Ptolemy in Philosophical Context:
A Study of the Relationships Between Physics, Mathematics, and Theology

by

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Abstract

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This study situates Ptolemy’s philosophy within the second-century milieu of Middle Platonism and the nascent Aristotelian commentary tradition. It focuses on Ptolemy’s adaptation and application of Aristotle’s tripartite division of theoretical philosophy into the physical, mathematical, and theological. In *Almagest* 1.1, Ptolemy defines these three sciences, describes their relations and objects of study, and addresses their epistemic success. According to Ptolemy, physics and theology are conjectural, and mathematics alone yields knowledge. This claim is unprecedented in the history of ancient Greek philosophy.

Ptolemy substantiates this claim by constructing and employing a scientific method consistent with it. In *Almagest* 1.1, after defining the theoretical sciences, Ptolemy adds that, while theology and physics are conjectural, mathematics can make a good guess at the nature of theological objects and contribute significantly to the study of physics. He puts this claim into practice in the remainder of his corpus by applying mathematics to theology and physics in order to produce results in these fields.

After the introductory chapter, I present Ptolemy’s philosophy and practice of the three theoretical sciences. In Chapter 2, I examine how and why Ptolemy defines the sciences in
Almagest 1.1. In Chapter 3, I further analyze how Ptolemy defines mathematical objects, how he
describes the relationships between the tools and branches of mathematics, and whether he
demonstrates in the Harmonics and Almagest that he believed mathematics yields sure and
incontrovertible knowledge, as he claims in Almagest 1.1. In Chapter 4, I present Ptolemy’s
natural philosophy. While in Chapter 2 I discuss his element theory, in Chapter 4 I focus on his
physics of composite bodies: astrology, psychology, and cosmology as conveyed in the
Tetrabiblos, On the Kritērion, Harmonics, and Planetary Hypotheses. I do not devote a chapter
to theology, as Ptolemy refers to this science only once in his corpus. Therefore, I limit my
analysis of his definition and practice of theology to Chapter 2. In the concluding chapter, I
discuss Ptolemy’s ethical motivation for studying mathematics. What emerges from this
dissertation is a portrait of Ptolemy’s philosophy of science and the scientific method he employs
consistently in his texts.
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Chapter 1

Introduction

Klaudios Ptolemaios, or Ptolemy, is known today mainly for his scientific contributions. Living in the second century C.E. in or around Alexandria, he developed astronomical models that served as the western world’s paradigm in astronomy for approximately 1400 years, up to the time of the Scientific Revolution. He composed an astrological work, the Tetrabiblos, which modern astrologers still hold in high regard,¹ and he wrote treatises on harmonics, optics, and geography, which influenced the practice of these sciences from antiquity to the renaissance.

In the Greco-Roman world, the study and practice of the sciences was generally a philosophical endeavor. What we translate as science was epistême, knowledge or a field of intellectual activity. Aristotle distinguishes theoretical, productive, and practical knowledge in the Metaphysics, and this categorization became paradigmatic in ancient Greek philosophy. As a student and practitioner of the theoretical sciences, Ptolemy identifies himself as a genuine philosopher in the introduction to the Almagest.

¹ For instance, James R. Lewis, a professional astrologer and author of The Astrology Encyclopedia, calls Ptolemy “the father of Western astrology” and “the most influential single astrologer in Western history.” See James R. Lewis, The Astrology Encyclopedia (Detroit: Visible Ink Press, 1994), 442.
The *Almagest*, originally called the *Mathematical Composition* (*mathêmatikê syntaxis*), is Ptolemy’s longest and arguably most influential text. In it, he presents a series of astronomical models, which aim to account for the movements of the stars and planets, including the sun and moon. The models are both demonstrative and predictive, since by using the tables, an astrologer would have been able to determine the perceptible location of any celestial body on any given date. The first chapter, *Almagest* 1.1, serves as a philosophical introduction to the text. Ptolemy sets the philosophical groundwork for his astronomical *hypotheses* and provides one of his few citations of a philosophical predecessor, Aristotle. This citation is especially significant, because we have no direct evidence of Ptolemy’s education. The very little of Ptolemy’s life that we know derives mainly from his extant texts, and in them he neither affiliates himself with a specific school nor proclaims himself an eclectic, as did his contemporary Galen. Nevertheless, the citation of Aristotle establishes Ptolemy’s familiarity with the Aristotelian tradition. Moreover, after he cites Aristotle, Ptolemy affirms that philosophers are correct in distinguishing theoretical from practical philosophy, as Aristotle does in the *Metaphysics*, and he appropriates Aristotle’s trichotomy of the three theoretical sciences: physics, mathematics, and theology. Ptolemy’s definitions of the three theoretical sciences, as well as his descriptions of their relations, their objects of study, and their epistemic success, are the focus of this dissertation.

