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Astronomy and Geography
Some Unexplored Connections in Ptolemy

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Abstract The authors discuss the so-called 'zenith star method', first mentioned in Ptolemy's *Geography* (ca. AD 150), from an astronomical and historical perspective. They reach the conclusion that the exact representation in some texts, i.e. that the distance between the two points of culmination is 1°, does not in fact concern a pair of stars culminating at the zenith but only *one* star which is measured at an angle of 1° from the zenith. This peculiar condition points to a historical measurement carried out by an unknown Greek astronomer: it makes use of the fact that the bright star Pollux (*β Geminorum*) culminated at Alexandria with an angle distance of 1° from the zenith or (which is equivalent) culminated at the zenith over a place 1° south of Alexandria (ca. 110 km). Although a scholium to Ptolemy's *Geography* claims this, the unknown author of the experiment is in all probability not Hipparchus of Nicaea.

Keywords Hipparchus. Ptolemy. Circumference of the earth. Zenith star method.

1 Introduction

Geography and astronomy shared a much closer relationship in Antiquity than today.[1] Not only did they employ the same instruments and aimed at producing lists and maps of their objects, scientists in Antiquity worked quite often in both fields. To name just a few: Anaximander, who is credited with the invention of the gnomon, was also the first to draw a map of the *oikoumene*; Eudoxus of Cnidos, whose star catalogue was versified by the Hellenistic poet Aratus, not only wrote several treatises about astronomy

1 We should like to thank Renate Burri, Filippomaria Pontani, Anna Santoni, Søren Lund Sørensen and Vasileios Tsiotras for valuable remarks and help.

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and constructed a sundial, but also authored a *Ges periodos* (probably with a map); the polymath Eratosthenes did the same, writing books about astronomy and geography, drafting a map of the *oikoumene* and constructing a star globe. Hipparchus, arguably the best astronomer of ancient times, also worked in the field of geography, writing a commentary on Eratosthenes' geographical achievements. But the best known example is surely Claudius Ptolemaeus (Ptolemy), who wrote classical handbooks in the fields of both astronomy and geography, compiled long lists of stars and toponyms, drafted maps and developed new instruments such as the astrolabe and the meteoroscope.[2]

This link between astronomy and geography is not fully explored yet. In fact, the gap between these disciplines in the present sometimes prevents modern scholars from understanding the methods, aims and objectives of the Greek and Roman scientists. Ptolemy's *Geography*, for example, cannot be understood without some astronomical and mathematical knowledge, a fact to which the author himself refers in his introduction (see, especially, 1, 2-3). Still, modern scholars tend to read his works like a cultural geography in the vein of Strabo, trying to make sense of Ptolemy's coordinates, and lament his alleged 'inability' and 'ignorance' of geographical matters, when at a loss.[3]

For sure, this bias in the consideration of Ptolemy's *Geography* already started in late antiquity, when the first 'reader-friendly' translations, epitomae, revisions, and commentaries were produced. Most of these are lost forever, but even the few traces and hints which have survived, are rarely studied. This is especially true for the scholia to Ptolemy's *Geography*. The last two critical editions, that of Müller (1883-1901) and that of Stückelberger, Grasshoff (2006), do not even print them in their text.[4] One needs to go back to Nobbe's outdated edition (1843-1845) or even to the manuscripts themselves.

The aim of our paper is, among other things, to analyze one of these *scholia*.[5] The scholium in question is concerned with Ptolemy's claim that in order

2 Our list of ancient scientists could be expanded easily. A nearly complete inventory of ancient astronomers and geographers can be found in Keyser, Irby-Maissie 2008, 995-96, 999-1002. Leonid Zhmud (St. Petersburg) is currently working on a database of ancient scientists.

3 For a recent criticism of this approach, see Geus 2013, for another one Tupikova, Geus 2014.

4 Of course, the main goal of these editors was to produce a reliable edition of the original text of Ptolemy, not of its ancient commentaries, scholia, and glosses. Stückelberger, Grasshoff (2006, II, 914-17), however, do print and translate two small texts related to *Geography*, 8, 29.

