐτὸς Ἀπολλώνιος ἐν τῷ προοίμῳ τοῦ παντὸς βιβλίου φησίν. πάντα δὲ ὑφ' ἡμῶν σαφῶς ἔκκειται σοι δεικνύμενα διὰ τῶν προλαβόντων βιβλίων καὶ τῶν εἰς αὐτὰ σχολίων.

T3 τὸ τέταρτον βιβλίον, ὃ φίλε ἑταῖρε Ἀνθέμιε, ζητησιν μὲν ἔχει ποσαχῶς αἱ τῶν κώνων τομαὶ ἀλλήλαις τε καὶ τῇ τοῦ κύκλου περιφερείᾳ συμβάλλουσιν ἥτοι ἐφαπτόμεναι ἢ τέμνουσαι· ἔστι δὲ χαρίεν καὶ σαφὲς τοῖς ἐντυγχάνουσι καὶ μάλιστα ἀπὸ τῆς ἡμετέρας ἐκδόσεως, καὶ οὐδὲ σχολίων δεῖται· τὸ γὰρ ἐνδέον αἱ παραγραφαὶ πληροῦσιν.

Eutocius needed to solve a serious exegetic problem: how to introduce order into the complex tradition of *Con.*¹²⁷ without destroying its complex structure, pro-

¹²⁶ The passages are *ibid.* 2.176.17–22, 2.314.2–11, 2.354.2–8, respectively.

¹²⁷ Eutocius seems to think that the mere existence of two authorial editions (but Apollonius' prefaces show that this only happened with books 1 and 2) justifies the amount of divergent recensions in circulation (T1). One may well doubt this reconstruction: the huge number of variants almost certainly springs from uninterrupted exegetic work similar to that on *El.* and

vided above all by the alternative proofs. He could not resort to a *variorum* edition with interlinear variants, since the deductive (and hence also exegetic) “units of meaning” of a mathematical treatise are too long: entire propositions. For the same reason, he had to respect the standard format of mathematical writing: a series of propositions, each depending on those that precede it. As a consequence, Eutocius had to make selective choices: in order to make the explanation accessible (recall διὰ τὴν τῶν εἰσαγομένων εὐμάρειαν in T1), he assigned to each proposition of his edition the single proof he regarded as the best one, the alternative, and less perspicuous, proof(s) of the same result being relegated to the commentary. Such alternative proofs thereby assume the status of “variants”. Again, he performed the following structural adjustments on the “hypertext” of the several recensions of *Con.* he was able to locate: he drew the diagrams anew by making them more general; he adopted more general enunciations and proofs (*Con.* 1.18 and 38); he changed the order of, rewrote (*Con.* 1.32 and 3.5), eliminated, added (*Con.* 2.4), and, in particular, dismembered propositions; he made eclectic choices between different redactions of the same proposition (*Con.* 3.4–12); he interpolated lemmas found in the exegetic tradition and added internal references to book and proposition; he made the main text more metadiscursive than it was in origin. The outcome is a treatise that still presents many mathematical incongruities and displays stylistic inhomogeneities that are often glaring (cf. problems *Con.* 2.44–53).

The nature of such interventions and, in addition, the emphasis Eutocius placed on enumerating the several cases into which a single proposition can be divided, together with the resulting need to refer systematically to the diagrams, activate a text-commentary interaction stronger than that required by his Archimedean commentaries: Eutocius’ *in Con.* is a mute exegetic apparatus if it is not backed up by its own reference text. Thus in order to make this apparatus speak meaningfully, Eutocius had no alternative than to resort, probably for the first time in a mathematical commentary (and surely for the first time as a *pendant* of an edition), to a resource provided by the then predominant book format: the margins. In order to do this, Eutocius had to recalibrate the interpretative format he had adopted in his Archimedean commentaries: he was forced to eliminate the sometimes abnormous antiquarian digressions from the body of the commentary,

of which Eutocius’ commentary is the receptacle; he himself endorses this point of view when presenting book 3, transmitted in several recensions even if it was not issued in two authorial editions (T2). What is likely is that the differential scholarly interest in the books of *Con.* Eutocius testifies to was encouraged by the fact that the original treatise circulated in separate rolls: as we have seen, in the short prefatory epistle to book 2, Apollonius himself spurs Eudemos to enable it to circulate independently of the other books.

by relocating them to its liminar portion, and adjust the length of the specific annotations. As a consequence, the *pièce de force* of the Eutocean exegesis in *Con.* became the alternative proofs, which he might have found as isolated variants in some of his exemplars or as truly ἄλλως proofs in others¹²⁸.

Consequently, Eutocius “disappears” behind his commentary, which loses most of its authorial¹²⁹ connotation due to the elimination of the digressions: one need only compare it with Pappus’ or Theon’s commentaries on *Alm.*, or even with Eutocius’ Archimedean commentaries. What remains of authorial markers is by and large limited to the metadiscursive “rhetorische Elemente” that are present, as we have seen in the previous section, in any collection of scholia bearing a minimum of structure. Paradoxically enough, the real authorial mark in the whole affair of Eutocius’ handling of *Con.* is the structure of his edition.

I have thoroughly analysed Eutocius in *Con.* in this perspective elsewhere (Acerbi 2012), showing that the evidence deriving from the above passages and from Eutocius’ commentary in its present form entails that a) the commentary is, from the technical point of view, the receptacle of a rich exegetic tradition; that b) Eutocius collates and transcribes by introducing redactional interventions that cannot be regarded as authorial; and that c) the commentary was originally written in the margins of the Eutocean edition of *Con.*, whose *mise en page* and *mise en texte* must have been conceived so as to allot a suitable space to the lengthy introductory remarks, to the supplementary diagrams and, most importantly, to an effective system of links: commentary-text, commentary-commentary and commentary-diagrams.

As texts T1–3 are particularly relevant from the lexical point of view and partly justify some of my terminological choices throughout this contribution, I summarize here a discussion of the main terms of the exegetic jargon employed by Eutocius.

- a) ἔκδοσις. The term is traditional and well-established (van Groningen 1963 and Dorandi 2007). These are either Apollonius’ or Eutocius’ (only in T3) recensions; the former are πλείονες and πολύτροποι¹³⁰, this term appropri-

¹²⁸ Eutocius’ efforts were almost nullified by the pitfalls of the tradition: Apollonius’ *Con.* and Eutocius’ related commentary became disconnected quite early, and have been transmitted independently. The prototype of the entire tradition of *Con.* is in fact Vat. gr. 206: written by one single copyist in the middle of the XIIth century, it contains *Con.* (ff. 1r–160v) and the two treatises by Serenus on the same topic (ff. 161r–194r and 194r–239v). The prototype of Eutocius in *Con.*, Vat. gr. 204, precedes by three centuries that of the Apollonian tradition.

¹²⁹ On the meaning of “authorial” as referred to mathematical commentators see Acerbi 2012, 153–156.

¹³⁰ We read διαφόροι at *Apollonii Pergaei quae graece exstant* 3.246.16.

ately denoting the several variants involved. The noun ἔκδοσις often occurs in inscriptions of mathematical manuscripts or in similar paratexts: we find it in the books of Theon's editions of *El.*¹³¹ and *Data*, in the books of Theon's commentary in *Alm.* (both in those edited by Theon himself and in book 3, edited by his daughter Hypatia)¹³², in the three Eutocean commentaries on Archimedes edited by Isidorus of Miletus¹³³.