Liba Taub recognizes the significance of *Almagest* 1.1 as a statement of Ptolemy’s philosophy in her book *Ptolemy’s Universe: The Natural Philosophical and Ethical Foundations of Ptolemy’s Astronomy*. Taub discusses both the *Almagest* and the *Planetary Hypotheses*, but she dedicates the bulk of *Ptolemy’s Universe* to Book 1 of the *Almagest*. Her contribution

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3 Chicago: Open Court, 1993.
mainly consists in her arguments for the following two points: (1) Much of Ptolemy’s language and many of his ideas are not Aristotle’s, and (2) Ptolemy’s portrayal of the ethical benefits of studying astronomy is Platonic. I support these two conclusions in this dissertation; however, I aim to analyze Ptolemy’s philosophical statements in *Almagest* 1.1 more deeply by investigating their relationship to the philosophy in Ptolemy’s other texts as well as situating them within the contemporary philosophical context.

In his review of *Ptolemy’s Universe*, Alan Bowen rightly insists that *Almagest* 1.1 cannot be understood independently of Ptolemy’s other philosophical statements or his practice of the theoretical sciences in his technical works.\(^4\) In addition, Bowen proposes that *Almagest* 1.1 may not delineate Ptolemy’s philosophy in its final form or even be consistent with the ideas presented in the rest of his corpus. Rather, they may simply serve as a palatable introduction, presenting the common view of astronomy at the time rather than how Ptolemy himself theorized and practiced astronomy. If *Almagest* 1.1 does not represent Ptolemy’s view, then, Bowen suggests, Ptolemy may overturn the philosophical position of *Almagest* 1.1 in the subsequent chapters of the *Almagest*.

The methodology of this dissertation mediates between Taub’s and Bowen’s approaches. I do not take the philosophy in *Almagest* 1.1 to be representative of Ptolemy’s philosophical position as a whole, nor do I treat the chapter as inconsistent with the rest of Ptolemy’s corpus. Rather, I emphasize the significance of *Almagest* 1.1 as a statement of Ptolemy’s philosophical ideas and analyze it in the context of the rest of his corpus as well as the contemporary philosophical milieu.

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The texts in Ptolemy’s corpus which I examine are those which contain philosophical content. Besides the Almagest, these texts include the Planetary Hypotheses, Tetrabiblos, Harmonics, Optics, On the Kritêrion and Hêgemonikon, and two of Ptolemy’s lost works, On the Elements and On Weights. While in the Almagest Ptolemy describes the heavens mathematically, in the Planetary Hypotheses and Tetrabiblos he characterizes the heavens in physical terms. In the Planetary Hypotheses, he provides a physical representation of his astronomical models that describes the number, order, shapes, and speeds of the aethereal bodies which constitute the heavens. In addition, Ptolemy expounds his theory of animistic causation by describing celestial souls, which control the aethereal bodies’ movements. Only a portion of the first book of the Planetary Hypotheses exists in the original Greek. The second of the two books, whose content is more relevant to this study, and the remainder of the first book exist only in a ninth-century Arabic translation as well as a Hebrew translation from the Arabic.

In the Tetrabiblos, Ptolemy defends the possibility and usefulness of astrology and summarizes the discipline’s principles, such as the powers of celestial bodies and the effects these powers have. Ptolemy does not distinguish astronomy and astrology terminologically as we do today. Rather, it is their predictive goals which distinguish them. What we call astronomy explains and predicts the configurations and movements of celestial bodies; what we

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5 For a complete list of Ptolemy’s texts, see Alexander Jones, “Ptolemy.” In New Dictionary of Scientific Biography 6 (Detroit: Charles Scribner’s Sons, 2008), 173-178.
call astrology studies and predicts physical changes in the sublunary realm caused by the powers emanating from celestial bodies.

In the *Harmonics*, Ptolemy elaborates on his criterion of truth and employs it in the analysis and demonstration of the mathematical relations between musical pitches. The text contains three books, and, after completing his study of music theory in *Harmonics* 3.2, Ptolemy applies harmonics to psychology, astrology, and astronomy in the remaining chapters. Unfortunately, the last three chapters, 3.14-16, are no longer extant; only their titles remain.