5 The research on Ptolemy's scholia is meagre, to say the least (but see Tsiotras 2006), and often focuses on pictorial aspects and questions of authorship. This is especially true for mss. Marcianus Graecus Z. 388 (333, siglum p) and Marcianus Graecus Z. 516 (904, siglum R). The former has, next to some of the scholia, some beautifully drawn miniatures, while the latter is not only one of the most important manuscripts within the stemma of

to understand the extent of our *oikoumene*, we must first of all determine the circumference of the Earth. And this has to be done through astronomy.

2 The Zenith Star Method in Ptolemy's *Geography*

Ptolemy (*Geography*, 1, 3) writes:[6]

> (1) Οἱ μὲν οὖν πρὸ ἡμῶν οὐκ ἰθυτενῆ μόνον ἐζήτουν ἐν τῇ γῇ διάστασιν, ἵνα μεγίστου κύκλου ποιῇ περιφέρειαν, ἀλλὰ καὶ τὴν θέσιν ἔχουσαν ἐν ἑνὸς ἐπιπέδῳ μεσημβρινοῦ. καὶ τηροῦντες διὰ τῶν σκιοθήρων τὰ κατὰ κορυφὴν σημεῖα τῶν δύο τῆς διαστάσεως περάτων, αὐτόθεν τὴν ἀπολαμβανομένην ὑπ' αὐτῶν τοῦ μεσημβρινοῦ περιφέρειαν ὁμοίαν εἶχον τῇ τῆς πορείας, διά τε τὸ καθ' ἑνός, ὡς ἔφαμεν, ἐπιπέδου ταῦτα συνίστασθαι, τῶν ἐκβαλλομένων εὐθειῶν, διὰ τῶν περάτων ἐπὶ τὰ κατὰ κορυφὴν σημεῖα συμπιπτουσῶν ἀλλήλαις, καὶ διὰ τὸ κοινὸν εἶναι τῶν κύκλων κέντρον τὸ τῆς συμπτώσεως σημεῖον.(2) Ὅσον οὖν ἐφαίνετο μέρος, οὖσα τοῦ διὰ τῶν πόλων κύκλου ἡ μεταξὺ τῶν κατὰ κορυφὴν σημείων περιφέρεια, τοσοῦτον ὑπετίθεντο καὶ τὴν ἐν τῇ γῇ διάστασιν τῆς ὅλης περιμέτρου.
>
> (1) The [astronomers] before us looked not only for a rectilinear interval on the earth, so that it may make an arc of a great circle, but also one that would lie in the plane of a single meridian. Using shadow-catching instruments, they observed the zenith points at both ends of the interval and obtained from there the arc of the meridian cut off by these [zenith points], which was [proportionally] similar to the journey [between the two locations on earth]; this is because these [points] were set up – as we mentioned – in a single plane, since the lines drawn through the two ends to the zenith points intersect, and since the intersection point is the common centre of the circles. (2) They therefore assumed that the fraction that the arc between the zenith points was seen to be of the circle through the [celestial] poles was the same fraction that the interval on the earth was of the whole [earth's] circumference. (Transl. by Berggren, Jones [2000, 61] with several adaptations)

Ptolemy's *Geography*, but also exhibits interesting comments on mapmaking, probably from late antique and medieval times. See, e.g., Fischer 1932, 253-61, 275-84; Bernardinello 1996-97; Mittenhuber 2009, 326-28 and 2010, 111; Burri 2013, 446-47, nos. 457, 499, on the Africa 4 map. For the pictures and the 'Arabian inscription' see Olshausen 1880 and Burri 2013, 450-51, 456-57.

6 Since we have already dealt with this passage in Geus, Tupikova 2013, we take up the opportunity to highlight and add some aspects.

This method attributed by Ptolemy to anonymous 'predecessors', makes use of the fact that some pairs of stars achieve their highest positions in the heavens at the same time. It is reminiscent of two other measurements of the earth, those of Eratosthenes and Posidonius. In fact, all of them are based on the same principle, namely that of comparing an arc in the heavens with a terrestrial distance along a great circle. The method described by Ptolemy is in fact superior to the other two. It can be employed easily with simple astronomical instruments at any time of the year. The refraction at the zenith is much lower than on the horizon, thus enabling better measurements. Finally, if you pick two stars and two observation points along a meridian, you avoid a potential error in longitude. Such an error indeed happened in earlier measurements, as, e.g., Alexandria and Syene or Rhodes and Alexandria do not lie exactly on the same meridian.