- b) παρατίθημι. The meaning is “to transcribe”¹³⁴. These are single items picked up and transcribed one by one: they are the “best” proofs, that Eutocius includes in the text of his own edition.
- c) ῥητόν. It is the Apollonian “text” commented on by Eutocius, that is, *Con.* as the result of his edition, transcribed as the main text on a well-defined substratum (cf. the correlate locative expressions ἐν τῷ ῥητῷ ... ἔξωθεν δέ)¹³⁵.
- d) ἔξωθεν. The demonstrative variants are placed “outside” the main text, within σχόλια συντεταγμένα. The context and a number of parallel passages make this reading of the adverb certain¹³⁶.
- e) σχόλια (συντεταγμένα). The “comments” are the main exegetic units of a commentary: the set of variant proofs and of completing lemmas pertaining to a single proposition. The plural denies unity and autonomy to that which follows the epistle: it is not a single ὑπόμνημα but a series of “comments” whose ordering principle coincides with that of the propositions. The participle alludes to the appropriate ordering of the annotations and to a suitable *mise en page* of them¹³⁷.

131 Theon himself designates his own edition in this manner in a celebrated *locus* at Rome 1931–1943, 492.7.

132 At Rome 1931–1943, 317.2, 463.2, 601.2, and 807.4.

133 At *Archimedis opera omnia* 3.48.29, 3.224.8, 3.260.11.

134 See most recently Montana 2010, 185–192 and the contribution in the present volume. It is impossible in this case to assign a locative value to the preverb, as if it were alluding to the fact that the propositions are placed one after the other.

135 Other occurrences at *Apollonii Pergaei quae graece exstant* 2.212.21, 2.252.20, 2.260.1, 2.316.9, 2.356.11 (always with the expression ἐν τῷ ῥητῷ); the occurrence *ibid.* 2.258.6 refers to a passage in an alternative proof already transcribed in the commentary: this “text” is itself unclear, and is clarified by a short lemma.

136 The evidence is collected in Devreesse 1954, 84 n. 7, and reassessed by Irigoin in the discussion following Maehler 1994, 138. To this should be added Galen's commentary on the Hippocratic *De officina*, 17B.876.1 Kühn, Simplicius, in *Cael.* 317.29 Heiberg, and in *Cat.* 88.26 Kalbfleisch, sch. 22 (in Vat. gr. 204, as we read in the previous section) *ad Opt.* 8 B, at *Euclidis opera omnia* 7.261.7–9, sch. 113 (in Vat. gr. 192) *ad Phaen.* 14 b, *ibid.* 8.150.1.

137 On the usage and meaning of the term σχόλιον see Supplement 3 *infra* and Lundon 1997.

- f) ἐπισημαίνομαι. The verb belongs to a lexical and semantic area that is current in the ancient scholarly jargon. Further specified in T1 by the expression ἐν τοῖς συντεταγμένοις σχολίοις, it suggests that a system of *réclames* had to be set up in order to discover the corresponding variants transcribed in the margins.
- g) βιβλίον. Eutocius in *Con.* has 26 occurrences, which always denote one of the books of a larger treatise: *El.*, *Con.* themselves, *Alm.*, Archimedes' *Sph. cyl.*
- h) παραγραφαί. These “short marginal annotations” are a constant feature of all mathematical manuscripts, and must have been a canonical form of annotation ever since the editions on papyrus roll. The meaning of the occurrence in T3, precisely because it designates a well-defined paratextual form¹³⁸, is confirmed by two parallel passages: Marinus *Vita Procli* 27¹³⁹, and the same denomination applied to the marginal annotations in bilingual juridical

138 The term in this meaning is quite infrequent: see the oscillations of Heiberg – who in the first place had considered emending it to καταγραφαί – at *Archimedis opera omnia* 3.355 n. 1. In fact, the correction would have been meaningless: the “diagrams” *always* make a mathematical text more perspicuous. The meaning here intended of παραγραφή has probably developed by metonymy from that of “marginal sign” marking a *locus* in need of scholarly attention and care. The term has exactly this meaning in Cyril *ad Tiberium* 15 (*Patrologia Latina* 76.1108b: παραγραφή δέ ἐστιν ἔξωθεν τιθεμένη). Early occurrences of παραγραφή as “marginal sign” can be found in Aristotle, *Rh.* 1409a19–21 (ἀλλὰ δεῖ τῇ μακρᾷ ἀποκόπτεσθαι, καὶ δὴλην εἶναι τὴν τελευτήν μὴ διὰ τὸν γραφέα, μηδὲ διὰ τὴν παραγραφὴν, ἀλλὰ διὰ τὸν ῥυθμόν) – who triggered the remarks of an anonymous commentator in *Arist. rhet.* 1.193.13–17 Rabe (“ἀλλὰ δεῖ” τὸν λόγον “ἀποκόπτεσθαι” ἥτοι ἡρεμεῖν καὶ ἴστασθαι καὶ βεβηκέναι καὶ τέλος λαμβάνειν δῆλον οὐ “διὰ τὸν γράφοντα”, ἥτοι οὐ διὰ τὸ στίξειν τὸν γραφέα ἄχρι τοῦδε φαίνεται ὡς ἔλαβεν ὁ λόγος τέλος, οὐδὲ “διὰ τὴν παραγραφὴν” ἥτοι παραγράψαι στιγμὴν, “ἀλλὰ διὰ τὸν ῥυθμόν”) – and in Isocrates, *Antid.* 59 (ἵν’ οὖν μὴ παντάπασιν ἐκλυθῶ πολλῶν ἔτι μοι λεκτέων ὄντων, ἀρξάμενος ἀπὸ τῆς παραγραφῆς ἀνάγνωθι τὰ περὶ τῆς ἡγεμονίας αὐτοῖς) – who triggered the remarks of Harp., *Lex.* π 17 Keaney (παραγραφή: οὐ μόνον ἐπὶ τοῦ κοινοῦ καὶ γνωρίμου τίθεται παρὰ τοῖς ῥήτορσιν, ἀλλ’ ἰδίως Ἰσοκράτης ἐν τῷ περὶ τῆς ἀντιδόσεως φησιν “λέγε ἀρξάμενος ἀπὸ τῆς παραγραφῆς”, ὅπερ ἐστὶν ἀπὸ τῆς γραμμῆς ἣν μέχρι νῦν παράγραφον καλοῦμεν· καὶ ἔστι τὸ λεγόμενον, ἀφ’ οὗ παρέγραψα· τοῦτο δ’ ἂν εἴη, ἀφ’ οὗ παρεθέμην. ὁ δ’ Ὑπερείδης ἐν τῷ κατὰ Δημοσθένους “οὐδὲ μέχρι παραγραφῆς” φησὶν ἀντὶ τοῦ οὐδὲ μέχρι τινὸς ὠρισμένου χρόνου καὶ παραγεγραμμένου, ὃ ἐστὶ περιγεγραμμένου). Apollonius Dyscolus emphasized the function as a marker of an argumentative hiatus assumed by the particle δὲ, comparing it to a παραγραφή (*Conj.* 253.15 Schneider, and cf. 251.19–23, and *Synt.* 379.8 and 380.15 Uhlig).

139 Marinus asked Proclus to παραγράψειν his opinions on the Orphic poems τοῖς τοῦ διδασκάλου [*scil.* of Syrianus] βιβλίοις. Proclus eagerly accepted, παραγράψαντος τοῖς μετῴποις τῶν ὑπομνημάτων. The two datives without a preposition suggest a locative value should be assigned to the preverb παρὰ- (but *contra* see Montana 2010, 192–194, and the contribution in this volume).

manuscripts¹⁴⁰. Note that Vat. gr. 206 bears no παραγραφαί to *Con.*: they were part of the edition, not of the commentary, and have been eliminated during its transmission.

