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The Language of Astronomy

Abstract: In this preliminary survey of the terminology of Greek astronomy, I have focused on the terms used to name the different circles of the celestial sphere, as well as on stellar positions and their phases. The analysis shows how Greek terminology is very effective at describing many phenomena as seen by an observer on the Earth – possibly even more precise (or clear) than modern analogues. In fact, even when the latter are derived from the Greek, they have lost the richness of their etymological primary meaning, which is important to understand the astronomical phenomena they express. The nomenclature of star phases also shows the development of a complete set of technical terminology for one specific field, which we can trace from the Hellenistic period until Ptolemy, who systematizes it and gives it consistency and order.

The technical terminology of Greek astronomy is fascinating and rich – yet no studies of it exist except some short discussions within the introductions of some foundational texts.[1] Starting from these studies and using my own work on astronomical texts, I will here provide a preliminary survey of some important features of this technical language. I will limit most of the analysis to the description of the celestial sphere, to star positions and phases since covering other fields like planetary motions or astrology would go beyond the scope of this chapter.[2] Yet, as I will show with some ad hoc examples, some technical terms used for the fixed stars apply to the planets as well.

The Greeks considered astronomy to be a branch of mathematics; in fact, an astronomer (*astronomos* (ἀστρονόμος) but also *astrologos* (ἀστρολόγος)) could also be called *mathēmatikos* (μαθηματικός).[3] Indeed, Greek astronomers modeled the sky geometrically on the idea of the celestial sphere on which all the heavenly bodies move, and their astronomy, which is mostly concerned with the motions of the celestial bodies, is to a large extent spherical geometry. Therefore, some of their prose is very similar to Euclid's *Elements* but applied to the sphere (e.g., Euclid's *Phaenomena*, Autolycus' *On the Movement*

1 See for example, Toomer 1984, 17–24; Evans & Berggren 2006, 68–72, 140–145, 291–299. A very good discussion of some key astronomical terms is offered by Jones 2016, 481–486, who also provides an exemplary translation of a passage of Theon's *The Mathematics Useful for Reading Plato*, in which he attempts to translate the text without 'modernizing' the ancient terminology using modern astronomical counterparts (which, for example, Toomer does in his translation of the *Almagest*).

2 For some discussion of the language of astronomical papyri, mostly horoscopes, see Jones 1999, 1, 9–11, 61–63. For a glossary of terms used in horoscopes, see Neugebauer & Van Hoesen 1959, 2–13.

3 In fact, Ptolemy only uses *mathēmatikos* and never *astronomos* or *astrologos*.

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of the Sphere, and parts of Ptolemy's *Almagest*). Yet astronomy is also concerned with the 'appearances' or 'visible phenomena' (*ta phainomena* (τὰ φαινόμενα)), which means that astronomical texts often also have a strong descriptive component. For this component, as well as for the new concepts introduced by different astronomers, terminology is very important and rich in Greek astronomy.

The names of the Greek constellations are traditional. Those of some stars and constellations are already attested in Homer and Hesiod: the Pleiades (*Iliad* 18.486, *Odyssey* 5.272; Hesiod *Works and Days* 383, 572), the Hyades (*Il.* 18.486), Orion (*Il.* 18.486, 488, *Od.* 5.274, *WD* 609), the Great Bear or Wagon (*Il.* 18.487, *Od.* 5.273), Boötes (*Od.* 5.272), the stars Sirius (*WD* 609), also called the 'dog of Orion' (*Il.* 22.29–30), and Arcturus (*WD* 566, 610). The most complete and ancient list of constellations is offered by Aratus, whose poem *Phaenomena* (based on the work of the astronomer Eudoxus) is the first description of constellations in the Greek world. The list became traditional and these names standard, as they were 'canonized' in Ptolemy's Catalogue of Stars (in books 7 and 8 of the *Almagest*) and transmitted by the Islamic astronomers to the modern world. Precisely because they are not 'technical' terms, I will not discuss constellation names here;[4] rather, I will focus on how Greek astronomers built a technical terminology around stars and their motions in the celestial sphere.

1 Naming the Celestial Sphere

The celestial sphere is an innovation of Greek astronomy, since the Babylonians never conceived of the cosmos in geometrical terms and their astronomy was mostly based on arithmetical computations and observations. For the Greeks, however, the cosmos is a sphere with the Earth at its center. Euclid's *Phaenomena* describes the celestial sphere and all the main circles upon it (Fig. 1). To a large extent, we still use the same model. Yet an analysis of the Greek words used to describe the celestial circles will highlight some additional features of the Greek conception of the celestial sphere as well as underscore some interesting differences with modern terminology.

4 For a discussion of the traditional names of Greek constellations, see Schironi (forthcoming), Chapter 9.

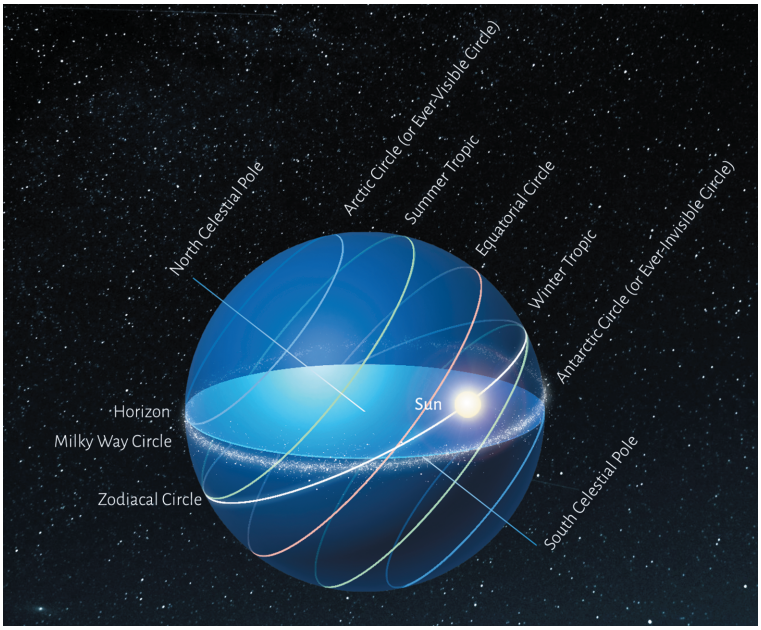

Fig. 1: The Main Celestial Circles – except the South Meridian and the Colures.

Some of the names of these circles are clearly derived from what an observer on the Earth perceives. One is the 'horizon' (*ho horizōn* (*kuklos*) (ὁ ὁρίζων (κύκλος))), the circle that 'delimits' (*horizein* (ὁρίζειν)) the visible and invisible parts of the cosmos. Furthermore, for an observer on the Earth there is a portion of the sky that is always visible and one which is never visible. The Greeks call these 'the ever-visible circle' (*ho aei phaneros kuklos* (ὁ ἀεὶ φανερὸς κύκλος)) or 'arctic' circle (*ho arktikos kuklos* (ὁ ἀρκτικὸς κύκλος)) and 'the ever-invisible circle' (*ho aei aphanēs kuklos* (ὁ ἀεὶ ἀφανὴς κύκλος)) or 'antarctic' circle (*ho antarktikos kuklos* (ὁ ἀνταρκτικὸς κύκλος))[5] – since of course the Greek point of observation is the northern hemisphere. In modern translations, they are often rendered with 'Arctic Circle' and 'Antarctic Circle'. However, this is not strictly correct. For the Greeks these circles, just like the horizon, were firmly connected with the observer and changed according to the position of the latter (assumed to be in the northern hemisphere). In addition, these circles were imaginary circles on the celestial sphere; they delimited the area of circumpolar stars that never set and the area in the southern hemisphere where stars are never visible for someone in the northern hemisphere. Indeed, one of the first phenomena that an observer on the Earth notices is that some stars are always visible in the sky, and that they trace circular orbits. The Greeks

5 For example, Hipparchus mostly uses ὁ ἀεὶ φανερὸς κύκλος and ὁ ἀεὶ ἀφανὴς κύκλος while Geminus (*Isagoge* 5.2 and 5.9) speaks of ὁ ἀρκτικὸς κύκλος and ὁ ἀνταρκτικὸς κύκλος.

noted this phenomenon (which led Aristotle to say that circular movement is typical of the heavens) and named those circles after it. On the contrary, the modern 'Arctic Circle' and 'Antarctic Circle' are actually imaginary circles on the surface of the Earth: in particular, the Arctic Circle is located at +66°33′ and the Antarctic Circle at −66°33′. In other words, these circles are measured relatively to their distance from the terrestrial equator and, most importantly, are fixed and do not depend on the location of the observer, since they delimit the zones in the northern (Arctic) and southern (Antarctic) hemispheres in which, at certain times of the year, there is no day or no night. Yet the modern names do not reflect this definition: 'arctic' and 'antarctic' are borrowed from the Greek (*arktikos* (ἀρκτικός)) and *antarktikos* (ἀνταρκτικός)), but the Greeks used the terms for a different concept and named them according to their supposed proximity to the Great 'Bear' (*arktos* (ἄρκτος) in Greek), i.e., close to the north celestial pole, or in opposition (*anti-* (ἀντι-)) to it.

Another name derived from the observer's perception concerns the only circle really visible in the celestial sphere: the Milky Way, which appears as a whitish luminescent strip in the sky. In Greek, it is called *ho galaxiou kuklos* (ὁ γαλαξίου κύκλος) or *ho galaxias* (ὁ γαλαξίας), from *gala* (γάλα), 'milk'. Interestingly, modern terminology loaned the word but gave it a different meaning. In fact, the Greeks, who could only see this single whitish strip, simply named it 'Milky Way' or *Galaxias*. Modern astronomers borrowed the term but changed its meaning after better understanding the physical phenomenon. They realized that the Milky Way is the stellar conglomerate hosting our solar system and extended this name generically to refer to any similar conglomerate in the universe (the galaxies), giving each either its own identifier (e.g., NGC 224 or M 31 according to the catalogue) and in a few cases its own name (e.g., the Andromeda galaxy).