3 Ancient and Modern Commentaries on the Zenith Star Method

However, the method described by Ptolemy is not without pitfalls either, and it requires a critical evaluation: *skiothera*, 'shadow-chasing' instruments, are not well equipped to observe zenith points in the sky – at least not at night when no shadow is cast at all. Basically, you can use any instrument which has a vertical axis, to determine the zenith direction. The crucial problem is, however, that you must know not only the zenith point at your own observation point, but also the zenith point at the other place in order to measure the corresponding arc in the heavens and on the earth's surface. Zenith points are not fixed but relative to the observation points. And the other zenith point is not *a priori* marked in the sky, as it can only be observed when a star culminates there. The main difficulty lies in the selection of a pair of stars, preferably bright ones, which may be easily observed with the naked eye, and culminate in Greece or in areas inhabited by Greeks, ideally at famous observation places like Alexandria, Rhodes, Syene or Lysimachia. These two criteria eliminate most of the stars observable by the Greeks in antiquity. The number of candidates is further reduced if we apply a third criterion not attested in Ptolemy's text but in two late antique commentaries on Aristotle: the distance between the two zenith stars has to be of one degree.[7] Simplicius in his *Commentary on Aristotle's On the Heavens* (298a15 [CAG 7, 549, 1-10]) writes:

> Ἐπειδὴ δὲ τοῦ μέτρου τῆς γῆς ἐμνημόνευσεν ὁ Ἀριστοτέλης τετταράκοντα μυριάδων αὐτῆς λέγεσθαι τὴν περιφέρειαν εἰπών, καλῶς ἂν ἔχοι καὶ

7 For the other, shorter, text – John Philoponus in his *Commentary on the First Book of Aristotle's Meteorology*, 15, 5-8, – see Lewis 2001, 334.

διὰ τοὺς ἀπιστοῦντας τῇ σοφίᾳ τῶν παλαιῶν ἀνδρῶν τὴν μέθοδον τῆς μετρήσεως συντόμως προσαναγράψαι. λαβόντες ἀπὸ διόπτρας δύο τῶν ἀπλανῶν ἀστέρων μοιριαῖον ἀλλήλων ἀπέχοντας διάστημα, τουτέστι τριακοσιοστοεξηκοστὸν μέρος τοῦ μεγίστου ἐν τῇ ἀπλανεῖ κύκλου, καὶ εὑρόντες ἀπὸ διόπτρας τόπους, οἷς κατὰ κορυφήν εἰσιν οἱ δύο ἀστέρες, καὶ τὸ μεταξὺ διάστημα διὰ ὁδομέτρου μετρήσαντες, πεντακοσίων ηὗρον αὐτὸ σταδίων. ἐξ οὗ συνάγεται, ὅτι ὁ μέγιστος τῶν ἐν τῇ γῇ κύκλων περίμετρον ἔχει μυριάδων δεκαοκτώ, ὡς ὁ Πτολεμαῖος ἐν τῇ Γεωγραφίᾳ ἀνελογίσατο.

Since Aristotle referred to the size of the earth and said that its circumference is 400,000 stades,[8] it may be fitting (for the benefit of those who mistrust the wisdom of the ancients) to add a short description of the measuring method: taking by dioptra two fixed stars distanced from each other by one degree, which is one 360th of the greatest circle in the fixed sphere, they [i.e. the ancients] located the places, at which the two stars culminated, by dioptra, while taking two stars one degree apart, they measured the line they subtended on earth by hodometer, and found it to be a distance of 500 stades. It follows that the greatest circle on earth has a circumference of 180,000 stades, as Ptolemy reckoned in this *Geography*.