- i) [ἄλλως]. The adverb usually identifies alternative proofs. It does not appear in T1–3, but frequently occurs in the commentary. Eutocius elliptically alludes to it in T1, with the expression διαφόρους ὡς εἰκός τρόπους τῶν ἀποδείξεων¹⁴¹.

4 Scholiastic activity on other mathematical works

Other mathematical works were awarded less attention by ancient scholars. As a consequence, the associated scholiastic apparatuses are mainly made up of annotations (if any is transmitted) dating to the Byzantine period. Before offering a state-of-the-art overview of such apparatuses, it is worth pointing out two general phenomena:

- Byzantine scholarly activity (that is, scholia that must be assigned to hands different from that of the main copyist) on these treatises usually took place well after the date of transcription of their main manuscript witnesses. Arethas annotating his own Euclid is an exception.
- The mathematical production of Late Antiquity was almost entirely made up of commentaries, a kind of writing one would not expect to be the object of further scholarly attention, in the form either of second-order commentaries (but see *infra* for an exception) or of scholia¹⁴².

¹⁴⁰ I rely for this on McNamee 1998, 273–274, 280, who does not mention primary sources.

¹⁴¹ In this passage, it is difficult to give an immediately clear statement of the meaning of the adverbial syntagma ὡς εἰκός, which characterises the act of ἐπισημαίνεισθαι the alternative proofs ἔξωθεν: whether it is εἰκός to expect that such variants exist, or whether it is εἰκός (for instance because it is a widespread practice) to write them down in the margins – or even to write them down at all, as a sign of respect for the whole of the exegetic tradition.

¹⁴² A partial exception is found in the very short “summaries” accompanying Theon’s commentary in *Alm.* in Laur. Plut. 28.18 and dividing it into sections. They are written in majuscule by the main copyist and are all transcribed in Rome 1931–1943. They amount to an epitome-commentary of the commentary itself, but it is not clear whether the former was composed along with the final redaction of the latter, or apposed in a subsequent transcription.

With the exception of Eutocius' commentaries on *Sph. cyl.* 1–2, *Circ.*, and *Aequil.* 1–2, Archimedes' works were totally neglected by ancient scholarship; the manuscript tradition hands down only a handful of *scholia vetera*¹⁴³.

The scholiastic apparatus to Euclid's *Data* is rich but strictly technical: apart from a number of internal references to the text or the scholia¹⁴⁴ and of mentions of *El.*¹⁴⁵, it offers one interesting metadiscursive piece of information: the ascription to Apollonius of the last three definitions (*sch.* 13)¹⁴⁶.

Hero's *Metrica* has been transmitted by a single manuscript, the Seragl. G.I.1, written by the copyist Ephrem ca. 950–960; this codex also contains a number of important collections of metrological problems (Acerbi/Vitrac 2014, in particular section 7). Two hands in the Seragliensis later than Ephrem's selectively add annotations: the older one ("second hand") can be assigned to the XIIth century and is quite active; it also supplies well-founded integrations of the lacunae. This hand, whose script has been qualified as "cursive sauvage", has been identified with *manus* 3 of the Matrit. 4678 of Diophantus. A more recent hand ("third hand") can be dated to the XIIIth–XIVth centuries. The script, well-ordered and of small module, has been identified with that of Maximus Planudes, who also annotated the Matritensis (Pérez Martín 2006, 447–448, and 2009, n. 62)¹⁴⁷. As a consequence, three layers of scholia can be found in the Seragliensis. Their distribution is as follows¹⁴⁸.

- 1) ff. 3r1–17v13: text with scholia of the first (ff. 5v, 9r, 12r, 14r), second (ff. 7v–9r, 10r, 11r, 12r–13v, 14v, 15v–17v) and third hand (f. 7r), edited in *Heronis opera omnia* 5.222.2–232.2, the scholium at f. 5v excepted, to be read *ibid.*, 190.19 *app.*
- 2) ff. 17v16–19r17: text with four scholia of the second hand (ff. 18r–19r), edited in Heiberg 1927b, 68.2–18, and in *Heronis opera omnia* 4.XXIII; the first scholium at f. 19r is also edited *ibid.*, 5.28.1 *app.*

¹⁴³ They are edited in *Archimedis opera omnia* 3.322–329.

¹⁴⁴ These are in *sch.* 71 (διὰ τὸ σχόλιον μάλιστα τοῦ ἰ' θεωρήματος ὅπου σημεῖον τόδε P), 104 (ἐδείχθη γὰρ ἐν τῷ σχολίῳ τῷ ἐν τοῖς πρώτοις σχολίοις τοῦ πρό ὅπου σημεῖον τόδε * ...), 115 (καὶ ὁμοίως τῷ σχολίῳ τῷ αὐτῷ πρό αὐτοῦ θεωρήματος), 174 (τοῦτου τοῦ θεωρήματος ἔνστασις κείται ἐν τῇ πρώτῃ ἐξωχίῃ ὅπου σημεῖον τόδε *), 175 (ἔνστασις εἰς τὸ π' θεωρήμα *), 193 (δέδεικται ἐν τῷ σχολίῳ τῷ ἐν τῷ ἐπάνωθεν, ὅπου σημεῖον τόδε *).

¹⁴⁵ These are in *sch.* 71, 117, 126, 129, 141, 161, 170, 176, 184, 191, 192, 194, 197 (*El.* 5.19, 6.26, 2.12, 2.13, 1.14, converse of 6.1, 3.33, 6.17, 2.2, 3.18, 3.16, 3.35, 6.3, respectively).

¹⁴⁶ The scholia are edited in *Euclidis opera omnia* 6.261–319; *sch.* 13 is *ibid.* 6.264.2–3.

¹⁴⁷ The single word ἐτηρήθη(η) in the upper margin of f. 3r of Seragl. G.I.1 seems to have been written by a hand of the XIVth century.

¹⁴⁸ Canonical marginal signs ση(μείωσαι), even of abnormous dimensions, can be found at ff. 17v, 67r, 76v, followed by a demonstrative τοῦτο or ταῦτα.

- 3) ff. 19r19–23r15: text with scholia of the first (ff. 19r–v, 22v, 23r) and the second hand (ff. 19r–v, 20r), edited in Heiberg 1927b, 68.20–71.27, 42.11 and 46.8 *app.* for the last two first-hand scholia, and also in *Heronis opera omnia* 4.XXIII–XXVI.
- 4) ff. 23v1–24v21: text with one scholium of the second hand (f. 23v) edited in Heiberg 1927b, 72.2–3, and in *Heronis opera omnia* 4.XXVI.
- 5) ff. 24v23–25r11 and 25r12–26r26: texts without scholia.
- 6) f. 26v1–25: text with one scholium of the second hand, edited in Heiberg 1927b, 72.5–7.
- 7) f. 27r1–22 and 27r23–28v10: texts without scholia.
- 8) ff. 28v12–42r16: text with one scholium of the second hand (f. 33r), edited in *Heronis opera omnia* 4.430.18 *app.*
- 9) ff. 42r18–51r10: text with two scholia of the first hand (ff. 45v et 47r), edited *ibid.* 5.232.3–18.
- 10) ff. 51r12–54r10: text with one scholium of the first hand (f. 52r), edited *ibid.* 5.124.9 *app.*
- 11) ff. 54r12–54v15, 55r1–61r6, 61r21–62v13, 63r1–63v25, and 64r1–66r23: texts without scholia; f. 66v is blank.
- 12) ff. 67r1–110v1: Hero's *Metrica*: book 1, ff. 67r1–87r18; book 2, ff. 87v1–99r11; book 3, ff. 99v1–110v1. Some scholia by the first hand (ff. 75r, 79v, 81r–v, 82r–v) and others, more frequent, by the second (*passim*) and the third hand (ff. 73v, 74r, 77r–v, 78r–v, 79r) are concentrated around specific sections¹⁴⁹.