Other celestial circles are connected with other observable phenomena: the time passing on the Earth and the Sun's motions in the sky. The celestial equator is *ho isēmerinos (kuklos)* (ὁ ἰσημερινός (κύκλος)), literally meaning '(the circle) with days of equal duration' or 'equinoctial (circle)'. Ptolemy himself explains the etymological reason for this name:

> *Syntaxis* 1.8. (vol. 1,1, 26.19–23 Heiberg): ὁ μέγιστος κύκλος ἰσημερινὸς καλεῖται διὰ τὸ μόνον αὐτὸν ὑπὸ μεγίστου ὄντος τοῦ ὁρίζοντος δίχα πάντοτε διαιρεῖσθαι καὶ τὴν κατ' αὐτὸν γιγνομένην τοῦ ἡλίου περιστροφὴν ἰσημερίαν πρὸς αἴσθησιν πανταχοῦ ποιεῖν.
>
> [Of the parallel circles on the celestial sphere] the greatest circle is called 'equinoctial' because it is the only one to be always divided in half by the horizon, which is a great circle, and because the course of the Sun along it always produces 'an equinox' to our perception.[6]

The equator is the only one of the parallel circles (i.e., the circles lying on planes perpendicular to the Earth's rotation axis) which is also a great circle, such that it is al-

6 All translations are mine unless otherwise noted.

ways cut into two equal parts by the horizon (another great circle). In addition, the equator includes the equinoxes or equinoctial points (*isēmerina sēmeia* (ἰσημερινὰ σημεῖα)), which are the points where the equator intersects the ecliptic. They are temporally significant because, as Ptolemy says, when the Sun is on those points, the length of the day is equal to the length of the night. Indeed, *isēmeria* (ἰσημερία) is the 'equinox', which is the 24 h period in which night and day are of equal length.[7] The adjective *isēmerinos* (ἰσημερινός), 'equinoctial', is also often used in connection with time, rather than space – this is the case with *isēmerinai hōrai* (ἰσημεριναὶ ὧραι), 'the equinoctial hours', which are the hours of 60 min each as opposed to the 'seasonal hours' (*kairikai hōrai* (καιρικαὶ ὧραι)).[8] What seems at first to be an ambiguity between 'equator' and 'equinox' in fact demonstrates the way in which Greek terminology connects the place on the sphere (the celestial equator) with its important function regarding time. On the contrary, the modern terminology, which derives from the Latin equivalents, *aequator* and *aequinoctium* (the latter from *aequus* and *nox*), keeps the two ideas distinct, concealing the astronomical connection between the Sun's trajectory and its important function in terms of time on the Earth.

Another important circle on the celestial sphere is the tropic, *ho tropikos* (*kuklos*) (ὁ τροπικὸς (κύκλος)), the point at which the Sun 'turns' (*trepetai* (τρέπεται)) its course.[9] There are two tropics: *ho therinos tropikos kuklos* (ὁ θερινὸς τροπικὸς κύκλος), the 'summer tropic circle', which we call the Tropic of Cancer because the sign of Cancer lies on it, and *ho kheimerinos tropikos kuklos* (ὁ χειμερινὸς τροπικὸς κύκλος), the 'winter tropic circle', which we call the Tropic of Capricorn, because the sign of Capricorn lies on it. Just as in the case of the equator, the Greek names connect these circles on the celestial sphere with a time in the year: the two tropics are linguistically connected with the solstices, the *therinē tropē* (θερινὴ τροπή), 'summer solstice', and the *kheimerinē tropē* (χειμερινὴ τροπή), the 'winter solstice', which occur when the Sun is on the solstitial points (*tropika sēmeia*, τροπικὰ σημεῖα), that is, the points at which the ecliptic, which is slanted with respect to the celestial equator, reaches its maximum or minimum declination. These points mark the beginning of

7 As Geminus clarifies there are two meanings of 'day': *Isag.* 6.1 Ἡμέρα λέγεται διχῶς, καθ' ἕνα μὲν τρόπον χρόνος ὁ ἀπ' ἀνατολῆς ἡλίου μέχρι δύσεως, καθ' ἕτερον δὲ τρόπον ἡμέρα λέγεται χρόνος ὁ ἀφ' ἡλίου ἀνατολῆς μέχρις ἡλίου ἀνατολῆς (the word 'day' is used in two ways: in one way, [it is used for] the time from the rising of the Sun to its setting; in the other way, 'day' is used for the time from the Sun's rising until the [next] Sun's rising).

8 The latter are a twelfth part of a day or a night, independent from the time of the year. As such they were hours of unequal length. They were commonly used in Greece. In the Hellenistic period, 'equinoctial' hours were introduced for astronomical calculations, becoming the standard for Greek mathematical astronomers.

9 As Geminus clearly says: *Isag.* 5.5 Μετὰ μέντοι γε τὴν θερινὴν τροπὴν οὐκέτι πρὸς τὰς ἄρκτους παροδεύων ὁ ἥλιος θεωρεῖται, ἀλλ' ἐπὶ τὰ ἕτερα μέρη τρέπεται τοῦ κόσμου, διὸ καὶ κέκληται τροπικός (after the summer solstice the Sun is not seen proceeding any longer toward the north but it turns toward the other part of the cosmos, and for this reason it has been called 'tropic').

the signs of Cancer (northernmost declination) and of Capricorn (southernmost declination). Just like the previous case, the modern terminology blurs this distinction. 'Solstice' is derived from the Latin *solstitium*, from *sol*, 'sun', and the verbal root of *sistere*, which means 'to stand still' (as the Sun 'stands still' at the tropics just before 'turning'); yet in English (as well as in other modern languages with similarly Latin-derived terms), this sense is lost, as well as the connection between the longest or shortest day of the year and the Sun's position in the sky.

To conclude, while Greek terminology makes it easier to connect the celestial sphere and the Sun's motion in it with what occurs on the Earth in terms of seasonal changes, this connection is far less evident in modern terminology, where the 'tropics' and the 'equator' both refer to circles in the celestial sphere and on the Earth, and 'equinoxes' and 'solstices' no longer linguistically connect these times in the year to the positions of the Sun on those circles.

Another name that connects what we see from the Earth to the path of the Sun is *ho mesēmbrinos* (ὁ μεσημβρινός (κύκλος)), 'the meridian'. In this case, the modern terminology is close to the ancient one but, again, far less precise: in Greek, μεσημβρινός is the standard word for 'midday'; hence, it indicates the south meridian because in the northern hemisphere this is where the Sun reaches the highest point in its daily path (i.e., culminates).[10] Yet, because of this reason, μεσημβρινός can also indicate 'south', as we will see below. As a consequence, unlike in modern astronomy, there is only one 'meridian' in Greek that changes with the observer, but always points at south/midday. Any other 'meridian' is simply called 'the circle [traced] through the poles' (*ho dia tōn polōn [graphomenos] kuklos* (ὁ διὰ τῶν πόλων [γραφόμενος] κύκλος)) by Hipparchus and Ptolemy. There are only two more specific meridians: the colures (*kolouroi* (κόλουροι)). The solstitial colure passes through the poles and the solstitial points, and the equinoctial colure passes through the poles and the equinoctial points. They bear the name κόλουροι – 'with a cut tail' (κόλος + οὐρά) – because their respective segments located around the antarctic circle are always hidden.[11]

Similar is the case with the other great circle, the ecliptic. It has a Greek-sounding name which derives from the word 'eclipse', since eclipses occur near it. This is so because, from the point of view of an observer on the Earth, the ecliptic path is that which the Sun travels relative to the fixed stars; the Moon too moves along this path

10 Gem. *Isag*. 5.64 Μεσημβρινὸς δέ ἐστι κύκλος ὁ διὰ τῶν τοῦ κόσμου πόλων καὶ τοῦ κατὰ κορυφὴν σημείου γραφόμενος κύκλος, ἐφ' οὗ γενόμενος ὁ ἥλιος τὰ μέσα τῶν ἡμερῶν καὶ τὰ μέσα τῶν νυκτῶν ποιεῖται (the meridian circle is the circle traced through the poles of the cosmos and through the zenith point; when it comes upon it, the Sun marks the middle of the days and the middle of the nights).
11 Achilles, *Isag*. 27.3 κόλουροι δὲ κέκληνται διότι δοκοῦσιν ἡμῖν κεκολοῦσθαι ὥσπερ τὰς οὐρὰς διὰ τὸ ἡμῖν μὴ φαίνεσθαι αὐτῶν τὰ ἀπὸ ἀνταρκτικοῦ καὶ ἀεὶ ἀφανοῦς κύκλου καὶ δοκεῖν κεκολοῦσθαι αὐτοὺς κατὰ τοῦτο τὸ μέρος· (They have been called colures because they seem to us to have been 'cut' [*kekolousthai*] like 'tails' [*ourai*] because their parts from the antarctic and ever-invisible circle are not visible to us and they seem to have been cut [*kekolousthai*] at this part) (trans. Aratus Project: https://aratus.classics.lsa.umich.edu/).

(with a deviation of around 5° relative to the orbital plane of the Earth around the Sun); because of this, we can only see eclipses of the Moon or of the Sun along this path. However, the term 'ecliptic' is almost never used by Greek astronomers,[12] who use 'zodiacal [circle]' (*ho zōdiakos* [*kuklos*] (ὁ ζῳδιακὸς [κύκλος])) or circle through the middle of the 'zodiacal signs' (*ho dia mesōn tōn zōdiōn kuklos* (ὁ διὰ μέσων τῶν ζῳδίων κύκλος)). Indeed, in the night the ecliptic is marked by the zodiacal constellations and this is how the ancients could identify it in the sky – hence it is a much more natural way to denote this circle than our 'ecliptic', which requires some in-depth knowledge of astronomy to understand what it is.

2 Naming Star Motions

Most of Greek astronomy is concerned with tracking the positions of the heavenly bodies in the sky. Most often this means expressing the relative position of a heavenly body with respect to one specific point. We are used to spherical coordinates and above all to cardinal points to place objects in spheres, specifically on the Earth and on the celestial sphere. This is the result of the many efforts of Greek astronomers to define 'points of reference' on the sky in order to measure the celestial bodies' paths in it. Still, there are important differences between our terminology and the Greek terminology when discussing directions and motions in the sky.

2.1 Positions of Stars as Viewed from the Earth

The Greeks had two ways of naming cardinal points, either with respect to the winds or with celestial phenomena. In the latter system, North is called *arktos* (ἄρκτος), which means 'bear' and, more specifically, the Ursa Major. We have to remember that at the time there was no Polaris to indicate the north, while the Great Bear is a very recognizable constellation close to the northern celestial pole. All other directions are connected with the Sun. East and west are, respectively, *anatolē* (ἀνατολή), the place of the 'rising' of the Sun, and *dusis* (δύσις) or *dusmē* (δυσμή), the place of the 'setting' of the Sun, while south is *mesēmbria* (μεσημβρία), 'noon', where the Sun can be seen at midday when it culminates. Of course, since μεσημβρία, ἀνατολή and δύσις also (and primarily) indicate the positions of the Sun, sometimes this can create confusion in translating an astronomical text. On the other hand, this system makes it very easy

12 The term 'ecliptic' occurs only once in Achilles who in his *Isagoge* says: 23.2 διὸ καὶ ἡλιακὸς ὑπὸ τῶν ταῦτα δεινῶν προσηγόρευται καὶ ἐκλειπτικός, ἐπειδὴ ἐν αὐτῶι αἱ ἡλιακαὶ ἐκλείψεις γίνονται (Therefore it has been called both the heliacal [i.e. the 'Sun's'] and ecliptic [circle] by those who are experts in these things, since the heliacal [i.e. solar] eclipses occur on it) (trans. Aratus Project).

for a user to orientate himself according to the Sun. Just like with the circles of the celestial sphere, Greek terminology exploits specific phenomena which we can all perceive to indicate points in space. These four terms are the standard in Greek to indicate directions; yet they are also used by astronomers.