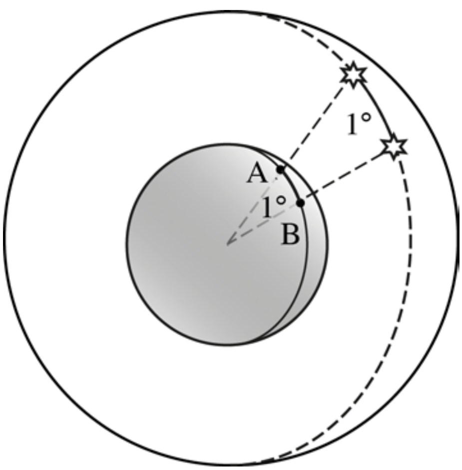

Figure 1.[9] Special case of the zenith star method: one star culminates at the zenith of the observation point A, another star at the same time at the zenith of B.
The zenith distance is 1°. Consequently, the distance between A and B on a meridian of the earth is 1°[10]

8 Cf. Arist., *De caelo*, II 14, 298a15.

9 A somewhat rudimentary scheme can already be found in some manuscripts, e.g. in X, S, B, r, n, and g. See Burri 2013, 125-26.

10 Due to the great distance between the observation point on the earth and the sphere of the fixed stars, the angular distance between both stars, measured on the earth's surface can be considered to be equal to a central angle subtending the meridianal arc AB.

The simultaneous culmination of two stars at the zenith at a distance of 1° also defines two locations on earth which are lying 1° apart on the same meridian. Since 1° is the 360th part of a full circle and 1° corresponds to 500 stades, the whole circumference of the Earth amounts to 180,000 stades (360 × 500 stades).

From an astronomical point of view, this third criterion – fixing the distance of the pair of stars to exactly 1 degree – is striking. By choosing a larger distance than 1°, one could achieve a higher precision. In principle, each pair of stars can be used for such a measurement, provided they culminate for the observers at the same time. Perhaps in the short commentary, an intermediate step is omitted and the ideal case of 1° is mentioned for didactic purposes. The adverb συντόμως in Simplicius' text may point to that.

In the next step, we searched for a possible historical background to this special case and tried to identify such a pair of stars. The scenario must fulfil the following preconditions:

- Visibility of the pair of stars in the Greek *oikoumene* in Hellenistic and Imperial times
- Culmination of this pair at the zenith with an angular distance of 1°
- The same right ascension (*rectascension*, α)[11]

We used Ptolemy's star catalogue in his *Almagest* for identifying such a pair of stars. The result is shown in table 1.

Table 1. Pair of stars in Ptolemy's *Almagest* which culminate with approximately 1° in declination

constellation	star number	right ascension (Almagest)	declination (Almagest)	magnitude
ν UMa	31	141;40	42;41	3
ξ UMa	32	141;50	41;45	3
ν Crb	97	208;57	38;47	> 4
ο Crb	98	208;56	37;37	5
ν Lyr	153	271;13	37;30	4
θ Her	154	271;02	36;29	4
ν And	352	358;19	31;16	4
τ And	353	358;33	30;14	4

For any possible combination of pairs or stars (in his *Almagest* Ptolemy lists more than 1,000 visible stars), only four pairs culminate in the ancient Mediterranean under the required preconditions. The best candidates for

11 The same right ascension (α) guarantees that the stars culminate simultaneously on the same celestial meridian. Thus the problem of the synchronous time-keeping is bypassed.

our pair of stars are *ν* and ξ in Ursa maior (the first pair in table 1). They are not only part of the most famous and important constellation, they also have a magnitude of 3 and hence make up the brightest stars among our short list of candidates.

Still our preliminary result is far from convincing. A magnitude of 3 for both stars is insignificant. And while it is true that one star, *ν*, culminates almost exactly at the zenith of Lysimachia, a known observation point in antiquity, the second star, ξ, cannot be assigned to any city to the south of Lysimachia, at least not to any attested in the *Geography* of Ptolemy. Another problem is that *ν* indeed culminated over Lysimachia at the time of Ptolemy, but not at the time of his unknown 'predecessors'. At the time of the Hellenistic astronomer Hipparchus, for example, this condition would not be met.

Hence, we have reached a dead end. None of the four pairs of stars fulfils our criteria properly. This speaks in favor of a thought experiment, i.e. a theoretical or ideal case without a practical or historical background.