The scholia written by Ephrem are in a slightly cursive Alexandrine *Auszeichnungsmajuskel* of small module; they usually are very short, quite often in form of παραγραφαί.

Diagrammatic scholia are traced by Ephrem, at ff. 68r, 71v, 74r, 75r, 76r, 76v, 82v; the last one had in origin no denotative letters, which were added by the second hand. All these additional diagrams, except for those at ff. 75r and 82v, are included in the indentations which in the text are reserved to the main diagrams: thus in these cases, each diagram is reproduced in two or three copies. This phenomenon can be explained on the basis of what is found in *Metr.* 1.16. The diagram of this proposition is reproduced six times, of which three at the end of f. 76r, and three at the beginning of the subsequent page. In any of such triples, the main diagram (the largest one) is faulty, for it does not conform to the proposition's requirement that a certain angle be obtuse and another be a right

¹⁴⁹ These scholia are transcribed and translated (very often quite incorrectly), after the propositions they refer to, in volume 3 of Bruins 1964.

angle. The second diagram corrects the first mistake but not the second, the third diagram corrects both. It follows that the second and third diagram were diagrammatic scholia in origin, traced in order to correct the first and second diagram, respectively. Some copyist included in the main “text” both the diagrammatic scholium and the scholium to the scholium. The triple was doubled according to a practice that we also see at work with the diagram of *Metr.* 1.15: this proposition is very long (as long as 1.16) and some scholiast decided that it was worth giving a preview of the diagram in the lower margin of f. 75r before the reader encountered it, in due form and at the usual place at the end of the proposition, in f. 75v (indentation of 12 lines $\times$ 4/5 of a line, that is, about 1/3 of the written surface). Some diagrammatic scholia, drawn freehand by the second hand, can also be found at ff. 70r, 75v, 76r, 78v, 82v.

Ephrem’s codex in Istanbul offers the occasion for a digression on a kind of mathematical paratexts which, while not being scholia, were treated as such by the copyists: the indication of the fact that the diagram is to be found in the following page, by means of the expression ἐξ(ῆς) ἡ κ(ατα)γραφ(αφή). One finds such *réclames* in almost all the oldest mathematical manuscripts; a fair amount of them can be found in Laur. Plut. 28.18 (Theon and Pappus in *Alm.*), at¹⁵⁰ ff. 13r, 66v (only ἐξς), 86r, 96r, 139v (the *réclame* follows the diagram!), 149v (only ἐξς), 168v, 171r, 173r (only ἐξς), 206v (it precedes a calculation, the indication accordingly becoming ἐξῆς οἱ ἀριθμοί), 292r*, 297v*, 299r*, 308r*, 309r*, 318v (an incongruous ἐξῆς τὸ θεώρημα), 322r*, 343v, and in Paris. gr. 2389, ff. 42r, 272r, 338v. The fact that these *réclames* are almost always written in *Auszeichnungsmajuskel* and followed by the diagram on the same page shows that the copyists of these manuscripts had found the *réclames* in their exemplars, of which they did not respect the *mise en page*, and that they misinterpreted them as titles or scholia¹⁵¹. Now, this does not happen in Seragl. G.I.1¹⁵²; we find the *réclames*, again in Alexandrine *Auszeichnungsmajuskel* and normally centered in the page, at ff. 6v, 7r, 14r, 21v, 29r, 29v (only ἐξς), 36v, 46r, 53v, 55r, 55v, 56v, 60r, 78v, 96r, 102r, 103v, 106r. In all these cases, the diagram is on the next page: this shows that Ephrem tries to reproduce the *mise en page* of his model. On the other hand, the fact that

¹⁵⁰ The first occurrence is included in the text; with asterisk when σχῆμα replaces the more appropriate καταγραφῆ; this always and only happens in Pappus’ commentary. The difference between the two terms is well-established in the technical (meta-)terminology: σχῆμα is a geometric figure, καταγραφῆ its graphic representation.

¹⁵¹ By converse, there are dozens of diagrams opening a page but not preceded by the *réclame*.

¹⁵² The Seragliensis was written by Ephrem in the same period as Laur. Plut. 28.3 (Euclid; see section 2.1 *supra*). The *réclames* are here absent, but one must take into account that the diagrams of this square-shaped codex are drawn in the margins.

the *réclame* is absent, even if required on the basis of the same criterion, at ff. 8v, 10r, 13v, 15v, 31v, 35v, 53r, 82v, 88v, 97r, 108v, shows that it often was impossible to reproduce the *mise en page* of the model. In no case is the *réclame* followed by the diagram on the same page.

One single commentary on Nicomachus' *Introductio arithmetica* (= *Ar.*) proved so successful that we have four different versions of it, traditionally referred to as Recensions I–IV (Tannery 1886, 302–310 of the reprint). Recensions I–III refer to Ammonius' teaching, so that one may assume a course of his as the ultimate origin of this group of commentaries. In addition to the four recensions, there are also contaminated versions, which offer conflation of Recensions I and II as well as III and IV, and L. Tarán (1969, 12 n. 53) saw a Recension II manuscript which offers lemmas significantly different from the "usual" Recension II. Recension I, which both the manuscripts and modern scholarship assign to John Philoponus, was edited in the 1860s by R. Hoche in a series of three *Schulprogramme*¹⁵³. Recension II is, when compared to Recension I, characterized by additions. Most manuscripts assign it to Philoponus, but P. Tannery (1886, 302) noted that Isaac Argyros (†ca. 1375) was mentioned in some additions and suggested that he should be credited with the entire Recension II. Yet Tarán (1969, 18) showed that this recension should be at least partly attributed to Philoponus himself (or perhaps to a pupil of his). This contradictory evidence suggests a group of additions and modifications by different authors of perhaps widely varying date, applied to the basic Philoponus commentary (Recension I). Hoche, when editing Recension I, listed the differences between Recension I and Recension II for the first book of *Ar.* in the preface of a *Schulprogramm* (Hoche 1864–1865, II–XV), relying on exactly one manuscript (of Zeitz). Hoche never published an analogous list for the scholia to the second book. Almost a century later, A. Delatte (1939) edited the Recension II scholia for the second book, using two different manuscripts (held in the Vatican and at Athens). Recension III is the only version available in a reliable edition¹⁵⁴. Manuscripts and scholars concur in attributing Recension III to Asclepius, a contemporary of Philoponus. We know the least about Recension IV, which remains unpublished¹⁵⁵. There are two points to be emphasized in the attempt to unravel this scholarly tangle. First, all the Recensions are structured in the same way: a

¹⁵³ Hoche's work, based on a handful of German manuscripts, has not really been superseded; the main advantage of the recent edition by Giovanna Rita Giardina (1999) is its ready availability. For a *specimen novae editionis criticae*, unfortunately not achieved, see Haase 1982, 401–447.

¹⁵⁴ See Tarán 1969, who based himself on Monac. gr. 431 (XIVth–XVth century) and on Ambr. B 77 sup. (XVth century).