Another option is using wind directions; however, in this case, the terminology seems to be less standardized. North and south are indicated by the winds that come from those directions: north is *boreas* or *borras* (βορέας or βορρᾶς) and south is *notos* (νότος). In fact, while Notos is the wind from the south, Boreas is sometimes considered a wind from the north and sometimes from north-east.[13] On the other hand, the two names for east and west vary. In Aratus (*Phaen.* 933–934), for example, east is Euros, properly a wind from south-east, and west is Zephyrus, the wind from west.[14] However, geographers and astronomers also use *apēliōtēs* (ἀπηλιώτης) for east and *lips* (λίψ) for west. Among astronomical texts, the use of νότος, βορέας, ἀπηλιώτης, and λίψ to indicate the four cardinal points is found in the so-called *Ars Eudoxi* or Leptines papyrus (P.Par.1 = Paris, Louvre N 2388 Ro, and Louvre N 2329 Ro). The papyrus, dated to the second half of the second century BCE, contains a rather basic introduction to several astronomical concepts; in cols. i.9-ii.25 and xxi.6–14 these four winds are used with reference to the yearly journey of the Sun. Ptolemy most often uses βορέας for north, νότος for south, ἀνατολή for east, and δύσις or δυσμή for west. However, he uses ἀπηλιώτης and λίψ for east and west in a passage which we will analyze below. The noun ἀπηλιώτης is a compound from ἀπό and ἡλιώτης, which is the region of the Sun (*hēlios* (ἥλιος)), i.e., the east – so, in a way it becomes a synonym of ἀνατολή. The noun λίψ is derived from λείβω, 'to drip', and indicates the 'rainy wind' from south-west.[15] In fact, Ps.-Aristotle says that the name λίψ derives from Libya from where the wind blows.[16] If this is right, then, since Ptolemy is writing at

13 For example, in Aristotle, Boreas is from the north (see Bowen 2020, 2) but in Ptolemy's *Geography* it is from north-north-east (see Berggren & Jones 2000, 15).

14 *Phaen.* 933–936: Αὐτὰρ ὅτ' ἐξ εὔροιο καὶ ἐκ νότου ἀστράπτῃσιν, / ἄλλοτε δ' ἐκ ζεφύροιο καὶ ἄλλοτε πὰρ βορέαο, / δὴ τότε τις πελάγει ἔνι δείδιε ναυτίλος ἀνήρ, / μή μιν τῇ μὲν ἔχῃ πέλαγος, τῇ δ' ἐκ Διὸς ὕδωρ (But when it flashes with lightening from the Euros wind and from the Notos wind and sometimes from the Zephyr wind and sometimes from the Boreas wind, then some sailor on the open sea fears that the sea might take him on the one hand or the rain from Zeus on the other).

15 See chart in Berggren & Jones 2000, 15 and Bowen 2020, 3. While in the *Geography* Ptolemy uses δύσις for west, he also states (*Geog.* 1.8.6) Δι' ὧν εἰκὸς ἢ τερατεύσασθαι τοὺς ἄνδρας ἢ τὸ πρὸς μεσημβρίαν οὕτως εἰπεῖν, ὡς εἰώθασιν οἱ ἐπιχώριοι λέγειν εἰς τὸν νότον ἢ εἰς τὸν λίβα, καταχρώμενοι τῷ μᾶλλον ἀντὶ τῆς ἀκριβείας (For these reasons it is likely that [these] men either told travelers' tales or used the expression 'to the south' for 'toward the Notos wind' or 'toward the Lips wind', as the locals tend to talk, misusing the rough [term] in place of the exact) (trans. Berggren & Jones 2000, 68); here it looks as if Ptolemy uses εἰς τὸν λίβα to indicate the south-west and εἰς τὸν νότον to indicate the south, while he considers 'πρὸς μεσημβρίαν' as a less precise term for 'south' in general.

16 Cf. Bowen 2020, 13.

Alexandria, λίψ can indicate the west (and not the south-west).[17] The same location must then be assumed for the author of the *Ars Eudoxi*.

2.2 Positions of Stars as Viewed in the Celestial Sphere

All the terms analyzed above are used when the observer on the Earth is somehow implied, since they depend on the latter's own perception of certain natural phenomena (the Sun's motion in the sky or wind direction). When Greek astronomers wanted to describe the position of a heavenly body and especially a star within the celestial sphere without reference to the observer, they used a different system based on the apparent motion of the Sun and fixed stars in the sky, which is from east to west. For example, to describe positions of stars Hipparchus uses two sets of verbs, most often used as participles:

hēgoumenos (ἡγούμενος) = leading
hepomenos (ἑπόμενος) = trailing

prohēgoumenos (προηγούμενος) = preceding
hupoleipomenos (ὑπολειπόμενος) = remaining behind

While these two sets of verbs only indicate two relative positions ('eastward' for ἑπόμενος and ὑπολειπόμενος, and 'westward' for ἡγούμενος and προηγούμενος), Hipparchus uses them in specific contexts and never as synonyms. He uses ἡγούμενος, 'leading', and ἑπόμενος, 'trailing', when describing a group of stars, often within the same constellation. The stars that 'lead' in a constellation are those on the western part of it; the stars that 'trail' are those in the eastern part of it. In this case, ἡγούμενος and ἑπόμενος are used absolutely. On the other hand, Hipparchus uses προηγούμενος, 'preceding', and ὑπολειπόμενος, 'remaining behind' in a transitive way, taking the local (i.e., south) meridian as its most common (genitive) object. In this case, Hipparchus gives the relative position of a star not within its constellation but rather with respect to its culmination, that is, its crossing of the south meridian. If a star has yet to reach it (so it is ὑπολειπόμενος τοῦ μεσημβρινοῦ), it is still in the eastern part of its nightly path; if it has passed it (so it is προηγούμενος τοῦ μεσημβρινοῦ), it is now in its second, western part of its nightly path. Ptolemy adopts the same system, but since in his catalogue of stars (in Books 7 and 8 of the *Almagest*) he is only concerned with describing the position of stars within their constellation, he never speaks of the position of a star relative to the meridian. Ptolemy generally uses both ἡγούμενος and προηγούμενος (which cor-

17 Cf. Rehm 1916, 62 n. 1. In the passage of the *Geography* quoted above in n. 15 the *Lips* wind indicated the south-west, but there Ptolemy is reporting Marinus' account of Septimius Flaccus' campaign in Ethiopia. Thus, it is possible that *Lips* wind was used in that context in a different sense than in the *Almagest*, where it definitely means west (and this is the only occurrence of *Lips* in the *Geography*).

respond to Hipparchus' ἡγούμενος) and ἑπόμενος (in the sense of Hipparchus' ἑπόμενος). However, he can also say that that a star is προηγούμενος another one (in the genitive, to mean that it precedes it) or ἑπόμενος another one (in the dative, to mean that it is behind it). The same conventions are applied to the planets that move relatively to the stars; hence, the Greeks called the former 'wandering stars', as Geminus puts it (using the same verbs):

> *Isag.* 12.22 (. . .) ἐκεῖνοι γὰρ ὁτὲ μὲν ὑπολείπονται τῶν ἀπλανῶν ἀστέρων, ὁτὲ δὲ προηγοῦνται, ὁτὲ δὲ κατὰ τοὺς αὐτοὺς ἀστέρας μένουσιν, οἳ δὴ καὶ καλοῦνται στηριγμοί.
>
> (. . .) for they [i.e. the wandering stars] sometimes remain behind the fixed stars, sometimes they precede them, and sometimes they stay still with respect to those stars— which are called their 'stations.'[18]

Clearly this system is based on the idea that stars move from east to west on the celestial sphere. In fact, while fixed stars do indeed have fixed positions relative to each other (so that one star will always be 'leading' or 'preceding' with respect to another one), the Greeks perceived them to be constantly moving westward on the celestial sphere. Yet ancient astronomers did not use cardinal points to measure this motion but rather looked at the position of the stars relative either to another or to the south meridian. Therefore, translating these phrases as 'eastward' and 'westward' is a modernization of the original Greek.

3 Describing Celestial Phenomena: Rising, Setting, and Culmination

An observer from the Earth sees celestial bodies rising on the eastern horizon and setting on the western horizon. 'To rise' is *anatellein* (ἀνατέλλειν) and 'to set' is *(kata) dunein* ((κατα)δύνειν). Again, these are standard Greek verbs maintained by Greek astronomers. Yet astronomers were also interested in other aspects of a star's path. In its trajectory in the night sky a star draws an arc from the east, where it rises, to the west, where it sets. In modern terminology, the highest point of this arc is called the 'culmination' or 'transit'. It occurs when the star passes through the local south meridian. In Greek, the verb used to indicate the culmination is *mesouranein* (μεσουρανεῖν),

18 A problem, already noted by Toomer 1984, 20, arises with *proēgēsis* (προήγησις), which he translated as 'retrogradation' (of planets). In Greek it literally means 'motion in advance'. Since for us the natural movement of planets is eastward relative to the fixed stars, when they move westward they seem to us to go backward, hence our 'retrogradation'. For the Greeks, however, the main movement of the sky was the daily revolution of the stars from east to west: hence when the planet goes westward, it 'leads ahead' or moves 'in advance to' the fixed stars; see also Jones 2016, 485.

which means 'to be in the middle of the sky'. This is a more technical term, not because it is a particularly difficult compound to understand but because it is used in a very specific context – yet its meaning is quite transparent per se, while the modern 'culmination' and 'transit' require some more abstract thinking.

4 Star Phases: The Building of a Scientific Terminology

Greek astronomers were particularly interested in tracking the so-called simultaneous risings and settings, that is, when a star rises or sets together with another star, the Sun or even a specific point in the celestial sphere, most often a point on the ecliptic. So, for example, Hipparchus uses ἀνατέλλειν and (κατα)δύνειν for generic rising and setting, but *sunanatellein* (συνανατέλλειν) and *antikataduneιn* (ἀντικαταδύνειν) for a star that 'rises simultaneously with' or 'sets in opposition to' a specific arc of the ecliptic rising.