But there may be another solution. It is interesting to see that Ptolemy is speaking of zenith points (σημεῖα) and not of zenith stars (ἀστέρες), as Simplicius does. What at first sight looks like a meaningless stylistic variation, proves to be important on closer inspection.

Ptolemy or rather his predecessor was probably thinking not only of the case when two stars culminate at a distance of 1°, but also when a single star culminates, and at an angular distance of 1° relative to the zenith of the observer and at a known place. Using a suitable instrument you can easily observe any distance from the zenith point. In other words: the arc segment, which we need for the measurement, can be marked not only by two different stars, but by one single star. The correct reformulation of the astronomical and historical problem would read as follows: find a bright star, which culminates at an angular distance of 1° relative to the zenith of a prominent observation point of the Greek *oikoumene*.

We have used the case of an angular value of 1° to respect the special condition mentioned in the text of Simplicius.[12] As prominent sites we tried Lysimachia, Rhodes, Alexandria and Syene, since these are attested for ancient astronomers who were concerned with the measurement of the Earth. Of the more than 1,000 stars in Ptolemy's catalogue, we considered only those with a brightness of 3 or higher. Our search for a suitable candidate yields a better result now.

12 Using a larger value would produce more alternatives, of course.

Table 2. The single star in Ptolemy's *Almagest*, which fulfils all the required preconditions

constellation	star name	right ascension (Almagest)	declination (Almagest)	magnitude
β Gem	Pollux	86;10	30;03	1.16

At the time of both Ptolemy and Hipparchus one of the brightest and most significant stars culminated at a zenith distance of almost exactly 1° to the south of Alexandria. This is the brightest star of the constellation *Gemini*: the giant star called Pollux.[13]

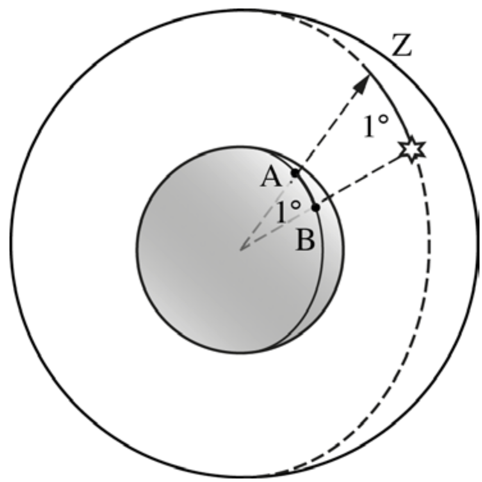

Figure 2. Observation of a zenith star, alternative interpretation. Pollux was culminating with almost exactly 1° zenith distance from Alexandria at the time of Ptolemy and was at the zenith over a location 111 km to the south

To sum up: of all ancient attempts to determine the measurement of the earth, the zenith star method is the easiest and most reliable one. In all likelihood, the observation was not made with a pair of stars which culminated at the zenith at the same time, but rather with one single star, the culmination distance of which was measured from the zenith. That this distance should be exactly 1°, was not only a didactic or theoretical requirement, but rather a historical one. The observation procedure utilized the fact that 1° to the south of Alexandria the bright star Pollux culminated at the zenith. The terrestrial distance of 500 stades (ca. 110 km) between the two points then results in the circumference of the earth being of 180,000 stades.[14]

13 For the constellation *Gemini* in Antiquity, see, e.g., Ross 2015, Zucker 2016, 188-91.

14 The procedure is comparable, *paris passibus*, with the famous measurement of al-Mahmun.

4 Hipparchus as Inventor of the Zenith Star Method?

One last question remains: who was the ingenious forerunner of Ptolemy who invented this method?