In the *Optics*, Ptolemy advances his theory of visual perception. While some scholars have questioned Ptolemy’s authorship of the *Optics*, the bulk of the evidence supports the text’s authenticity. According to Ptolemy’s optical theory, the eye emits a visual flux in the form of a cone, which is resolvable into a collection of rays traveling in straight lines. As the visual flux, being physical in nature, comes into contact with external objects, it provides sensory data that the soul’s governing faculty interprets. This role that the governing faculty plays in perception leads Ptolemy to discuss his epistemological theory. As in the case of the *Harmonics*, sections of the *Optics* have disappeared. Book 1—in which Ptolemy would have presented the philosophical foundation of his optics—as well as the last part of Book 5 and any subsequent books that might have existed are no longer extant. Furthermore, the only surviving text is a twelfth-century Latin translation of a lost Arabic translation.

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On the Kritêrion and Hêgemonikon is the only text in Ptolemy’s extant corpus that is devoid of mathematics. As the title indicates, it examines the criterion of truth, the method by which one gains knowledge, and the nature and parts of the human soul. Even more than the Optics, the text has sparked a highly polarized debate over its authorship. While in the nineteenth-century Franz Boll argued in favor of attributing the text to Ptolemy, more recently Gerald Toomer and Noel Swerdlow have doubted the attribution. Liba Taub dismisses all discussion of On the Kritêrion with a single parenthetical aside in Ptolemy’s Universe. She calls it merely “a work whose attribution to Ptolemy has been questioned.” These scholars’ doubt rests on the following observations: (1) On the Kritêrion contains no mathematics; (2) It includes no references to any other of Ptolemy’s texts; (3) Its arguments appear to be fairly simplistic; (4) Its style, according to Gerald Toomer, is dissimilar to the style of Ptolemy’s authentic texts. These doubts, however, are outweighed by thematic, stylistic, and linguistic arguments. In his forthcoming “The Place of On the Criterion in Ptolemy’s Works,” Alexander Jones aims to demonstrate the text’s authenticity. He argues that (1) On the Kritêrion consists of extremely long sentences with numerous dependent clauses, as do Ptolemy’s other extant texts, (2) it applies Ptolemy’s tendency to sum up a section with the perfect passive imperative, and, most decisively, (3) On the Kritêrion contains at least three words and phrases that are either unique to

14 Taub, 9.
15 Toomer, 201.
Ptolemy’s corpus or do not appear in other Greek texts until late antiquity.16 From this evidence, Jones concludes that the manuscript’s ascription of On the Kritêrion to Ptolemy is correct.

More than establishing Ptolemy’s authorship, Jones ventures a guess at when Ptolemy composed On the Kritêrion. He reckons that Ptolemy probably wrote the text as early as the 120s, before he was immersed in his large-scale scientific projects and before he was fully comfortable with philosophical jargon.17 Another argument for the early dating of On the Kritêrion appeals to its relation to the Harmonics. Swerdlow argues that the Harmonics predates the Almagest because the titles of the three lost chapters, 3.14-16, indicate that they examined the relations between musical pitches and celestial bodies tabulated in the Canobic Inscription.18 Considering that Ptolemy must have written the Canobic Inscription before the Almagest—because in the latter he corrects numerical values in the former19—the Harmonics most likely predates the Almagest. As for On the Kritêrion, it is reasonable to conclude that Ptolemy completed it before the Harmonics for two thematic reasons: (1) The criterion Ptolemy introduces in On the Kritêrion is elaborated in the Harmonics, and (2) Ptolemy gives a detailed account of the nature and parts of the human soul in On the Kritêrion but he merely summarizes its parts in the Harmonics. If these arguments for dating On the Kritêrion around, if not before, the Harmonics are plausible, then it is reasonable to conclude that On the Kritêrion is one of the earliest—perhaps the earliest—of Ptolemy’s extant texts.