A specific type of simultaneous rising and setting is the so-called 'stellar phase' – this is the modern terminology but for now I will use the Greek word, *phasis*, for reasons that will become clear in what follows. The Greeks, like many other ancient civilizations, were greatly concerned with the risings of stars as they indicated important moments of the farming seasons. In particular, star *phaseis* are the risings and settings of stars that occur close to sunrise or sunset.[19]

4.1 Autolycus and the Simultaneous Risings and Settings

Because knowledge of stellar *phaseis* was crucial for agricultural practice, Greek astronomers had begun to study the phenomenon from early on. The first treatise we have on the topic is *On Risings and Settings* (Περὶ ἐπιτολῶν καὶ δύσεων) by Autolycus (ca. 320 BCE). In this treatise in two books, Autolycus makes an important distinction between 'true' (*alēthinai* (ἀληθιναί)) and 'visible' (*phainomenai* (φαινόμεναι)) risings (*epitolai* (ἐπιτολαί)) and settings (*duseis* (δύσεις)) (*De ort. et occ.* 1.1). The true risings and settings occur when the stars rise or set at the exact same moment when the Sun is rising or setting. However, due to the brightness of the sky, these 'real' risings and settings are not visible. In order for an observer to see a star rising or setting, the Sun needs to be sufficiently below the horizon. For Autolycus, sufficient meant at least 15° below the horizon along the ecliptic. As a result, the visible risings and settings occur shortly before sunrise or shortly after sunset. Taking into account all these distinc-

19 See Lehoux 2007, 2–12. On star *phaseis* from a more technical point of view, see Neugebauer 1975, 760–763; Evans 1998, 190–199.

tions, for each star we have the following possibilities, each taking place at a different time of the year:

True risings and settings (αἱ ἀληθιναὶ ἐπιτολαί τε καὶ δύσεις)
True morning rising (ἀληθινὴ ἑῴα ἐπιτολή) = star rises at sunrise
True morning setting (ἀληθινὴ ἑῴα δύσις) = star sets at sunrise
True evening rising (ἀληθινὴ ἑσπερία ἐπιτολή) = star rises at sunset
True evening setting (ἀληθινὴ ἑσπερία δύσις) = star sets at sunset
Visible risings and settings (αἱ δὲ φαινόμεναι ἐπιτολαί τε καὶ δύσεις)
Visible morning rising (φαινομένη ἑῴα ἐπιτολή) = star rises before sunrise
Visible morning setting (φαινομένη ἑῴα δύσις) = star sets before sunrise
Visible evening rising (φαινομένη ἑσπερία ἀνατολή) = star rises after sunset
Visible evening setting (φαινομένη ἑσπερία δύσις) = star sets after sunset

The visible risings and settings are those of interest to farmers and sailors because they are the only ones which can be observed with the naked eye. However, Greek astronomers working on a celestial globe could also study the true risings and settings, which are not visible to those who observe the sky. During the year, the visible morning risings and settings occur 15 days after the true morning risings and settings (that is, when the Sun is 15 degrees below the horizon), while the visible evening risings and settings occur 15 days before the true evening risings and settings (that, is, when the Sun, again, is 15 degrees below the horizon). This is due to the Sun's apparent motion on the ecliptic from west to east (due to the orbit of the Earth around the Sun) which is contrary to the apparent motion of the other celestial bodies from east to west (due to the Earth's rotation on its axis). Since the Sun needs to be 15° below the horizon along the ecliptic and the Sun moves ca. 1° per day along the ecliptic, there are 15 days between visible and true risings and settings (see Fig. 2).

4.2 Geminus and the Simultaneous Risings and Settings

A rather intense debate arose among ancient astronomers about how to differentiate between these concepts. It is interesting to analyze it in detail because it shows a specific example of 'terminology' *in fieri* from the late Hellenistic period to Ptolemy. After Autolycus, Geminus makes a distinction between 'generic' risings and 'simultaneous' risings and how they should be expressed:

> *Isag.* 13.2–4 Καὶ ἔστιν ἀνατολὴ μὲν ἡ καθ' ἑκάστην ἡμέραν γινομένη πρὸς τὸν ὁρίζοντα φάσις, δύσις δὲ ἡ καθ' ἑκάστην ἡμέραν γινομένη ὑπὸ τὸν ὁρίζοντα κρύψις. Ἄλλως δὲ λέγονται ἐπιτολαὶ καὶ δύσεις, ἃς ἔνιοι ἀγνοοῦντες κατὰ τὴν αὐτὴν ἔννοιαν ὑπολαμβάνουσι λέγεσθαι. Μεγάλη δέ ἐστι διαφορὰ ἀνατολῆς καὶ ἐπιτολῆς. Ἀνατολὴ μὲν γάρ ἐστιν ἡ προειρημένη, ἐπιτολὴ δὲ ἡ γινομένη πρὸς τὸν ὁρίζοντα φάσις μετὰ τῆς πρὸς τὸν ἥλιον ἀποστάσεως ἀπολαμβανομένη. Ὁ δὲ αὐτὸς λόγος καὶ ἐπὶ τῆς δύσεως· ἄλλως μὲν γὰρ λέγεται δύσις ἡ καθ' ἑκάστην ἡμέραν γινομένη ὑπὸ τὸν ὁρίζοντα κρύψις, ἄλλως δὲ ἡ γινομένη πρός τε τὸν ὁρίζοντα ἅμα καὶ τὸν ἥλιον.

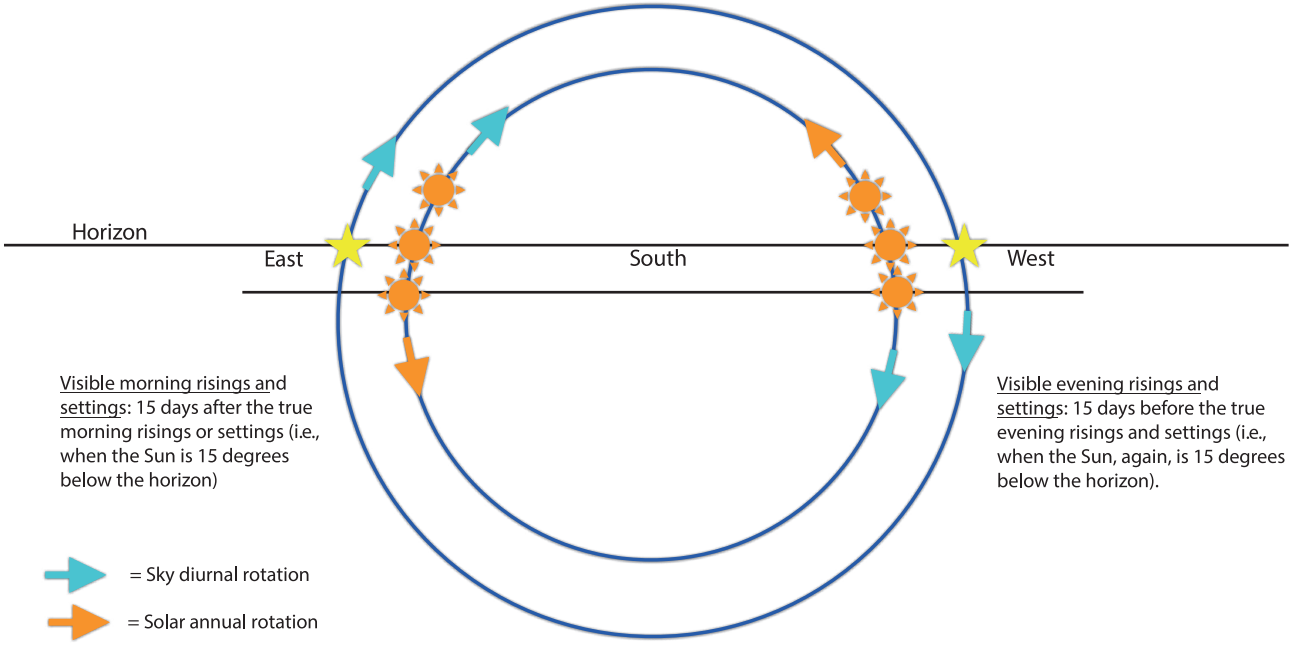

Fig. 2: True Risings and Settings vs. Visible Risings and Settings.

> And 'rising' (*anatolē* (ἀνατολή)) is the 'appearance' (*phasis* (φάσις)) at the horizon that occurs every day; and 'setting' (*dusis* (δύσις)) the 'hiding' (*krupsis* (κρύψις)) below the horizon that occurs every day. In a different sense one speaks of 'risings together' (*epitolai* (ἐπιτολαί)) and settings (δύσεις); yet some, ignoring this distinction, assume that they are used to mean the same concept. But there is a great difference between 'rising' (ἀνατολή) and 'rising together' (ἐπιτολή). For a 'rising' (ἀνατολή) is what has already been defined but a 'rising together' (ἐπιτολή) is an appearance (φάσις) occurring at the horizon in relation to the distance to the Sun. The same account also [applies] to the setting. For the word 'setting' (δύσις) is used for the 'hiding' (κρύψις) below the horizon that occurs every day but otherwise is also the [hiding] that occurs at the horizon together with the Sun.[20]

Geminus makes the distinction between a generic rising of a star, for which he uses the verb *anatellein* (ἀνατέλλειν), 'to rise up', and the noun *anatolē* (ἀνατολή), and a rising connected with the Sun, in which case he uses the verb *epitellein* (ἐπιτέλλειν), 'to rise together', and the noun *epitolē* (ἐπιτολή).[21] He criticizes those who do not make this distinction, which was apparently quite old, since it seems to have already been used by Hesiod in the phrase *Plēiadōn (. . .) epitellomenaōn* (Πληιάδων (. . .) ἐπιτελλομενάων, *WD* 383) to indicate the first visible rising of the Pleiades in May. On the other hand, the setting is not linguistically differentiated – the verb *dunein* (δύνειν), 'to set', and the noun *dusis* (δύσις) are used for both the generic and the simultaneous setting.[22]

4.3 Ptolemy and the Configurations of the Stars

Ptolemy further develops this distinction. In *Almagest* 8.4 he discusses the various 'configurations' (*skhēmatismoi* (σχηματισμοί)) in which stars can be observed with respect to:

1. the planets, Sun and Moon, or the parts of the zodiac alone;
2. the Earth alone;
3. to both the Earth and the planets, the Sun and the Moon, or the parts of the zodiac alone.