¹⁵⁵ A list of known testimonies is in Tarán 1969, 19–20.

set of remarks on specific passages of the Nicomachean text, usually referred to by means of a liminar citation; in the manuscripts, these remarks are mainly set out as a separate commentary, but they can also be found in the form of marginal annotations (for instance, in Gotting. philol. 66, the main manuscript of Hoche's edition of *Ar.*)¹⁵⁶: it is not clear what might have been their original layout. This means that these remarks taken as a whole do not have the canonical form that other Neoplatonic commentaries display, namely, a series of *praxeis* containing both a theoretical and a practical (that is, textual) part. Second, recent studies have shown that by far the most authoritative witness of *Ar.* is Matrit. 4678, which is in fact also the best manuscript of Diophantus (De Gregorio/Prato 2003 and Pérez Martín 2006). This manuscript, contrary to many other manuscripts of *Ar.*, is not accompanied by Philoponus' commentary but by an independent, and rich, apparatus of first-hand scholia, never studied to date.

The manuscript tradition of Diophantus' *Arithmetica* (*Ar.*) amounts to 31 witnesses but it rests on only four manuscripts: Matrit. 4678 (XIth century *p. m.*), Vat. gr. 191 (1296–1298), Vat. gr. 304 (XIVth century *in.*), and Marc. gr. 308 (XIIIth century *ex.*). As a matter of fact, the two Vaticani are copies of the Matritensis, Vat. gr. 191 including among other things corrections coming from infralinear or marginal annotations in the Madrid codex dating back to the XIIth and XIIIth centuries. A recension of *Ar.* made by Maximus Planudes (+1305), supplemented with a detailed commentary ranging over books 1–2¹⁵⁷, is partly contained in the incomplete Ambros. & 157 sup. but was copied therefrom in its entirety in Marc. gr. 308. Only five fragments of *Ar.*, amounting to about half of books 1–2, remain in Ambr. & 157 sup., now of 21 + 2 folios in a perturbed order. This autograph of Maximus Planudes was written about 1293 (Turyn 1972, 78–81 and plate 57, Allard 1979); it also contains fragments of the *Great Calculation according to the Indians*, likewise by Planudes (6 folios and 1 page) and of the pseudo-Iamblichean *Theologumena arithmeticae* (5 folios and 1 page), and a page of a text ascribed to Michael Psellus. The fragments of *Ar.* amount to 10 folios (in their correct order, these are ff. 13, 14, 8, 18, 20, 15, 9, 16, 17, 19) and contain the Planudean commentary, written in the margins and carrying authorial corrections. In Marc. gr. 308, the commentary was

¹⁵⁶ A check of the manuscript list in Haase 1982, 319–398, gives the following results: 40 manuscripts in which one of the Recensions is transcribed as a self-contained text (either following or preceding *Ar.*, or even in absence of the Nicomachean treatise), 19 manuscripts in which the Recension lies in the margins of *Ar.* About 50 manuscripts carry *Ar.* without full-fledged commentaries; only a handful of these have scholia unrelated to any of the Recensions.

¹⁵⁷ Diophantus' text and Planudes' commentary have been edited in the *Diophanti opera omnia* 1.2–448 and 2.125–255, respectively.

transcribed propositionwise after the main text, in a slightly smaller module and on the full page, whereas *Ar.* is on two columns.

The scholia to *Ar.* referred to above are a part of those contained in the oldest manuscripts of the non-Planudean family; they run approximately as far as the first two books of *Ar.* A number of them were edited by A. Allard (1983), who, however, was unable to correctly assign the several hands involved and did not realize that their common source is the huge scholiastic apparatus displayed by Matrit. 4678. This apparatus can be assigned to seven hands, according to the distribution here outlined and first given in Pérez Martín 2006.

- *Manus* 1 (= copyist 1, ff. 9–62r25, 137r–143v of the main text): ff. 10v–16r, 27r–29r, 42r, 58v, 60v–62r.
- *Manus* 2 (= copyist 2, ff. 62r26–135v): ff. 16v–22r, 24r–26v, 29v–33v, 35r–38v, 39v–42r, 43r–49r, 50r–57v, 59r, 62v–64r, 65r–69v, 70v–73r, 86r.
- *Manus* 3 (XIIth century *ex.*–XIIIth century *in.* = second hand of the Seragl. G.I.1): ff. 63v–64v, 65v, 66r, 67r, 68v–69r, 75r–77v, 78v–81v.
- *Manus* 4 (XIIIth century): ff. 11r, 14v–15, 16r, 21v, 35r, 40r, 44r–v, 45v, 47v–51r, 52r–v, 55r–v, 58v, 60v–62v, 64r–67r, 69v–70r, 72v, 73r–77v, 78v, 79r–80r, 81r–v, 82r.
- *Manus* 5 (XIIIth century *p. m.*): ff. 6v, 7v.
- *Manus* 6 (= Maximus Planudes = third hand of the Seragl. G.I.1): ff. 58v, 65r, 65v, 67r, 68v (*bis*), 70r, 76v, 78r, 78v, 79r, 79v, 89v (*bis*).
- *Manus* 7 (= John Chortasmenos): ff. 4r, 57v, 58r–60r, 61r–v, 63v–66v, 67v–68r, 69v–70r, 73v, 74r–v, 75v, 77v, 78r–79r, 82r–v, 83v–84v, 86v–87r.

Most importantly, still unedited are the hundreds of infralinear remarks and corrections with which the Byzantine scholar John Chortasmenos (†1431) greatly enriched the Diophantine text (see Acerbi 2013a for a first assessment).

One can read fragments of opinions by Marinus of Neapolis related to specific passages in *Alm.* (the milky way is part of the sphere of the fixed stars) and in the *Handy tables* (which is the best method for determining the lunar parallax). They can be found in scholia to these works, and show that Marinus annotated Theon's "Little Commentary" (Tihon 1976). While the first scholium is contained in Vat. gr. 1594, the second is carried by a less celebrated vector: Paris. gr. 2394, copied in 1733¹⁵⁸. This manuscript is important because it contains a version of the "Little Commentary" with peculiar variant readings and, most notably, a course on this very treatise (and by implication on the *Handy tables* themselves) redacted at the end of the Vth century and fragmented into a series of marginal annotations.

¹⁵⁸ A subscription at p. 617 of this codex dates the model to 1220: Boudreaux 1921, 20.

These lecture notes have never been edited nor studied (but see Tihon 1978, 171–182); it is likely that we read them in their original form, that is, as a set of specific annotations.