17 Ibid.
18 Swerdlow, 175.
On the whole, Ptolemy’s texts offer few clues to their chronology. In both *Tetrabiblos* 1.1 and the opening paragraph of the *Planetary Hypotheses*, Ptolemy refers to the “mathematical syntaxis,” manifestly the *Almagest*. Consequently, Ptolemy must have completed the *Tetrabiblos* and *Planetary Hypotheses* after the *Almagest*. It is reasonable to suppose that Ptolemy also completed the *Optics* after the *Almagest*, because Ptolemy expounds a theory of atmospheric refraction in the *Optics* which he virtually ignores in the *Almagest* but which is consistent with his account in the latter part of *Planetary Hypotheses* 1.20 I have already mentioned the evidence for dating the *Harmonics* and *On the Kritêrion*. Hence, one can reasonably conclude that Ptolemy composed these texts in the following order: (1) *On the Kritêrion and Hégemonikon*, (2) *Harmonics*, (3) *Almagest*, (4) *Tetrabiblos*, *Planetary Hypotheses*, and *Optics* in an indeterminate order.21

In his commentary on the *De Caelo*, Simplicius mentions two further books of Ptolemy that I examine: *On the Elements* and *On Weights*.22 Both of these books are completely lost to us. According to Simplicius, in *On the Elements* Ptolemy propounds a theory of natural motion similar to Xenarchus’. According to this theory, elements move rectilinearly only when displaced from their natural places, but, when in their natural places, they either rest or move circularly. In *On Weights*, Ptolemy purportedly argues that neither air nor water has weight in its natural place. Because the subject matter of *On the Elements* and *On Weights* is so similar, it is plausible that the two were originally a single book, later referred to by two names.23

Despite the significance of the mathematical and natural philosophical contributions in these texts, few historians have analyzed the philosophy which Ptolemy presents as the

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20 See Smith, 2.
21 Smith (3) argues that the *Optics* postdates the *Planetary Hypotheses*.
22 Heiberg, 1907, 263-265.
foundation of his scientific *hypotheseis*. His philosophy, his motivation and method for studying mathematics and natural philosophy, remains relatively unstudied.

Recently, a few scholars of ancient philosophy have examined Ptolemy’s *On the Kritêrion and Hégemonikon*. This treatise has presumably attracted their attention because, unlike every other of Ptolemy’s extant texts, it is explicitly an epistemological treatise. The first modern editor of the text, Ismael Bullialdus,\(^{24}\) drew attention to its pertinence to seventeenth-century philosophical debates. Specifically, he composed an essay utilizing Ptolemy’s arguments to controvert Descartes’ inference that the body and soul are independent of one another. No philosopher today would use *On the Kritêrion* as a definitive epistemological account, but the topics with which the text deals still resonate with the concerns of modern philosophy.

The most notable, recent pieces of scholarship on Ptolemy’s *On the Kritêrion* are Friedrich Lammert’s two-part “*Eine neue Quelle für die Philosophie der mittleren Stoa*”\(^{25}\) and A.A. Long’s “Ptolemy on the Criterion: An Epistemology for the Practising Scientist,”\(^{26}\) which accompanies the recent edition of the text by the Liverpool/Manchester Seminar on Ancient Philosophy. In his two articles, Lammert applies source criticism to the question of Ptolemy’s philosophical position. Through a philological analysis, he argues that *On the Kritêrion* is representative of Middle Stoic philosophy. A.A. Long criticizes Lammert’s approach, laments the lack of an intellectual history of the text,\(^{27}\) and devotes his article to examining the epistemological ideas in *On the Kritêrion*. As a result, Long overturns Lammert’s arguments for

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\(^{24}\) *Tractatus de judicandi facultate et animi principatu* (Paris: Cramoisy, 1663).
\(^{27}\) Ibid., 152.
the classification of *On the Kritērion* as Middle Stoic. While Lammert’s method is to find parallel passages between *On the Kritērion* and Stoic texts, Long argues that many of the terms used in *On the Kritērion* were common intellectual property in the second century.\(^{28}\) Accordingly, Ptolemy’s philosophical allegiance cannot be determined by philology alone.

While comparing Ptolemy’s philosophy in *On the Kritērion* to Sextus Empiricus\(^{29}\) and Galen’s, Long ultimately concludes that Ptolemy was an eclectic who, as a practicing scientist, propounded a theory which maximally agrees with the philosophies of the contemporary philosophical schools. With this portrayal of Ptolemy, Long acknowledges that, in order to determine Ptolemy’s general philosophical stance, one must recognize the eclecticism of the second century C.E. Eduard Zeller labels the philosophy from the second century B.C.E. to the second century C.E. eclectic in his *A History of Eclecticism in Greek Philosophy*.\(^{30}\) In *The Question of “Eclecticism”: Studies in Later Greek Philosophy*, John Dillon and A.A. Long dispel the negative connotations of the term and, by means of a set of colloquium papers, depict the various philosophical standpoints of the period.\(^{31}\) Long remarks in “Ptolemy on the Criterion: An Epistemology for the Practising Scientist” that Ptolemy’s eclecticism, in particular, is not undifferentiated. His philosophy is preferential and, according to Long, his empiricism is more Aristotelian than Stoic.\(^{32}\) Still, the question of the relation and consistency of Ptolemy’s philosophy in *On the Kritērion* with his philosophy in the rest of his corpus remains open.\(^{33}\)