The configurations with respect to the planets and the parts of the zodiac (1) mostly concern positions that are important in astrology, so we will not discuss them. In this section, however, Ptolemy gives an important definition concerning the positions of

20 See also *Sch. Arat.* 137 B.

21 On this terminology, see Evans & Berggren 2006, 70–72.

22 The verb ἐπιδύνειν/ἐπιδύειν is used only in late Greek and by Christian or Jewish authors; the noun ἐπίδυσις is not attested. In the rest of the section, Geminus follows Autolycus' distinction between morning and evening risings (*Isag.* 13.5) and between true and visible risings (*Isag.* 13.6). The same distinctions apply to the settings (*Isag.* 13.14–18).

stars relative to the Sun and the Moon. He says (*Synt*. 8.4, vol. 1.2, 186.9–15 Heiberg) that with respect to the Sun and the Moon, we can have the following stellar configurations:

1. 'Hiding' (*krupsis* (κρύψις)), when stars cease to be visible because of the rays of the Sun or Moon;
2. 'Conjunction' (*sunodos* (σύνοδος)), when they are eclipsed by them; and
3. 'Visibility' (*epitolē* (ἐπιτολή)), when they escape their rays and start to become visible.

While κρύψις and σύνοδος are standard terms, Ptolemy uses the term ἐπιτολή, which was previously used by Autolycus and Geminus for any (i.e., true and visible) rising with the Sun, for the *first* visible rising or, better, 'visibility' of a star. With respect to the Earth (2), a star can have four main configurations:

1. Rising (*anatolē* (ἀνατολή))
2. Culmination above the Earth (*mesouranēma huper gēs* (μεσουράνημα ὑπὲρ γῆς))
3. Setting (*dusis* (δύσις))
4. Culmination below the Earth (*mesouranēma hupo gēn* (μεσουράνημα ὑπὸ γῆν))

There are nine configurations of stars with respect to the Sun and the Earth (a subdivision of configuration 3), each divided into subcategories, each with its proper name. They are discussed in detail in *Almagest* 8.4 (1.2, 189.11–193.13 Heiberg).[23] Here I have organized Ptolemy's detailed definitions into a table in order to make his taxonomy easier to grasp:[24]

Configuration (*skhēmatismos* (σχηματισμός))	**Variety (*diaphora* (διαφορά))**
(1) Early easterly position (πρωινὸς ἀπηλιώτης) = the star is on the eastern horizon together with the Sun	Morning invisible later rising (ἑῴα μὴ φαινομένη ἐπανατολή) = the star starting its hiding (κρύψις) rises right after the Sun
	Morning true simultaneous rising (ἑῴα συνανατολὴ ἀληθινή) = the star is on the eastern horizon together with and at the same moment as the Sun
	Morning visible earlier rising (ἑῴα προανατολὴ φαινομένη) = the star starting its visibility (ἐπιτολή) rises right before the Sun

23 Cf. Toomer 1984, 409–410. My translations, however, differ from those of Toomer.

24 What follows in the table is a pretty close translation of Ptolemy's text, hence, the inconsistencies in describing similar moment (e.g., 1(b) and 9(b)). When his phrasing was too convoluted I have added a footnote to explain Ptolemy's precise words.

(continued)

Configuration (*skhēmatismos* (σχηματισμός))	Variety (*diaphora* (διαφορά))
(2) Early culmination (πρωινὸν μεσουράνημα) = the star is on the meridian either above or below the Earth while the Sun is on the eastern horizon	Morning invisible later culmination (ἑῷον ἐπιμεσουράνημα μὴ φαινόμενον) = the star culminates right after the rising of the Sun
	Morning true simultaneous culmination (ἑῷον συμμεσουράνημα ἀληθινόν) = the star culminates together with the rising of the Sun
	Morning earlier culmination (ἑῷον προμεσουράνημα) = the star culminates right before the rising of the Sun;[25] when the star culminates above the Earth, it is visible
(3) Early westerly position (πρωινὸς λίψ) = the star is on the western horizon while the Sun is on the eastern horizon	Morning invisible later setting (ἑῴα ἐπικατάδυσις μὴ φαινομένη) = the star sets right after the rising of the Sun[26]
	Morning true simultaneous setting (ἑῴα συγκατάδυσις ἀληθινή) = the star sets together with the rising of the Sun
	Morning visible earlier setting (ἑῴα πρόδυσις φαινομένη) = the star sets right before the rising of the Sun[27]
(4) Meridian easterly position (μεσημβρινὸς ἀπηλιώτης) = the star is on the eastern horizon while the Sun is on the meridian	Daily invisible [rising] (ἡμερινὸς καὶ μὴ φαινόμενος[28]) = the star rises while the Sun culminates above the Earth
	Nightly visible [rising] (νυκτερινὸν καὶ φαινόμενον[29]) = the star rises while the Sun culminates below the Earth

25 Yet Ptolemy says: "The Sun rises right after the star has culminated."

26 On the reading adopted here, see Toomer 1984, 409, n. 195.

27 Yet Ptolemy says: "The Sun rises right after the star has set"; on the reading adopted here, see Toomer 1984, 409, n. 196.

28 Here Ptolemy uses the masculine singular (ὃ μέν τί ἐστιν ἡμερινὸς καὶ μὴ φαινόμενος), probably assuming a σχηματισμός. I have supplied 'rising' (which would be the feminine ἀνατολή) to make the concept clearer.

29 Here (τὸ δέ τι νυκτερινὸν καὶ φαινόμενον) and in other cases below Ptolemy uses the neuter; it is less clear what he assumes to be the referent; but it might be a generic neuter to indicate the 'position' of the star (e.g., τὸ τοῦ ἀστέρος). I have supplied 'rising' (which would be the feminine ἀνατολή) to make the concept clearer.

(continued)

Configuration (*skhēmatismos* (σχηματισμός))	**Variety (*diaphora* (διαφορά))**
(5) Meridian culmination (μεσημβρινὸν μεσουράνημα) = both the star and the Sun are on the meridian at the same time	Daily and invisible [culminations] (ἡμερινὰ καὶ μὴ φαινόμενα) = while the Sun culminates above the Earth, the star culminates either (1) above the Earth together with it, or (2) below the Earth diametrically opposite to it
	Nightly [culminations] (νυκτερινά) = while the Sun culminates below the Earth, the star culminates either (1) below the Earth together with the Sun, and so it is invisible (τὸ μὲν μὴ φαινόμενον), or (2) above the Earth diametrically opposite to it, and so it is visible (τὸ δὲ φαινόμενον)
(6) Meridian westerly position (μεσημβρινὸς λίψ) = the star is on the western horizon while the Sun is on the meridian	Daily invisible [setting] (ἡμερινὸν καὶ μὴ φαινόμενον) = the star sets while the Sun culminates above the Earth
	Nightly visible [setting] (νυκτερινὸν καὶ φαινόμενον) = the star sets while the Sun culminates below the Earth
(7) Late easterly position (ὀψινὸς ἀπηλιώτης) = the star is on the eastern horizon while the Sun is on the western horizon	Evening visible later rising (ἑσπερία ἐπανατολὴ φαινομένη) = the star rises right after the setting of the Sun
	Evening true simultaneous rising (ἑσπερία συνανατολὴ ἀληθινή) = the star rises together with the setting of the Sun
	Evening invisible earlier rising (ἑσπερία προανατολὴ μὴ φαινομένη) = the star rises right before the setting of the Sun[30]

30 Yet Ptolemy says: "The Sun sets right after the star has risen."

(continued)

Configuration (*skhēmatismos* (σχηματισμός))	Variety (*diaphora* (διαφορά))
(8) Late culmination (ὀψινὸν μεσουράνημα) = the star is on the meridian either above or below the Earth while the Sun is on the western horizon	Evening later culmination (ἑσπερινὸν ἐπιμεσουράνημα) = the star culminates right after the setting of the Sun [it is visible when the star culminates above the Earth[31]]
	Evening true simultaneous culmination (ἑσπερινὸν συμμεσουράνημα ἀληθινόν) = the star culminates together with the setting of the Sun
	Evening invisible earlier culmination (ἑσπερινὸν προμεσουράνημα μὴ φαινόμενον) = the star culminates right before the setting of the Sun[32]
(9) Late westerly position (ὀψινὸς λίψ) = the star is on the western horizon together with the Sun	Evening visible later setting (ἑσπερία ἐπικατάδυσις φαινομένη) = the star starting its hiding (κρύψις) sets right after the Sun
	Evening true simultaneous setting (ἑσπερία συγκατάδυσις ἀληθινή) = the star sets together with and at the same moment as the Sun
	Evening invisible earlier setting (ἑσπερία πρόδυσις μὴ φαινομένη) = the star starting its visibility (ἐπιτολή) sets right before the Sun

In this very specific list of definitions Ptolemy adopts an interesting linguistic strategy. The 'configurations' are organized in nine kinds (*tropoi* (τρόποι)), formed by two terms. One is a noun indicating a position of the star in the sky, which can be *apēliōtēs* (ἀπηλιώτης), 'easterly position' (i.e., the star is rising on the eastern horizon), *mesouranēma* (μεσουράνημα), 'culmination' (i.e., the star is in the middle of the sky, halfway between its rising and setting), or *lips* (λίψ), 'westerly position' (i.e., the star is setting on the western horizon). The other term is an adjective and refers to the Sun; it too focuses on the position of the Sun but does so through the time of the day, rather than with a position in space – but, of course, since the Sun indicates time with its position in the sky, *prōinos* (πρωινός), 'of early morning', *mesēmbrinos* (μεσημβρινός), 'of midday', and *opsinos* (ὀψινός), 'of late evening', also indicate the Sun's position in the sky as seen from the Earth. In particular, μεσημβρινός means both 'midday' and 'midnight' since it refers to the culmination of the Sun on the meridian either above or

31 On this passage and the reading adopted, see Toomer 1984, 410 n. 197.

32 Yet Ptolemy says: "The Sun sets right after the star has culminated."

below the Earth.[33] This combination of noun and adjective identifies a 'configuration' of two heavenly bodies: the noun refers to the star's position and the adjective refers to the Sun's position. In this way, each of the nine 'configurations' is unambiguously defined and quite straightforward to discern.