Supplement 1 An analysis of Leo's ὑπόμνημα σχολιον on composition and removal of ratios

According to the inscription, the scholium deals with “composition and removal of ratios”; this subject is only marginally dealt with in *El.* 6, even if the (spurious) def. 5 provides a definition of “compound ratio”. It is, therefore, misleading to assert, as is commonly done, that the scholium is related to *El.* 6 def. 5¹⁵⁹. The structure of this text is as follows: a series of four arithmetic “lemmas” followed by the proof of the main result on composition of ratios. Lemma 2 is in its turn followed by an “arithmetical clarification” of both lemmas 1 and 2, the proof of the main result being followed by a numerical ὑπόδειγμα, where it is shown, by passage to the “values” of the ratios and subsequent calculation, that ratio 7 to 5 is composed of ratios 7 to 11 and 11 to 5¹⁶⁰. The scholium ends with a short prescriptive statement on how to remove ratios. Let us read the enunciations of the lemmas and of the main result, and see the numerical examples following them:

- «Lemma 1: “Let A, B, Γ be numbers, and let Δ be «the product» of A, B, and E of B, Γ , and again Z of A, Γ , and once more H of A, E, and Θ of B, Z, and again K of Γ , Δ . I say that numbers H, Θ , K are equal to each other”. In short, the product of three numbers is the same, whichever is the order of the factors (recall that multiplication is a binary operator, and that its commutativity is proved in *El.* 7.16; the proof of the lemma is a straightforward adaptation of that of 7.16).
- Lemma 2: “Let a number A be a multiple of B according to Γ . I say that B is also a multiple of A according to the part homonymous to Γ ”¹⁶¹. Arithmetical

¹⁵⁹ The scholium, on the basis of a misinterpretation of the alphabetic letters there employed as ordinals, was also absurdly held to contain germs of algebraic notation: see Vogel 1960, 661. To employ ordinals as dummy letters is a common and widespread practice in Greek mathematics: one need only take a look at *El.* 5 and at Diophantus' *Arithmetica*. These alphabetic signs are treated in the scholium as real denotative letters, since they are marked by a superimposed bar and not by an apex, as ordinals usually are.

¹⁶⁰ The πηλικότης (“value”) of ratio 7 to 5 is simply number 7/5.

¹⁶¹ A part is homonymous to a number if it bears the same name as the number, only transformed into an ordinal, e.g., “three” and “one third”.

clarification: lemma 1: $4 \times 5 \times 6$ is equal to $5 \times 6 \times 4$, that is, to 120; lemma 2: 100 is a multiple of 20 according to 5, while 20 is a multiple of 100 according to $1/5$.

- Lemma 3: “Let a A be epimoric of B according to Γ . I say that, alternately, B is also epimoric of A according to the part homonymous to Γ ”. Example: the epimoric ratio 4 to 3 and the (sub)epimoric ratio 3 to 4.
- Lemma 4: “The same also happens with epimeric $\langle$ ratios $\rangle$... one must also conceive the same for composed ratios, such as multiple-epimoric and multiple-epimeric”¹⁶². Examples: 7 to 5 and 5 to 7; 7 to 3 and 3 to 7; 13 to 5 and 5 to 13.
- Main result: “Let there be a magnitude A, having to B a ratio whose ratio value be Γ , and between A, B let a chance magnitude fall, Δ . I say that the ratio of A to B is composed of the $\langle$ ratio $\rangle$ that A has to Δ and of $\langle$ the ratio $\rangle$ that Δ has to B”.

Only the proofs of lemma 1 and of the main result are full-fledged demonstrations (the latter ends with a sentence that can be read as a hint of how to iterate the proof to include nested compositions); those of lemmas 2–4 and of the final prescriptive statement are nothing but explanations carried out on paradigmatic examples; in particular, the procedure of removal of ratios remains quite obscure. Only lemmas 2–4 are identified as such in the text, which begins directly with the enunciation of “lemma 1”. Lemma 1 is expressly referred to (expression διὰ τὸ ἀλῆμμεν) within the “arithmetical clarification” of lemma 2 and within the main proof; lemma 2 is expressly referred to again within the “arithmetical clarification”.

As is clear from the enunciations listed above, the scholium has an obvious deductive problem: lemmas 2–4 have nothing to do with the rest of the text, and in fact they are not used in the proof of the main result. If we were presented with such a state of affairs in a more structured exposition, there is no doubt that we would surely regard lemmas 2–4 as interpolated.

There are a number of ancient expositions on composition and removal of ratios that try to explain the rationale behind these operations¹⁶³. If we skip lemmas 2–4, the combination “ $\langle$ lemma 1 $\rangle$ + main result” adopts a deductive pro-

¹⁶² An epimoric ratio has the form $(n + 1)/n$; an epimeric ratio has the form $(n + k)/n$, with $n > k$.

¹⁶³ See Pappus, *Coll.* 7.240; Theon, in *Alm.*, in Rome 1931–1943, 532.1–535.9 (*Alm.* 1.13) and 759.8–762.2 (*Alm.* 2.11); the final section of *Prol.*; Eutocius, in *Con.*, in *Apollonii Pergaei quae graece exstant* 2.218.6–220.25, and in *Sph. cyl.* 2.4, in *Archimedis opera omnia* 3.120.3–126.20. To this should be added a few splinters in scholia 2–11 to book 6 of *El.* (*Euclidis Elementa* 5.2.1.5–10.25 – actually, scholium 4 coincides with the first exposition in Theon’s commentary), where we read a definition of “compound ratio”.

gression that, exactly in this form, is not found anywhere in ancient sources, even if it can be seen as a rewriting (longer and more cumbersome) of the proof presented by Eutocius in his two expositions. The terminology of ratios adopted in lemmas 2–4 is at best misleading, owing to the fact that the standard prefix ὑπο- for ratios lesser than unit is systematically omitted: see the example above, where it is said that “20 is a multiple of 100” instead of “20 is a submultiple of 100”.

In sum, the scholium is badly organized and located, and sometimes inappropriately worded. My impression is that it is the result of the stratification of at least two layers: a core text comprising lemma 1 and the proof of the main result – maybe extracted from an ancient exposition to which we no longer have access – and the rest: lemmas 2–4, all numerical examples and the final prescription. Add to this that lemmas 1 and 2 are in turn annotated (recall that the text is written on the full page) by three παραγραφαί referring to appropriate propositions of *El.* 7, which amounts to a logical *hysteron proteron* once the scholium is appended to *El.* 6; a short comment scholium designed to clarify the notion of homonymous part (in exactly the same way as in my footnote 161 above) is instead contained in an indentation of the text at the beginning of lemma 2. The two- or multi-layered composition of the resulting text could explain its seemingly bizarre designation as ὑπόμνημα σχόλιον¹⁶⁴.

Supplement 2 Complete list of the first-hand scholia in majuscule in Vat. gr. 1594

ff. 6r πολλαπλασιασμοῦ ὀρισμός, 9r epigram (in *Auszeichnungsmajuskel*, of the same size as the titles of the chapters) οἷδ' ὅτι θνητὸς ἔφυν καὶ ἔφάμερος· ἄλλ' ὅτ' ἄν ἄστρων | ἰχνεύω κατὰ νοῦν ἀμφιδρόμους ἔλικας | οὐκ ἔτ' ἐπιψαύω γαίης ποσὶν. ἀλλὰ παρ' αὐτῷ | ζηνὶ διοτρεφέος πίμπλαμαι ἀμβροσίης¹⁶⁵, 12r short schematic summary, 16r ἀν(τι) ἀεὶ, 19r λῆμμα, 19v τὸ λῆμμα, 22v *ter* π(ερὶ) κ(ατα)σκευῆς, π(ερὶ) θέσε(ως), π(ερὶ) χρήσε(ως), 23r *ter* π(ερὶ) κ(ατα)σκευῆς πλινθίδων, π(ερὶ) θέσεως, π(ερὶ) χρήσεως, 23v α' λῆμμα(α) | εὐθύγρα(μ)|μ(ον) κ(ατὰ) σύν|θεσιν, 24r *bis* β' λῆμμα(α) | κ(ατὰ) διαίρ(εσιν), γ' λῆμμα(α) | κυκλικ(όν), 25r *quinquies* θεώ(ρημα) κ(ατὰ) διαίρ(εσιν), (διὰ) τὸ β' λῆμμα(α), (διὰ) τὸ γ' λῆμμα(α), (διὰ) τὸ γ' λῆμμα(α),

¹⁶⁴ The second word is given in abbreviated form; Heiberg, and most scholars after him, tentatively, and unnecessarily in my opinion, proposed the reading σχολικόν.