\(^{28}\) Ibid., 155.  
\(^{30}\) London: Longmans, 1883.  
\(^{32}\) Long, 163.  
\(^{33}\) Daryn Lehoux makes some headway in addressing this question by treating Ptolemy’s empiricism in *On the Kritērion* and the *Optics* as consistent in his article “Observers, Objects,
While a few scholars of ancient philosophy have studied *On the Kritêrion*, a handful of historians of science have touched upon the philosophy in Ptolemy`s mathematical and natural philosophical texts. In his article “Ptolemy`s *Harmonics* and the ‘Tones of the Universe’ in the *Canobic Inscription,*” for instance, Noel Swerdlow discusses some of the philosophical concepts in the *Harmonics* while elucidating Ptolemy`s application of harmonics to astronomy in Book 3. Andrew Barker analyzes the scientific method Ptolemy employs in the *Harmonics* in his book appropriately titled *Scientific Method in Ptolemy`s Harmonics.* He examines Ptolemy`s explicitly methodological statements and then establishes that Ptolemy applies this method in his study and demonstration of harmonic principles. Barker keeps the *Harmonics*` chapters on astrology and the human soul at arm`s length, and his book examines only one of Ptolemy`s texts. Barker admits this restricted focus in his introduction by stating, “Here I intend to keep the focus as sharp as possible, restricting myself to an examination of this single text, without drawing elaborate comparisons or attempting to generate large conclusions about Greek science in general.” While this approach produced an excellent book on Ptolemy`s study and practice of harmonics, it left open the question, which I address in this dissertation, whether Ptolemy utilizes the same scientific method throughout his corpus and what Ptolemy`s general philosophical allegiances were.

Anna de Pace remarks on Ptolemy`s philosophical commitment in the *Optics* in her two-part “Elementi Aristotelici nell` *Ottica* di Claudio Tolomeo.” She argues that Ptolemy is an Aristotelian, as opposed to a Platonist, because he treats perceptible reality as ontologically prior and the Embedded Eye; or, Seeing and Knowing in Ptolemy and Galen,” *Isis* 98 (2007): 447-467.

35 Ibid., 3.
to the mathematical forms he uses to analyze physical bodies. In other words, Ptolemy is an Aristotelian because of his empiricism. In *Ptolemy’s Theory of Visual Perception*, A. Mark Smith counters de Pace’s argument by contending that Ptolemy’s optics may equally be characterized as Platonic because the aim of ancient Greek optics was to save the appearances, albeit, for Ptolemy, via a realist approach.\(^\text{37}\) Despite his specific focus on Ptolemy’s *Optics*, in the introduction to his translation Smith considers the larger question of Ptolemy’s general philosophical stance. He observes that scholars have run the gambit in identifying Ptolemy’s philosophical allegiance:

> A fair amount has been written about Ptolemy’s philosophical leanings, the vast majority of it based upon works other than the *Optics*. Depending upon the treatise, in fact, Ptolemy has been variously portrayed as a Platonist-Pythagorean, an Aristotelian, a Stoic, an Empiricist, and even a Positivist. The resulting impression is of an intellectual schizophrenic whose philosophical allegiances are sworn and resworn whenever the analytic circumstances demand.\(^\text{38}\)

In contrast, Smith concludes that Ptolemy is an eclectic.\(^\text{39}\) Yet, as stated above, Ptolemy’s eclecticism was preferential, as A.A. Long observes. Ptolemy drew his ideas from many philosophical traditions, but to label him simply as an eclectic does nothing more than to state that he was a man of his time. A more interesting account would consider why Ptolemy, in his many texts, prefers and appropriates the ideas of some philosophical traditions over others. This, too, is a question which my dissertation addresses.


\(^{38}\) Smith, 1996, 17.

\(^{39}\) Ibid., 18.
The principal reason that scholars have portrayed Ptolemy’s philosophy as belonging to any number of philosophical traditions is that they have tended to focus their analysis on a single text of Ptolemy. I have just discussed the most influential studies of Ptolemy’s philosophy, and in almost every case the historian has concentrated on only one text. Lammert and Long examine *On the Kritêrion*, Swerdlow and Barker analyze the *Harmonics*, and de Pace and Smith study the *Optics*. As stated above, Liba Taub has made some progress towards a holistic study by appending chapters on the *Planetary Hypotheses* to her dissertation on *Almagest* 1.