The same clarity and systematicity in covering every possible phenomenon apply to the 'varieties' (*diaphorai* (διαφοραί)) of these configurations, which are described with three defining terms, a noun and two adjectives. The noun identifies the star phenomenon in relation to the Sun. Starting from the generic terms 'rising' (*anatolē* (ἀνατολή)), 'culmination' (*mesouranēma* (μεσουράνημα)), and 'setting' (*dusis* (δύσις) or *katadusis* (κατάδυσις)), Ptolemy uses prefixes to define additional astronomical concepts that define the position of a star with respect to the Sun:

Before the Sun	**Simultaneous with the Sun**	**After the Sun**
Earlier rising (προανατολή)	Simultaneous rising (συνανατολή)	Later rising (ἐπανατολή)
Earlier culmination (προμεσουράνημα)	Simultaneous culmination (συμμεσουράνημα)	Later culmination (ἐπιμεσουράνημα)
Earlier setting (πρόδυσις)	Simultaneous setting (συγκατάδυσις)	Later setting (ἐπικατάδυσις)

The first prefix in these double compounds has a temporal meaning: *pro-* (προ-) for earlier, *sun* (συν-) for simultaneous, and *epi-* (ἐπι-) for 'later' (in the latter case, then, ἐπί has not the comitative value of the ἐπί in ἐπιτολή, which Ptolemy still uses to indicate the first visible rising of star, as we saw above). Then, one adjective defines the time at which the phenomenon takes place (morning, evening, or night) and the second one clarifies whether the phenomenon is 'true' or 'visible'. In this case, the head noun focuses on the temporal relationship between the positions of the star with respect to the Sun – which is key for star *phaseis*. The two adjectives then specify the time of the event (in absolute terms) and its quality. This complex linguistic *tour de force* thus allows Ptolemy to define and, more importantly, almost to explain these 24 phenomena (i.e., the 24 'varieties') by providing labels that describe the configuration of the star relative to the Sun for each of them. The system is exhaustive, economic, and unambiguous – the goal of any technical terminology.[34]

33 Unfortunately, it is impossible to render this term in English using one specific noun. I have therefore used 'meridian', albeit less transparent than the Greek μεσημβρινός.

34 Cf. Schironi 2019, 245–246. On some characteristics of ancient technical language, see Langslow 2000, 6–26; Fögen 2003; Willi 2003, 51–57. For theoretical studies on (modern) technical language, see Fluck 1996; Roelcke 2020.

4.4 Ptolemy: From Stellar Configurations to Stellar Phaseis

A further refinement of the terminology connected with the stellar *phaseis* is carried out in Ptolemy's *Phaseis*, a work specifically dedicated to the topic. In the introductory chapters, Ptolemy is concerned with the definition of *phasis:*

> *Phaseis* 2, vol. 2, 5.4–17 Heiberg: Φάσιν μὲν δὴ καλοῦμεν ἀπλανοῦς ἀστέρος τὸν πρὸς ἥλιον καὶ τὸν ὁρίζοντα λαμβανόμενον αὐτοῦ σχηματισμὸν τὸν πρῶτον ἢ ἔσχατον τῶν φαινομένων, παρ' ὃ καὶ τοιαύτης ἔτυχε προσηγορίας. τῶν δὲ τοῦτον τὸν τρόπον ὑποτιθεμένων σχηματισμῶν τέσσαρες αἱ γενικώτεραι συνίστανται διαφοραί· τοσαῦται γὰρ θέσεις μεταλαμβάνονται τοῦ τε ἡλίου καὶ τοῦ ἀστέρος πρὸς ἀλλήλους τε καὶ τὰ δύο τοῦ ὁρίζοντος ἡμικύκλια τό τε πρὸς ἀνατολὰς καὶ τὸ πρὸς δυσμάς. σημαίνεται δὲ ἡ μὲν τῶν ἀστέρων καθ' ἑκάτερον τῶν ἡμικυκλίων θέσις κοινότερον ἀπό τε τῆς ἀνατολῆς καὶ δύσεως, ἡ δὲ τοῦ ἡλίου κατὰ τὸ τῶν ὑπ' αὐτοῦ δεικνυμένων χρόνων ἴδιον ἀπό τε τῆς ἑῴας καὶ τῆς ἑσπερίας.
>
> By 'phasis' [i.e. appearance] of a fixed star we mean its first or last visible configuration taken with respect to the Sun and the horizon, and it gets this name from this [i.e. φάσις from φαίνεσθαι = "to appear", "to be visible"]. Among the configurations assumed in this manner, there are four varieties that are more significant; for they all involve positions of the Sun and the star relative to each other and to the two semicircles of the horizon, the one to the east and the one to the west. The position of the fixed stars on either of the semicircles is signified more commonly as 'east' and 'west', and that of the Sun [is signified] according to the particular character of the times exhibited by it as 'morning' and 'evening'.[35]

So far, I have not translated the word *phasis*, because the English 'phase', which we still use for these phenomena (e.g., stellar phases and lunar phases), is quite misleading. As Ptolemy clarifies, *phasis* comes from *phainesthai* (φαίνεσθαι), 'to be visible'. As he clearly says, a *phasis* is a type of configuration (σχηματισμός), and indeed a visible one – so the best translation for φάσις is 'appearance' or 'visibility'.

As for stellar configurations (σχηματισμοί), Ptolemy returns to the classification of the *Almagest* but here he uses the 'more common' (*koinoteron* (κοινότερον)) terminology, so *pros anatolas* (πρὸς ἀνατολάς) and *pros dusmas* (πρὸς δυσμάς) for 'east' and 'west', rather than *apēliōtēs* (ἀπηλιώτης) and *lips* (λίψ), and *apo tēs heōas* (ἀπὸ τῆς ἑῴας) and *apo tēs hesperias* (ἀπὸ τῆς ἑσπερίας) for 'morning' and 'evening', rather than *prōinos* (πρωινός) and *opsinos* (ὀψινός). This confirms what I suggested regarding the two set of labels for the cardinal points. Those connected with the winds, especially ἀπηλιώτης and λίψ, are technical and used only by professionals.[36] It also suggests that the terminology in the *Almagest* is more technical (as expected); the *Pha-*

35 For this translation of the *Phaseis* I am using (and adapting) a provisional, unpublished translation by Alexander Jones, who kindly shared his text with me.

36 Here Ptolemy is dealing with two sets of synonyms to indicate the same phenomena. While technical languages should avoid synonyms, it is common, even in modern technical languages, to have two terms, one used by professionals when addressing colleagues, and one used by professionals when speaking to laypeople. To take a recent example, what we normally call 'COVID-19' or 'coronavirus', is technically 'severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)'.

seis instead uses a more common terminology, probably because this work was addressed to a wider audience. Indeed, the bulk of Ptolemy's short treatise, after this introduction, is a *parapēgma*, a calendar connecting celestial phenomena, and especially star phases, with weather predictions, which was a rather popular genre in agricultural societies such as the Graeco-Roman one; hence, the readership of the *Phaseis* was not limited to professional astronomers.[37] Yet the point that Ptolemy makes here, namely that the stars are measured on the basis of a spatial criterion and the Sun on the basis of a temporal one, corresponds to the same terminological distinction for the configurations in the *Almagest*. In what follows (*Phaseis* 2, vol. 2, 5.17–6.2 Heiberg), Ptolemy selects four configurations as the most important ones and they coincide with four listed in the *Almagest*:

1. Morning rising (ἑῴα ἀνατολή) = configuration 1 in the *Almagest*: early easterly position (πρωινὸς ἀπηλιώτης)
2. Morning setting (ἑῴα δύσις) = configuration 3 in the *Almagest*: early westerly position (πρωινὸς λίψ)
3. Evening rising (ἑσπερία ἀνατολή) = configuration 7 in the *Almagest*: late easterly position (ὀψινὸς ἀπηλιώτης)
4. Evening setting (ἑσπερία δύσις) = configuration 9 in the *Almagest*: late westerly position (ὀψινὸς λίψ)

He then clarifies that all these configurations can be 'true' (*alēthinoi* (ἀληθινοί)) or 'visible' (*phainomenoi* (φαινόμενοι)). This is exactly what we read in Autolycus, where the only difference is the use of ἐπιτολή, for what Ptolemy calls ἀνατολή.[38]

However, in this work, Ptolemy adds a further important terminological distinction to better describe the phenomena. Ptolemy further explains that when we speak of 'true' configurations (ἀληθινοὶ σχηματισμοί), we take into account both the Sun and the stars, as they must both lie on the horizon. However, for the 'visible' ones, 'insofar as we understand them in a simplistic way' (*eph' hoson houtōs haplōs autous akouomen* (ἐφ' ὅσον οὕτως ἁπλῶς αὐτοὺς ἀκούομεν)), we do not consider the Sun any longer, since the only requirement for the Sun is to be far enough below the horizon that the sky is dark enough for the star's rising or setting to be visible. This requirement

37 On *parapēgmata*, including the one by Ptolemy, see Lehoux 2007.

38 *Ort. et Occ. Praef.* 8–13: Τῶν δὲ φαινομένων ἑῴα μέν ἐστιν ἐπιτολή, ὅταν πρὶν τὸν ἥλιον ἀνατεῖλαι ἄστρον τι πρώτως φανῇ ἀνατέλλον· ἑῴα δὲ δύσις, ὅταν πρὶν τὸν ἥλιον ἀνατεῖλαι ἄστρον τι πρώτως φανῇ δῦνον· ἑσπερία δὲ ἐπιτολή, ὅταν μετὰ τὸ τὸν ἥλιον δῦναι ἄστρον τι ἐσχάτως φανῇ ἀνατέλλον· ἑσπερία δὲ δύσις, ὅταν μετὰ τὸ τὸν ἥλιον δῦναι ἄστρον τι ἐσχάτως φανῇ δῦνον (of the visible [risings and settings], the morning rising is when a star is first seen rising before the Sun rises; the morning setting is when a star is first seen setting before the Sun rises; the evening rising is when a star is last seen rising after the Sun sets; the evening setting is when a star is last seen setting after the Sun sets).

would be met by any position of the Sun below 15° along the ecliptic.[39] As a result of this additional important scientific distinction, Ptolemy can now give a better definition of '*phasis*':

> *Phaseis* 4, vol. 2, 7.9–21 Heiberg: διόπερ οὐδέτερον τῶν κατειλεγμένων σχηματισμῶν ἤδη καὶ φάσεις ῥητέον· ἡ μὲν γὰρ φάσις δήλωσίς ἐστιν ὡρισμένου τε ἅμα καὶ φαινομένου σχηματισμοῦ, τῶν δ' ἐκκειμένων οἱ μὲν ἀληθινοὶ τοὺς χρόνους αὐτοὺς καθιστῶσιν ἀφανεῖς, οἱ δὲ φαινόμενοι τοὺς τοῦ ἡλίου τόπους. ὅταν οὖν τοὺς φαινομένους μηκέθ' ἁπλῶς οὕτως εἰκῆ καὶ ὡς ἔτυχεν ἐκδεχώμεθα, προσδιοριζόμενοι δὲ τοὺς πρώτους ἢ ἐσχάτους τῶν ἀνατολῶν καὶ τῶν δύσεων, τότε καὶ τὸ τῆς φάσεως ἴδιον περιέξουσιν ἑνὸς ἤδη γινομένου καὶ τοῦ κατὰ τὸν ἥλιον τόπου, καθ' ὃν ὄντος αὐτοῦ πρῶτον ἢ ἔσχατον οἱ ἀστέρες ἀνατέλλοντες καὶ δύνοντες φαίνεσθαι δύνανται.
>
> For this reason, neither of the configurations that have been described so far ought to be called 'phaseis' [i.e. 'appearances']. For an 'appearance' is a revelation of a configuration that is at the same time well defined and visible, but among those under consideration the true ones result in the times themselves being invisible, and the visible ones [result in] the positions of the Sun [being invisible]. Hence, when we no longer take the visible ones in this careless and random manner but further define them as the first or last of the risings and settings, then they will possess the characteristic of an 'appearance' since now the position for the Sun is also unique, where it is when the stars can first or last be seen rising and setting.