An answer to this question is provided by the vastly neglected scholium to *Geography* 1.3.3 to which we alluded in our introduction.[15] The crucial passage reads as follows:[16]

> †Πολλάκις γάρ εἰσι τόποι καὶ ὡς ἐπὶ τὸ πλεῖστον μὴ ἐπ' εὐθείας καὶ ἀδυνάτου περιπίπτειν†.[17] ἐπὶ δὲ κύκλου τμήματος δυνατόν ἐστιν εἰπεῖν, τὸ μεταξὺ διάστημα τίνα λόγον ἔχει πρὸς τὸν ἐν αὐτῇ γραφόμενον μέγιστον κύκλον. Τοὺς γὰρ κατὰ κορυφὴν ὄντας, καθὼς ἐμαρτυρήθη Ἱππάρχῳ καὶ αὐτῷ Πτολεμαίῳ, λαμβάνοντες καὶ τὰς μεταξὺ διαστάσεις ὅσων εἰσὶ μοιρῶν, εὑρήσομεν, τίνα λόγον ἔχει πρὸς τὸν μέγιστον κύκλον. ὁμοίως καὶ ἐπὶ τῆς γῆς· ὁμοίας γὰρ περιφερείας περιέξουσιν ὅ τε τῶν οὐρανίων κύκλος καὶ ὁ ἐν τῇ γῇ γραφόμενος.[18] ἔστω γὰρ[19] κύκλος ὁ αβ τῶν οὐρανίων καὶ ὁ ἐν τῇ γῇ γδ, οἱ δὲ δοθέντες τόποι εζ, οἱ δὲ κατὰ κορυφὴν οἱ[20] ηθ, ὧν σημεῖα εὑρήσομεν, ἐὰν ζεύξωμεν[21] εἰς τὸ ἑξῆς τὴν καταγραφὴν τοῦ κύκλου. Εὑρόντες γὰρ τὴν πρὸς ἀλλήλους διάστασιν[22] τῶν ἀστέρων διὰ τοῦ μετεωροσκόπου πόσας μοίρας ἀφεστήκασιν, ἕξομεν καὶ ἐν σταδίοις πόσον ἀφεστήκασιν.[23] Ἐν γὰρ τοῖς δοθεῖσι τόποις γενόμενοι, καὶ λαβόντες τὰ κατὰ κορυφὴν διὰ τοῦ ὀργάνου, εὑρήσομεν κἀν τῇ γῇ τὸ αὐτὸ διάστημα ἀπέχοντας, ὅσον καὶ ἡ ὑποκειμένη ἑκάστη μοῖρα ἔχει τὸν σταδιασμόν, καὶ οὐκ ἔστι χρεία ποιεῖν τὸν λόγον πρὸς τὴν περίμετρον τῆς ὅλης γῆς· τοῦτο δὲ ἔσται, ἐὰν καὶ μὴ ἐπ' εὐθείας καὶ ἰθυτενὴς ᾖ ἡ ὁδὸς ἡ δοθεῖσα.

15 We do not know much about the provenance of this scholium, usually referred to as 'Nobbe 3'. It is transmitted, e.g., in mss. D (BNF, Paris. gr. 1402, mid-15th century) and f (BNF, Paris. Coisl. 337, early 14th century). According to Burri (2013, 350), the scholia in ms. f are written "vielleicht von einem wohl zeitgenössischen gebildeten Leser".

16 We give the Greek text as printed by Nobbe, with some corrections and additions based on inspection of ms. f, fols 1*v*-2*r*. Vasileios Tsiotras is currently working on an edition of the scholia vetera to Ptolemy´s *Geography*. Our translation is in part based on Lewis' (2001, 334) incomplete one. We thank Filippomaria Pontani for some suggestions.

17 This sentence is clearly corrupt.

18 κύκλος *add f.*

19 γὰρ *om. f.*

20 οἱ *om. f.*

21 ζεύξαντες *f.*

22 διάστασιν *scripsimus*, *om. Nobbe*, τιήστ (?) *f.*

23 ἕξομεν … ἀφεστήκασιν *om. f.*

> †For sure, there are often *topoi* and most times they do not work by way of straight demonstration or reduction to the absurd†. For the segment of a circle it is possible to say what proportion the distance between [two points] has in regard to the greatest circle drawn on it [the earth]. If, as Hipparchus and Ptolemy himself bear witness, we take stars at the zenith and the distance between them in degrees, we will find what proportion it is of the greatest circle. The proportion will also be the same on the earth, for the circle of the heavens and the circle drawn on the earth have the same circumferences. Let AB be a circle of the heavens and GD one on earth, and EZ be the given places, and HT be the points at the zenith whose positions we will find if we project [the radii through E and Z] to the line of the circle. Now, having discovered with the meteoroscope the distance in degrees between the stars, we will also know the [distance] in stades. If we stand at the given places and with the instrument take the stars at the zenith, we will also find that the distance on earth between them is the same according to the number of stades pertaining to each terrestrial degree. There is no need to relate this figure to the circumference of the whole earth and this will be true even if the given journey is not straight and direct.