The most comprehensive study to date of Ptolemy’s philosophical commitments is Franz Boll’s “Studien über Claudius Ptolemäus: Ein Beitrag zur Geschichte der griechischen Philosophie und Astrologie.” Published in 1894, this study, like my own, examines the philosophy in several of Ptolemy’s texts, including the *Almagest*, *On the Kritêrion*, *Harmonics*, and, especially, the *Tetrabiblos*. Boll takes a philological approach, and his philology is exemplary. He traces the philosophical concepts of Ptolemy’s texts to their predecessors and emphasizes the influence of Aristotle and Posidonius in particular. Yet, despite his study of several of Ptolemy’s texts, Boll draws few conclusions about Ptolemy’s general philosophical stance. He offers no explanation as to why, so he claims, Ptolemy favors Aristotle’s ideas in *Almagest* 1.1 as well as *On the Kritêrion* but adopts Posidonius as his principal source for the *Tetrabiblos*. In other words, Boll’s “Studien” is not a history of ideas, as is this dissertation; it is a philological account.\(^{40}\) Furthermore, over the past one hundred years, a great deal of scholarship has informed our understanding of Hellenistic and Middle Platonic philosophy. Without this scholarship, Boll could not and did not adequately situate Ptolemy’s philosophical statements within the contemporary philosophical trends. Accordingly, Boll downplays the

\(^{40}\) For his critique of Boll’s approach, see Long, 173.
influence of Platonic thought on Ptolemy,\textsuperscript{41} but it is Middle Platonism in particular which I will emphasize as influencing Ptolemy’s philosophy.

Ptolemy’s philosophical statements reveal him to be what I call a Platonist empiricist. While this label appears oxymoronic at first glance, it aptly describes Ptolemy’s appropriation of both the Platonic and empiricist traditions. First, as was the trend in the second century, Ptolemy adopts Platonic, Aristotelian, and, to a lesser extent, Stoic and Epicurean ideas, but the manner in which he mixes these philosophical influences depends heavily on contemporary Platonic concerns. While he does not identify himself as a Platonist, the ideas he promulgates reveal a substantial Platonic influence on his philosophy. Second, Ptolemy adapts these Platonic ideas to a theory of knowledge which is best described by the anachronistic term ‘empiricism’. This empiricism is founded on an ontology that is, as I will argue, distinctively Aristotelian. In arguing for Ptolemy’s Platonic empiricism, I will not attempt to discover which sources served as the bases for his philosophical position. After all, as Liba Taub notes in \textit{Ptolemy’s Universe}, this task is impossible due to the paucity of extant texts from the time period.\textsuperscript{42} Instead my aim is to situate Ptolemy’s philosophical statements within the contemporary milieu of Middle Platonism and the rise of the Aristotelian commentary tradition.

My focus is Ptolemy’s adaptation and application of Aristotle’s tripartite division of theoretical philosophy into the physical, mathematical, and theological. While today the discourse surrounding the relations between religious and scientific traditions is heated and even antagonistic, in the Greco-Roman world theology was a science alongside physics and mathematics. In the introduction to the \textit{Almagest}, Ptolemy defines these three sciences, he describes their relations and objects of study, and he addresses their epistemic success, i.e.,

\textsuperscript{41} Boll, 110-111.
\textsuperscript{42} Taub, 16.
whether they produce knowledge or conjecture. According to Ptolemy, physics and theology are merely conjectural, and mathematics alone yields sure and incontrovertible knowledge. This claim—that mathematics alone produces knowledge—is unprecedented in the history of ancient Greek philosophy. While the Platonic tradition emphasized the utility of mathematics, the identification of mathematics with knowledge appears to be unique to Ptolemy.

Ptolemy substantiates his unprecedented claim by constructing and employing a scientific method entirely consistent with it. In *Almagest* 1.1, after defining the three theoretical sciences, he adds that, while theology and physics on their own amount to mere conjecture, mathematics can make a good guess at the nature of theological objects and contribute significantly to the study of physics. Ptolemy puts this claim into practice in the remainder of his corpus by consistently applying mathematics to theology and physics in order to produce tangible results in these fields.