'True' risings and settings are unambiguously defined moments in time: they occur when the star and the Sun are both exactly on the horizon. On the contrary, the definition of 'visible' rising and setting is ambiguous, since it can indicate many different configurations of a star with respect to the Sun, namely, whenever a star can be seen either rising or setting due to the position of the Sun sufficiently below the horizon. Yet Ptolemy wants to define one precise moment called 'phasis', so he rejects this approximate definition (*mēketh' haplōs houtōs eikē kai hōs etukhen* (μηκέθ' ἁπλῶς οὕτως εἰκῆ καὶ ὡς ἔτυχεν)) and redefines it as the *first* and *last* visibility of a star. In other words, while 'true' risings and settings are phenomena unique in time (hence Ptolemy accepts the traditional definitions), he adds a further category to the 'visible' phenomena in order to single out a phenomenon occurring only once in a year: the *phaseis* or 'appearances'. In this way, a *phasis* indicates one precise moment in time when the position of the Sun is also fixed. Once Ptolemy has established this new definition he can proceed with more precise definitions:

> *Phaseis* 4, vol. 2, 7.23–8.2 Heiberg: ἑῴα μὲν ἀνατολικὴ φάσις ἡ πρώτη τῶν φαινομένων ἀνατολή, ἑσπερία δὲ ἀνατολικὴ φάσις ἡ ἐσχάτη τῶν φαινομένων τοῦ ἀστέρος ἀνατολή, καὶ πάλιν ἑῴα μὲν δυτικὴ φάσις ἡ πρώτη τῶν φαινομένων τοῦ ἀστέρος δύσις, ἑσπερία δὲ δυτικὴ φάσις ἡ ἐσχάτη τῶν φαινομένων τοῦ ἀστέρος δύσις.
>
> The 'morning-rising appearance' is the first rising of the visible ones, and the 'evening-rising appearance' is the last rising of the star's visible ones, and again the 'morning-setting appearance'

39 In fact, Ptolemy does not mention explicitly the 15° along the ecliptic as a minimum distance below the horizon.

> is the first setting of the star's visible ones, and the 'evening-setting appearance' is the last setting of the star's visible ones.

The terminology is the usual one; however, by placing additional adjectives (*prōtē* (πρώτη) and *eskhatē* (ἐσχάτη)) into the definitions, Ptolemy can now identify one specific event in time. In other words, whereas in the *Almagest* he distinguished between 'configurations' (σχηματισμοί) and their 'varieties' (διαφοραί), in the *Phaseis* he adds a further subgroup to some of these 'varieties': the 'phasis' or first or last appearance, as follows:

Visible morning rising (φαινομένη ἑῴα ἐπιτολή) = star rises before sunrise
  Morning-rising appearance (ἑῴα ἀνατολικὴ φάσις) = first visible [morning] rising
Visible evening rising (φαινομένη ἑσπερία ἀνατολή) = star rises after sunset
  Evening-rising appearance (ἑσπερία ἀνατολικὴ φάσις) = last visible [evening] rising
Visible morning setting (φαινομένη ἑῴα δύσις) = star sets before sunrise
  Morning-setting appearance (ἑῴα δυτικὴ φάσις) = first visible [morning] setting
Visible evening setting (φαινομένη ἑσπερία δύσις) = star sets after sunset
  Evening-setting appearance (ἑσπερία δυτικὴ φάσις) = last visible [evening] setting

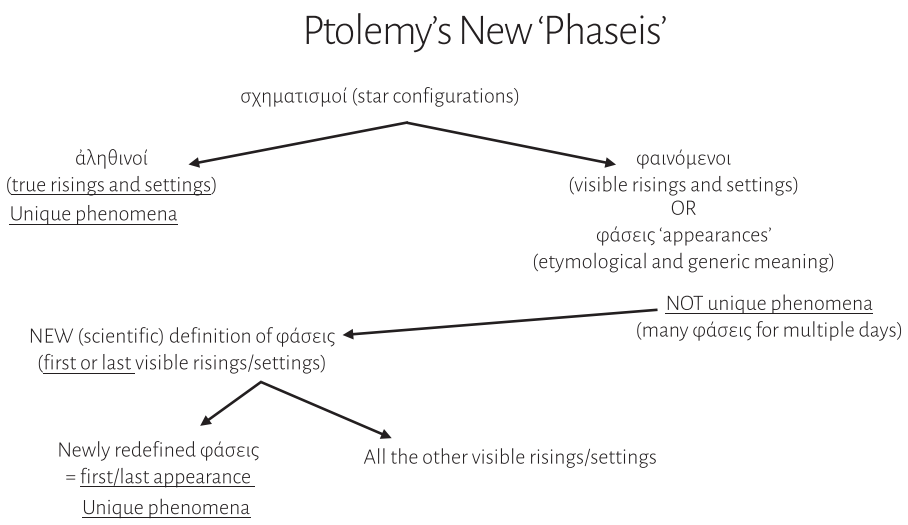

Fig. 3: Ptolemy's taxonomy of stellar phases.

Once he has defined the specific term (φάσις) as first or last appearance (see Fig. 3), Ptolemy can then add further specifications, or rather connect this new term to previously defined labels: the first visibility is also called ἐπιτολή (first visible rising) and the last visibility is also called κρύψις (hiding).[40] This is exactly the same distinction

40 *Phaseis* 5, vol. 2, 8.12–15 Heiberg: τούτους δέ, ὅτε μὲν ἀφανίζονταί τινα χρόνον, καλοῦμεν ἐπιτέλλοντας καὶ κρυπτομένους, καὶ τὴν μὲν ἑῴαν αὐτῶν ἀνατολὴν ἁπλῶς ἐπιτολὴν καλοῦμεν, τὴν δ' ἑσπε-

Ptolemy had spelled out in *Almagest* 8.4 (vol. 1.2, 186.9–15 Heiberg), quoted above, however, there the term φάσις was not used.[41]

Within these two concepts, first φάσις or ἐπιτολή (first visibility or first rising) and last φάσις or κρύψις (last visibility or hiding), Ptolemy can then classify stars according to how they behave in the sky. In addition to being *epitellontes* (ἐπιτέλλοντες), 'first rising', when we see them in the sky rising after a period of invisibility or being *kruptomenoi* (κρυπτόμενοι), 'hidden', when we do not see them in the sky for a period of time, stars can also display different behaviors during the night according to their positions within the celestial sphere. A star can be *kolobodiexhodos* (κολοβοδιέξοδος), 'with a truncated (*kolobos* (κολοβός)) path', when it rises and sets with the Sun, meaning that it cannot be seen in its rising and setting but it can be seen during the night; this is typical of stars that lie close to the ecliptic.[42] Alternatively, a star can be *nuktidiexhodos* (νυκτιδιέξοδος), 'with a nightly path', when it rises after sunset and sets before sunrise, so it can be seen for the entire night; this is typical of stars that lie below the tropic of the Capricorn (for an observer in the northern hemisphere).[43] Finally, a star can be *amphiphanēs* (ἀμφιφανής), 'doubly visible', when it sets after sunset and rises before sunrise, so it can be seen twice in a night but not throughout the entire night; this is typical of stars that lie above the tropic of Cancer (for an observer in the northern hemisphere). Ptolemy also calls them *eniautophanēs* (ἐνιαυτοφανής), 'year-visible', since they never hide.[44] Without discussing what these labels mean astronomically, since this would go beyond the scope of this chapter, I have included this final

ρίαν δύσιν ἁπλῶς κρύψιν (We call these [stars], when they disappear for some time, 'rising' and 'hidden', and we call their morning rising simply 'rising', and the evening setting simply 'hiding').

41 The word φάσις is used only in the final section (6) of Book 8 (Περὶ φάσεων καὶ κρύψεων τῶν ἀπλανῶν; *Synt*. 1.2.198.9–10 Heiberg) when Ptolemy discusses the trigonometrical methods for calculating the first and last visibility of stars – concluding that they are too complicated and so he will simply use past records or the globe. Yet Ptolemy never defines what a *phasis* is in the *Almagest*.

42 *Phaseis* 5, vol. 2, 8.15–17 Heiberg: ὅτε δὲ φαίνονταί τινα χρόνον μήτε ἀνατέλλοντες μήτε δύνοντες κολοβοδιεξόδους καλοῦσιν (But when they are visible for some time without either rising or setting, they call them 'with a truncated path').

43 *Phaseis* 6, vol. 2, 9.4–9 Heiberg: ἀλλὰ τὸ τῶν καλουμένων νυκτιδιεξόδων, ἐπειδὴ τὸν ἀπὸ τῆς ἑῴας δύσεως ἕως τῆς ἑσπερίας ἀνατολῆς χρόνον καὶ ἀνατέλλοντες καὶ δύνοντες καὶ ὅλον τὸ ὑπὲρ γῆν ἡμισφαίριον διεξιόντες φαίνονται μετὰ μὲν τὴν τοῦ ἡλίου δύσιν ἀνατέλλοντες, πρὸ δὲ τῆς ἀνατολῆς αὐτοῦ καταδύνοντες (but the [property] of what are called 'with a nightly path' [applies to them], since for the time from the morning setting until the evening rising they are visible both rising and setting and travelling the whole of the hemisphere above the Earth, since they rise after the setting of the Sun and set before its rising).

44 *Phaseis* 6, vol. 2, 9.17–22 Heiberg: ἀλλὰ τὸ τῶν καλουμένων ἐνιαυτοφανῶν, ἐπειδὴ καὶ τὸν ἀπὸ τῆς ἑῴας ἀνατολῆς ἕως τῆς ἑσπερίας δύσεως χρόνον φαίνεσθαι δύνανται δύνοντες μὲν μετὰ τὴν τοῦ ἡλίου δύσιν, ἀνατέλλοντες δὲ πρὸ τῆς ἀνατολῆς αὐτοῦ· καλοῦνται δὲ οἱ τοιοῦτοι καὶ ἀμφιφανεῖς (but [this is rather] the [property] of the [stars] that are called 'year-visible', since for the time from the morning rising until the evening setting they can be visible setting after the setting of the Sun and rising before its rising; such [stars] are also called 'doubly visible').

example to show fully Ptolemy's extraordinary attempt to build a coherent and systematic vocabulary regarding stellar *phaseis*. Just like in the previous cases, here the new terms are technical and yet clear. They are organized in two connected sets: (1) κολοβο-διέξοδος and νυκτι-διέξοδος and (2) ἀμφι-φανής and ἐνιαυτο-φανής, which again immediately give a clear picture of the phenomena they 'name'.