¹⁶⁵ I transcribe the epigram without correcting it; for an edited text, see *Ptolemaei opera omnia* 1.1.4.5 *app.*

διὰ τὸ ἀνάπαλιν | τ(οῦ) ε λημμάτος, 25v τεταρτημόριον γάρ ἐστι ἑκατέρα τῶν BE ΕΔ, 36r *bis* λῆμμ(α) | α, λῆμμ(α) | β, 37v *quater* (διὰ) τὸ α λῆμμα, (διὰ) τὸ β λῆμμα, λῆμμα, schematic summary of the ὀρθ(ῆς) σφαίρας ἀναφοραὶ διὰ ῥόδου, 38v table of καθόλου λόγοι et π(ερὶ) ῥόδου λόγοι, 39r tables of ζ(ωιδίων) μ(οῖραι), ὑπεροχαὶ | ἀναφορ(ῶν), ὀρθ(ῆς) σφαίρ(ας) | ἀναφορ(αί), διὰ ῥόδ(ου) | ἀναφ(οραί), δεκαμ(οιρία), 40r ἐνταῦθα ἐπὶ τ(ῆς) ὀρθ(ῆς) σφαίρ(ας) | ἀπὸ γ' ἔρχεται ἐν τῷ προ|χειρῶν ἀπὸ ς, 42r π(ερὶ) ὠρόσκ(οπος), 42v *quater* ἀπὸ κριοῦ, κατὰ τὸ α' σελί(διον), ἀπὸ γ', ἐκ τ(ῶν) μενε|λάου σφαιρικ(ῶν), 43r λῆμμ(α) α', 43v λῆμμα | β', 44r (διὰ) τὸ β' λῆμμ(α), 44v *quinquies* δ' μ(οῖραι) (γὰρ) ἡ ΕΚ, διὰ τὸ α' λῆμμα, διὰ τὸ β' λῆμμα, κ(ατὰ) τ(ὰς) ἀρ(χάς), (διὰ) τὸ β' λῆμμ(α), 45r *bis* λῆμμ(α) α', λῆμμα β', 46v *bis* λῆμμα α', schematic summary, 47r λῆμμα | β', 47v *bis* λῆμμα γ', λῆμμα δ', 48r (διὰ) τ(ῆς) λοξώσε(ως), 48v (διὰ) τὸ β' λῆμμα, 57v π(ερὶ) τ(ῆς) λοξώσε(ως), 61v ὁ ἵππαρ(χος), 64v *bis* π(ερὶ) τ(οῦ) ζωι(δίου)¹⁶⁶, π(ερὶ) τ(οῦ) ὁμο(κέντρου), 68v ὁμαλή (*bis*), 71r short schematic summary, 75v *ter* τίς ἡμία (*sic*) τ(οῦ) κόσμ(ου) π(ερὶ)στροφῇ, τί τὸ ἀπλ(ῶς) νυχθήμερ(ον), τί τὸ ὁμαλ(ὸν) νυχθήμερ(ον), 81v–82r annotations to the tables of the mean motions of the Moon, 92r τόποι, 97v ἀνωμα(λία) (*bis*), 100r ὅτε (ἀπὸ) τ(οῦ) ἀπο|γει(ου) τ(οῦ) ἐπι(κύκλου) ἀφέ|στηκ(εν) ἢ ≡ μ(οιρῶν) ρέ ησ|ξε, 102v διὰ τ(ὸν) προσυλλογισμ(όν), 106v τὰ σελίδια τῆς καθ' ὅλου σεληνιακῆς ἀνωμαλίας (εἰσὶν) οὕτως:– | ἐν τῇ συντάξει γ' δ' ε' ζ' ζ' | ἐν τῷ προχειρῶν | κανόνι γ' ε' ζ' δ' πλάτ(ος) | ≡¹⁶⁷, 110r ἀν(τι) τ(οῦ) φαινομέν(ου) | (χρόνου) τ(ῆς) ≡(ης), 116r π(ερὶ) τ(ῆς) (δια)φορ(ᾶς) | τ(ῶν) τ(ῆς) ≡ παραλ|λάξε(ων) τ(ῆς) (διὰ) τ(ῆν) | ἐν τ(ῶν) ἐπι(κύκλω) (ἀπὸ) | τ(ῆς) μ(ετὰ)βασιν | γινομέν(ης), 118r παραλλάξεις (ἡλίου) κ(αὶ) ≡(ης) ἐπὶ τ(ῶν) δι' αὐτ(ῶν) κ(αὶ) τοῦ κ(ατὰ) κορυφῇ γραφομέ|ν(ων) μεγίστ(ων) (κύκλων)¹⁶⁸, 120v γωνίαι, 122v τὰ ιβ' ια' κς' μα' κ' ιζ' νθ', 123r *bis* π(ερὶ) τ(οῦ) κανόν(ος) τ(ῆς) ὁμ(αλῆς) ≡(ης), π(ερὶ) τ(οῦ) μηνιαίου κανόν(ος), 123v π(ερὶ) τ(οῦ) ἐνιαυσιαίου κανόν(ος), 125r annotations to the tables of conjunctions, 126r π(ῶς) δεῖ λαμβάνει(ν) | ἀνώμα(λον) (ὠριαῖον) κ(ατὰ) μῆ|κ(ος) κίνημ(α) τ(ῆς) ≡, 127r π(ερὶ) τὸ περιγ|εῖον τ(οῦ) ἐπι(κύκλου), 128v *bis* (ἡλίου) ἐκλειπτικοὶ ὅροι, ≡(ης) ἐκλειπτικοὶ ὅροι, 132v *ter* ἐποχ(ῶν), κανόνι(ον) (ἡλι)κ(ῶν) ἐκλείψε(ων) μ(εγίστου) | (ἀπο)στήματος, (ἀπὸ) τ(οῦ) βορεί(ου) πέρατ(ος), 133r *bis* κανόνι(ον) ἡ|λιακ(ῶν) ἐκλείψεων, κανόνι(ον) σελη|νιακ(ῶν) ἐκλείψεων, 138v *ter* ἐμπτῶσε(ων), τ(ῶν) ἀνωμα|λίων (ὠριαῖα) κινή|ματα, τ(ῶν) τ(οῦ) ἵππαρ(χου), 140v *ter* τ(οῦ) μεγάλ(ου) (ἀπο)στήματ(ος), ἔμπτ(ωσις) κ(αὶ) ἀ|νακάθαρσις, τὸ ἐκ τ(ῆς) φαι|νομένης ἀνωμαλί(ας) | εὐρισκόμ(ενον), 141v ὠριαῖον, 148v πῶς τὰς ἐποχὰς τ(ῶν) ἀπλαν(ῶν) (ἀστέρων) ἔλαβεν ὁ πτολεμ(αί)ος, 154r τοῦ ἐπὶ κλ(ην)

166 *Nomen sacrum*.