In the following three chapters, I present Ptolemy’s philosophy and practice of the three theoretical sciences. In Chapter 2, “Ptolemy on the Definitions of Physics, Mathematics, and Theology,” I examine how and why Ptolemy defines the three sciences as he does in the introduction to the *Almagest*. In Chapter 3, “Ptolemy’s Epistemology and Ontology of Mathematics,” I further analyze how Ptolemy defines mathematical objects, how he describes the relationships between the tools and branches of mathematics, and whether he demonstrates in the *Harmonics* and *Almagest* that he believed mathematics yields sure and incontrovertible knowledge as he claims in *Almagest* 1.1. In Chapter 4, “Ptolemy’s Epistemology and Ontology of Physics,” I present Ptolemy’s natural philosophy. While in Chapter 2 I discuss his element theory, in Chapter 4 I focus on his physics of composite bodies: astrology, psychology, and cosmology as conveyed in the *Tetrabiblos*, *On the Kritērion*, *Harmonics*, and *Planetary*
Hypotheses. I do not devote an entire chapter to theology, as Ptolemy refers to this science only once in his corpus, in *Almagest* 1.1. Therefore, I limit my analysis of his definition and practice of theology to Chapter 2. In Chapter 5, the “Conclusion,” I discuss Ptolemy’s ethical motivation for studying mathematics and astronomy in particular.

What emerges from this dissertation is a portrait of the scientific method Ptolemy employs consistently in his texts. In *Almagest* 1.1, Ptolemy defines and evaluates the three theoretical sciences. While presenting his mathematical and natural philosophical *hypotheses* in the rest of his corpus, he continues to treat mathematics as knowledge, either absolute or qualified, he labels theology and physics conjecture, and he applies mathematics to the study of theology and physics. The only exception to this method is the natural philosophy in *On the Kritêrion*. While investigating the physics of the human soul, Ptolemy does not apply mathematics to the study as he does in the *Harmonics*’ psychological theory. I will argue in Chapter 4 that *On the Kritêrion* is distinct from Ptolemy’s other extant texts because of the chronology of the corpus. A broad unity of thought and method exists in Ptolemy’s texts, and, while they differ on minor points, these small differences represent the development of Ptolemy’s thought over time. On the whole, Ptolemy’s corpus is impressive in its consistency of ideas—some of them unprecedented—and the application of these ideas to the study of the three theoretical sciences.
Chapter 2

Ptolemy on the Definitions of Physics, Mathematics, and Theology

In the introduction to the *Almagest*, Ptolemy grounds his great compendium of astronomical models in a philosophical framework. Even though he mentions few of his predecessors, let alone his philosophical ones, he mentions Aristotle by name and presents what superficially appears to be Aristotle’s categorization of knowledge as presented in the *Metaphysics*. Ptolemy distinguishes between practical and theoretical philosophy, and he divides theoretical philosophy into three distinct categories: the physical, mathematical, and theological. The terms he uses to define these three sciences, however, differ from the concepts Aristotle utilizes in the *Metaphysics*. While Ptolemy appropriates Aristotle’s ontology of scientific objects, he ultimately defines them according to epistemic criteria. Applying an Aristotelian form of empiricism, he defines objects as physical, mathematical, or theological in relation to whether and how they are perceptible. Moreover, Ptolemy judges whether physics, mathematics, and theology produce knowledge or conjecture. He bases this judgment on whether the practitioner of each of these sciences has the ability to make skilled, reasoned inferences from sense perceptions. Undergirding his ontology with empiricism, Ptolemy reveals a characteristically Hellenistic, especially Stoic, concern with the criterion of truth, and this concern leads him to make a claim unprecedented in ancient Greek philosophy. In *Almagest* 1.1,
he pronounces theology and physics conjecture and asserts that mathematics alone yields sure and incontrovertible knowledge.

Ptolemy’s approach to philosophy is an eclectic one. He derives his ontology from several of Aristotle’s texts, and his epistemology blends Platonic and, to a lesser extent, Stoic concerns with an Aristotelian form of empiricism. Ptolemy’s synthesis of these philosophical traditions comfortably situates him within the contemporary milieu of Middle Platonism and the rise of the Aristotelian commentary tradition. Despite his eclectic approach, the general concepts of Ptolemy’s philosophy appear to be consistent throughout his corpus. The details may vary between the texts, but the fundamental principles of Ptolemy’s ontology and epistemology remain constant. Accordingly, I have drawn from several of Ptolemy’s texts—including the Harmonics, Optics, and On the Kritêrion—when examining his definitions of physics, mathematics, and theology as presented in Almagest 1.1. What results from this synthesis of philosophical statements is a clear, well-reasoned method offered by Ptolemy for the production of knowledge. Whether Ptolemy adhered to this method and whether he believed that it actually produces knowledge are questions I will pursue in the subsequent chapters.