This detailed overview of the terminology for star phases clearly demonstrates Ptolemy's efforts at building a terminology which is clear, consistent, and comprehensive for phenomena that are complex and yet important for both the common people and the agricultural calendar. He accomplishes this in two works: the *Almagest*, where he gives a more technical description of the configurations, and the *Phaseis*, where he uses a more common terminology and at the same time further specifies distinctions and introduces new definitions.

Compared to Ptolemy's efforts and accomplishments, the modern terminology is much scantier and in fact also confusing. Indeed, modern astronomers speak of '*heliacal*' rising/setting for a star's first and last visibility. While 'heliacal' is rather clear (if one knows Greek), the names 'heliacal rising' and 'heliacal setting' do not really convey the idea that the star is seen rising or setting because it *rises right before* or *sets right after* the Sun. In fact, 'heliacal' suggests that the solar phenomenon is contemporaneous to the rising or setting of the star – which is not the case. In addition, there is no suggestion that this is the first rising and the last setting. Indeed, other modern names for these phases are far less technical (and yet similarly ambiguous): 'morning first' and 'evening last'.

Modern astronomers also use 'acronychal rising' and 'cosmic setting', but what these terms indicate tends to vary. Generally, 'acronychal rising' is used to mean the 'visible evening rising' and 'cosmical setting' the 'visible morning setting'.[45] However, these labels are neither defined precisely nor used in a very specific way. Rather, a simple internet search verifies that a variety of definitions can be found.[46] 'Acronychal rising' is not immediately clear for an English speaker. The term 'acronychal' derives from the Greek *akronuktos* (ἀκρόνυκτος), meaning 'at the edge of the night'. Yet this could mean either the sunset or the sunrise. Theon correctly understands this when he uses it (*Exp.* 137.7–20) for both the visible evening rising and invisible morn-

45 See Evans 1998, 197; Lehoux 2007, 10–11.

46 See, for example, Kelley & Milone 2011, 40: "Several terms are used to describe the visibility of an object. When a star or planet formerly invisible due to proximity to the Sun first becomes visible in the morning sky, it is said to be at *heliacal rising*. When the object is last seen to set in the west after the Sun in the evening sky, it is said to be at *heliacal setting*. Two other pairs of terms are often confused with heliacal risings and settings. Either the rising or setting of a star in the evening, i.e., at or just after sunset, is referred to as *acronychal* and either the rising or setting of a star at sunrise is said to be *cosmical*. Thus, a star that is first seen to rise as the Sun sets is said to be at *acronychal rising*, and if it sets with the Sun, *acronychal setting*; one that sets as the Sun rises is at its *cosmical setting*, and if it rises as the Sun rises, it is at *cosmical rising*. Astronomers do not always follow these definitions strictly, however; so the context must be used to understand what the terms are intended to mean."

ing setting, as the former takes place when the night has begun and the latter when the day has begun, namely at the 'edges' of the night.[47] And yet, modern astronomers seem to have forgotten the true meaning of the word and how it was correctly used by the ancients. 'Cosmical setting', on the other hand, is clear but very generic. No doubt, the Greeks were much more precise than we are in naming and describing these phenomena, because, for them, these were crucial phenomena for daily life. We no longer need to observe when a star first rises or sets, nor are modern astrophysicists interested in tracking the phases of stars – and so we do not even need to 'name' those moments with precision.

5 Conclusions

Greek astronomical terminology is extremely rich, aimed at describing the phenomena as precisely as possible. The focus is 'positional', since this vocabulary is the natural result of the Greek approach to astronomy, which is fundamentally geometrical and concerned with tracking the motions and positions of the heavenly bodies. In particular, the examples discussed in this chapter make at least five important points.

First, Greek astronomical terminology, while 'technical' in the sense that it indicates very specific phenomena, is not obscure. All the terms used are either taken from common Greek or neologisms formed as compounds that are quite easily understandable. This might indeed have had an impact on the popularization of astronomy. While a poem like Aratus' *Phaenomena* is clearly nontechnical in its lack of use of these words, works like Ptolemy's *Almages*t and *Phaseis* as well as Hipparchus' *Commentary on Aratus* were certainly written by experts. A layperson, however, could

47 Theon, *Exp.* 137.7–20 ἀνατολὴ δὲ λέγεται πλεοναχῶς· κυρίως μὲν καὶ κοινῶς ἐπί τε ἡλίου καὶ τῶν ἄλλων ἄστρων ἡ πρώτη ἀναφορὰ ὑπὲρ τὸν ὁρίζοντα· ἕτερον δὲ τρόπον ἐπὶ τῶν ἄλλων ἡ πρώτη φαῦσις ἐκ τῶν τοῦ ἡλίου αὐγῶν, ἥτις καὶ κυρίως <φαῦσις> ὀνομάζεται· λοιπὴ δὲ ἡ καλουμένη ἀκρόνυχος, ἐπειδὰν ἡλίου δύνοντος τὸ κατὰ διάμετρον ἄστρον ἐπὶ τῆς ἀνατολῆς βλέπηται· καλεῖται δὲ ἀκρόνυχος, ἐπειδὴ ἡ τοιαύτη ἀνατολὴ γίνεται ἄκρας νυκτός, τουτέστιν ἀρχομένης. παραπλησίως δὲ καὶ δύσις κοινῶς μὲν ἡ πρώτη κάθοδος ἡ ὑπὸ τὸν ὁρίζοντα· τρόπον δὲ ἄλλον ὁ πρῶτος ἀφανισμὸς ἄστρου τινὸς ὑπὸ τῶν τοῦ ἡλίου αὐγῶν, ἥτις καὶ κυρίως κρύψις πάλιν προσαγορεύεται· λοιπὴ δὲ καὶ ἀκρόνυχος, ἐπειδὰν ἡλίου ἀνατέλλοντος τὸ κατὰ διάμετρον ἄστρον ἀντικαταδύνῃ (the word 'rising' is used in many ways; in the proper and common sense, for the Sun and the other stars, [it is] the first ascent above the horizon; in another way, for the other stars, [it is] the first illumination [the receive] from the Sun's rays, which is also properly called 'illumination'; then there is the [rising] called 'acronychal' when once the Sun has set, a star on the opposite side is seen at its rising; and it is called acronychal because this rising happens at the edges of the night, that is, when the [the night] begins. Similarly, also 'setting' is commonly the first descent below the horizon; in another way, [it is] the first occultation of a star because of the Sun's rays, which is again also properly called 'hiding'; then there is also the 'acronychal' [setting] when once the Sun has risen, a star on the opposite side sets). Interestingly, here Theon uses *phausis* (φαῦσις), 'illumination' for first visibility and *krupsis* (κρύψις), 'hiding', for last visibility.

read and understand them, at least in the descriptive parts. In fact, Greek astronomical terminology is characterized by what I call 'etymological transparency'. Because of its transparency, this terminology is often more precise and clearer than ours. At the same time, Greek astronomers strove toward building this (intelligible) terminology in the most precise way, as proven by the example of Ptolemy grappling with defining and re-defining '*phaseis*' on the basis of its etymology, which clearly exclude the 'true' phases, which are in fact invisible, and so they cannot be 'appearances' (i.e., *phaseis*). In other words, an 'invisible phase' is nonsense to a Greek astronomer, while it is a reality for a modern one.

Second, the terminology used to express positions of the stars in the sky reflects another important aspect of Greek astronomy: its obsession with tracking the motions of the heavenly bodies. It is often said that while modern astronomy is concerned with the nature of celestial bodies and the physical processes occurring in them, ancient astronomy is concerned with their motions, and this is so because their instruments and physical understanding only allowed them to measure and study their motions. This is no doubt true, and the language they used to express those concepts clearly reflects this interest: heavenly bodies are described in relation to each other, some preceding and some trailing, or in relation to important reference points, most often the south meridian.

Third, in addition to being 'positionally' significant, Greek astronomical terminology can also express important perceptible (to us) characteristics of the celestial bodies. Star phases are described by their names in a way that makes it easier to visualize the specific moment in the sky relative to the Sun's and star's positions. Similarly, the celestial circles have names that clearly connect them to the Sun's motion in the sky and to specific seasonal or temporal changes on the Earth, making these geometrical abstractions of the celestial sphere much more evident. Moreover, the cardinal points are named after celestial phenomena (a constellation pointing to the north or the position of the Sun in the sky) or winds – again, phenomena perceptible by people.

Fourth, by defining and re-defining a full-fledged system of terms for star phases, Ptolemy presents himself as the one who finally systematized a field that started in the fourth century BCE but was never precisely defined until his day. This is indeed Ptolemy's role in Greek astronomy in general – yet the example of star phases has shown that Ptolemy not only systemized astronomy as a science but also provided it with a better language to express its content. In other words, Ptolemy became an *auctoritas* not only because he had written the *Almagest* but also because he had created a specific and precise terminology to name astronomical concepts. The way he presents these definitions in the *Almagest* is also proof of his authorial attempt. Although written in continuous prose, the discussion of star configurations and varieties is almost a list with bullet points, lending itself to easy tabulation. This stylistic choice, where there is no discussion but just definitions one after the other, makes this systematization even more authoritative. Only in the *Phaseis*, which seems to be addressed to a more general audience, is Ptolemy more interlocutory and inclined to discuss his definitions, yet the

aim is always the same: to impose his own system, both of scientific concepts as well as of terminology.

Fifth, the detailed analysis of the star phases has shown another aspect of astronomical terminology: its systematic nature. The specific obsession with defining a full set of names and definitions is of course connected with the importance of stellar phases in ancient astronomy. The calculation of star phases needed trigonometrical concepts that were not trivial (and explained by Ptolemy in *Synt*. 8.5–6), yet its results were not limited to highly technical treatises such as the *Almagest*; they were also used in *parapēgmata* (like the one that follows in the *Phaseis*), a much more popular genre. The example of star configurations and phases has shown how an entire vocabulary with its own taxonomy was built up over the centuries (from Autolycus to Ptolemy) to clarify and name phenomena that were key to the science of that time.[48] They were also important for the common people, since stellar phases were connected to the farming calendar. The modern version of this vocabulary is not as precise because we are far less interested in these phenomena. In this respect, this is a clear instance where interest *creates* language. Greek astronomical terminology for stars and their motions reflects the interests of its users: the precise description of the *phainomena*, their geometrical interpretation, and their use to measure time and predict seasonal changes.

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48 On some principles of technical taxonomy, see Alinei 1991.

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