167 See *Ptolemaei opera omnia* 1.1.391 *app*.

168 See *Ptolemaei opera omnia* 1.1.443 *app*.

εὐσεβ(οῦς) | τοῦ μ(ετὰ) ἀδριάνον, 155–164 annotations to the star catalogue, 168r *bis* τ(οῦ) γραφέντ(ος), τ(οῦ) ἐλάττονος, 168v *quater* τοῦ κρίκου, κ(ατὰ) πλάτ(ος), κ(ατ') ἀναγραφὴν, τῶν ἀπλα|νῶν (ἀστέρων), 169r schematic summary, 169v *ter* τί κρύψις, τί σύνοδος, τί ἐπιτολή, 170r schematic summary, 174v ὦν (ἐστὶ) κ(αὶ) | ὁ πλάτος, 176r *ter* καθάπ(ερ) ἐν τ(ῶι) γ' | βιβλίωι πεπο|ι|μένον, μηδεμί(αν) αἰσθητ(ήν) | διαφορ(ὰν) ποιοῦντ(ων), ἐκ τ(ῶν) τηρήσεων, 178r, 179v, 181r, 182v, 184r annotations to the tables of the mean motions in longitude and anomaly of the five planets, 185v ἐν τῶι γ' βιβλίωι, 193r data concerning the Moon and Mercury, in tabular form, 196r (διὰ) τὸ γ' θεώ(ρημα) τ(οῦ) ζ' κεφ(αλαίου) τοῦ θ' βιβλίου, 196v εἰς τὰ προηγούμε(να), 197r τ(ήν) ὑπ' αὐτ(οῦ) κ(ατα)ληφθεῖς(ης), 199r πτολεμαίου, 207r *quinquies* ὡς ἐδείχθη | ἐν τ(ῶι) ε' θεω(ρήματι), ἐν τ(ῶι) ιε' θεω(ρήματι), προτ' ιγ' θεω^ρ, τοῦ ὀμαλ(οῦ), τ(ῆς) ἀναγραφῆς, 208r *ter* ἀν(ω)τέρω, (ὡς) ἄνω ἐδεί(χθη), (ὡς) ἀνωτέρω ἐδείχθη, 209v κ(ατὰ) διονύσιον, 211v *bis* ὀμαλῆς, τῆς α' ὀμαλῆς, 213r ὡς νῦν, 215v *bis* ἐπὶ τοῦ διός, κ(ατὰ) τὸ α' ἔτ(ος) ἀντωνίνου, 216v *bis* κ(ατὰ) διονύσι(ον), ὥραι ἡμ^ε ιβ', 217r *bis* τ(ῆς) β' φαινομ(ένης) διαστ(άσεως), τ(ῆς) β' ὀμαλ(ῆς) διαστ(άσε)ως), 221r μέσως, 222r *bis* ἐπὶ τοῦ τοῦ η, π(ερί) τὸ α' ἔτ(ος) ἀντωνίν(ου) ἀπογείλ(ον) η μ(οιρῶν) κγ', 222v κ(ατὰ) τὸ α' ἔτ(ος) ἀντωνίν(ου), 223v ἐκ τ(ῶν) ἐν τοῖς κανόσιν | ὀμαλ(ῶν) κινήσεων, 224r π(αρά) τ(ήν) ζωδιακ(ήν) | ἀνωμα(λῆ) διαφ(οράν), 228v *ter* τ(οῦ) τ(ῆς) ἀνωμα(λίας) κανον(ίου), τ(ῶν) ἐν τ(ῶι) θ' βιβ(λίωι) ἐκτεθειμ(ένων), τ(ήν) πρὸ | τ(ῆς) διακρίσεως, 229r ἐκ τ(οῦ) γ' κ(αὶ) δ' | σελιδίου, 257v *ter* κ(ατὰ) πλά(τος) π(αρα)χλωρήσεις ἐν | τ(ῶι) ε' βιβλί(ωι), ἐπὶ τ(ῆς) ς(ης), ἐπὶ τ(ῶν) ε' πλα|νωμέ(νων).

Supplement 3 Σχόλιον and related terms in Pappus and Theon

As Pappus and Theon designate their commentaries by the term σχόλιον/α, it can be useful to have a complete list of the occurrences of such and other designations of their writings.

a) *Pappus*. He designates each book of his commentary *in Alm.* by the term σχόλιον, in the singular. He uses the same term to refer to *in Alm.* 1 in *Coll.* 8.46 (Hultsch 1876–1878, 1106.14), in the same manner as we read in the titles of *in Alm.* 5 and 6 (Rome 1931–1943, 1.2 and 171.2) and on two occasions during the commentary itself (*ibid.*, 76.21 and 302.16, references to *in Alm.* 1 and 5). Elsewhere, the singular is employed to designate a particular remark (*ibid.*, 243.11). We find the plural in a generic meaning (*ibid.*, 86.18), or to designate individual books (*ibid.*, 184.8, 199.4, 255.1, references to *in Alm.* 5, again 5 and 1, respectively) or the whole of the preceding annotations (*ibid.*, 66.9). The noun ὑπόμνημα is never

read in Pappus, who twice uses the expression ὑπομνήσεως ἕνεκεν (*ibid.*, 173.24 and 258.20) in order to open or close side-arguments, and who characterizes his own exegetic activity by the verbal form ὑπομνήσομεν (*ibid.*, 184.10).

b) *Theon*. In his designations he adopts the opposite convention compared to that of Pappus'. The term σχόλιον does not feature in his *in Alm.* 1–4, but, in the “Great Commentary” to the *Handy Tables*, he refers to the whole of his *magnum opus* by the term σχόλια (Mogenet/Tihon 1985–1999, 1.94.6, 1.106.6, 1.107.18, 1.108.9, 1.154.12); three occurrences of σχόλιον in the singular, of which two are dubious, designate specific remarks in the “Little Commentary” (*ibid.*, 1.123.4, 1.123.10, 1.134.23–24). On the other hand, the titles and subscriptions of *in Alm.* and of the “Great Commentary” designate each book as ὑπόμνημα: *in Alm.* 1 at Rome 1931–1943, 317.3 and 463.3, *in Alm.* 2 *ibid.*, 601.4, *in Alm.* 3 *ibid.*, 807.3, “Great Commentary” 1 at Mogenet/Tihon 1985–1999, 1.93.1 and 1.158.11, “Great Commentary” 2 *ibid.*, 2.58.6. In order to name the first treatise, Theon uses ὑπομνήμασις at Rome 1931–1943, 935.24; ὑπόμνημα for the first at Mogenet/Tihon 1985–1999, 2.197.26, and for the second at Rome 1931–1943, 914.1, 922.13, 938.12; in the “Little Commentary”, the “Great Commentary” is referred to as σύνταγμα (*var.* σύγγραμμα): Tihon 1978, 199.4. We again find ὑπόμνημα for the Ptolemaic “instructions” to the *Handy Tables* in Mogenet/Tihon 1985–1999, 2.21.18 and 2.27.4. Theon names his own activity ὑπομνηματισμός at Rome 1931–1943, 318.1, 319.2, 977.6, and at Mogenet/Tihon 1985–1999, 1.94.3, ὑπομνήμασις at Rome 1931–1943, 914.1. *Ibid.*, 318.7–8, what is at issue are ὑπομνήματα redacted by former ὑπομνηματισταί; the verb ὑπομνηματίζω can be found at Tihon 1978, 199.8, and Mogenet/Tihon 1985–1999, 1.93.7.

In *Prol.* we find the following scholium (Acerbi/Vinel/Vitrac 2010, 120.1 *app.*): ἐκ τῶν Ζηνοδώρου σχολίων ὡς ἱστορεῖ ὁ Θέων ἐν τῷ εἰς τὴν σύνταξιν ὑπομνήματι ἐποίησε δὲ ὁ Πάππος βιβλίον ὅλον περὶ τοῦ προκειμένου προβλήματος. Note the three different designations σχόλιον, ὑπόμνημα, βιβλίον, the first of which is quite unusual for a primary, “formal” mathematical treatise.

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