In this paragraph Hipparchus is mentioned next to Ptolemy in connection to the zenith star method. Is he our wanted astronomer? As tantalizing as such an idea may appear, there are some serious objections to it.

1. If Hipparchus was meant, Ptolemy would surely have stated this. In fact, he mentioned him shortly afterwards in the next chapter – not for the zenith star method but for a list of latitudes.
2. The method described in the scholium mentions stars, thus changing – or rather simplifying – the original argument.
3. The final statement of the scholium (from καὶ οὐκ to δοθεῖσα) is wrong from a mathematical point of view. It contradicts the earlier sentence “For having discovered with meteoroscope the distance in degrees between the stars, we will also know the distance in stades”. In other words: it is possible to measure the circumference of the earth, but only if you know the relation between degree and stades *beforehand*. The author is simply paraphrasing a passage of Ptolemy here.[24] Such a misunderstanding cannot be attributed to a mathematical and astronomical genius of Hipparchus’ caliber.
4. The fourth, and most important, argument is that the result of the zenith star method ends up with a circumference of 180,000 stades.

24 Ptol. *Geogr.* 1, 3, 5: Διὰ δὲ λοιπὸν καὶ τοὺς τῶν ἄλλων χωρὶς ἀναμετρήσεως, κἂν μὴ δι’ ὅλων ἰθυτενεῖς μηδ’ ὑπὸ τὸν αὐτὸν μεσημβρινὸν ἢ παράλληλον (…) Διὰ γὰρ τοῦ λόγου πάλιν τῆς ὑποτεινούσης τὴν διάστασιν περιφερείας πρὸς τὸν μέγιστον κύκλον καὶ τὸ τῶν σταδίων πλῆθος ἀπὸ τοῦ κατειλημμένου τῆς ὅλης περιμέτρου προχείρως ἔνεστιν ἐπιλογίζεσθαι.

> But we know from several other sources that Hipparchus himself subscribed to Eratosthenes' method which resulted in 250,000 or 252,000 stades.[25]

The author of the scholium clearly mixed up some information he found scattered in and next to Ptolemy's text. We have already mentioned the name-dropping of Hipparchus and the ill-fitting quote of Ptolemy. Another hint is the mention of the meteoroscope for the zenith star method: that instrument was invented by Ptolemy himself[26] and was therefore unavailable to his 'predecessors'. In other words: there is no evidence that the author of the scholium had access to external evidence for this method.

Thus, we must conclude with a positive and negative result. While we have shed some light on the zenith star method mentioned by Ptolemy, we are unable to attach it to any known astronomer from Alexandria between the time of Hipparchus and that of Ptolemy.[27]

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25 Strab. 1, 4, 1, C 62; 2, 6, 7, C 113; 2, 5, 34, C 131-32; Ptol. *Synt.* 1, 67, 22; Theo Alex. *Comm.* (2, 528 Rome) (= fr. 35; 36; 39; 41 Dicks), but see Plin. *Nat.* 2, 108 (= fr. 38 Dicks).

26 Ptol. *Geogr.* 1, 3, 3: παρεστήσαμεν ἡμεῖς διὰ κατασκευῆς ὀργάνου μετεωροσκοπικοῦ. For the meteoroscope, see Rome 1927.

27 Since astronomers before Hipparchus and Hypsicles segmented the full circle into "sixtieths", the wanted predecessor belongs in all probability to the 1st century BC or AD. Posidonius is ruled out by Lewis 2001, 40. Aujac's (1993, 313) claim that the procedure is similar to that of Eratosthenes is to be taken with a pinch of salt.

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