2.1 Aristotle’s Division of Knowledge

In general, Aristotle divides all intellectual activity into three categories: the practical (πρακτική), productive (ποιητική), and theoretical (θεωρητική). In Metaphysics E1.1025b25 and K7.1064a16-17, he classifies each type of intelligence, or understanding (διάνοια), according to the ἀρχή, or principle of motion, of the type of object that each field studies. In Metaphysics K7, Aristotle explains the subdivisions of understanding (διάνοια) as follows:

In a productive science the source of motion is in the producer and not in the thing produced, and is either an art or some other kind of capacity; and similarly in a
practical science the motion is not in the thing acted upon but rather in the agent. But the science of the natural philosopher (τοῦ φυσικοῦ) is concerned with things which contain in themselves a source of motion. From this it is clear that natural science must be neither practical nor productive, but theoretical; since it must fall under one of these classes.¹

Both productive and practical understanding concern that which has an external source of motion. The principle of motion is a producer—such as an art (τέχνη) or some other power (δύναμις) of production—or an agent that wills an action to occur, respectively. Theoretical understanding, on the other hand, concerns objects that have their principle of motion in themselves. According to Aristotle, all branches of knowledge fit into one of these three categories: productive, practical, or theoretical.

Aristotle examines theoretical knowledge in *Metaphysics* E1.1026a6-32 and K7.1064a28-1064b6. As in his division of διάνοια, he divides theoretical knowledge into three categories: the physical (φυσική), mathematical (μαθηματική), and theological (θεολογική). Each theoretical science studies a distinct set of objects in the world distinguished by their share in two dichotomies of characteristics: (1) whether the objects of study are separate (χωριστόν) or inseparable (οὐ χωριστόν) from another type of object, and (2) whether they are movable (κίνητον) or immovable (ἀκίνητον). By describing an object as movable, Aristotle indicates that it experiences change; an immovable object, on the other hand, does not undergo any type of change. Aristotle lists the various types of change an object may undergo in *On Generation and Corruption*. They include, as the title suggests, generation and corruption (or coming into and out of being) as well as alteration, growth, diminution, mixture, and motion from place to place. The pairing in an object of the characteristics separate or inseparable with movable or immovable determines which of the three theoretical sciences studies the object. Aristotle

unequivocally states that physical objects are separate and movable, and theological objects are separate and immovable. He labels mathematical objects as immovable, but he vacillates over whether they are separate or inseparable. He admits this uncertainty in the following:

It is obvious, then, from these considerations, that physics is a form of theoretical science. And mathematics is also theoretical; but it is not clear at present whether its objects are immovable and separate from matter; it is clear, however, that some branches of mathematics consider their objects qua immovable and qua separate from matter.²

After confessing his doubt, Aristotle goes on, albeit tentatively, to call at least some mathematical objects immovable and inseparable. He presumably elects this categorization in order to keep the three domains of theoretical knowledge distinct. He defines the three sciences accordingly: “For physics deals with things which exist separately but are not immovable; and some branches of mathematics deal with things which are immovable, but presumably not separate, but present in matter; but the primary science treats of things which are both separate and immovable.”³ Because theology deals with objects that are divine, and therefore prior, Aristotle labels theology the primary science (πρωτή). He accounts for the privileged position of theology in his discussion of theological objects:

Now all causes must be eternal, but these especially; since they are the causes of what is visible of things divine. Hence there will be three theoretical philosophies: mathematical, physical, and theological—since it is obvious that if the divine is present anywhere, it is present in this kind of nature; and also the most honorable science must deal with the most honorable class of subject.⁴

Aristotle justifies his labeling of the science of separate and immovable objects as ‘theological’ by appealing to secondary characteristics of theological objects. Besides being separate and

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² Aristotle Metaphysics 1026a6-10, after Hugh Tredennick (Cambridge, MA: Harvard University Press, 1933). An alternative translation is possible whereby the last clause reads, “it is clear, however, that one considers some mathematics qua immovable and qua separate.”

³ Ibid. 1026a13-16.

⁴ Ibid. 1026a16-22.
immovable, they are eternal, divine, and the (final) cause of visible divine objects. Aristotle presumably alludes here to his account in *Metaphysics* Λ of the role of the unmoved mover(s) as the final cause of the motion of aethereal bodies.

The authenticity of Book K of the *Metaphysics* has been doubted, but its account in K7 of the three theoretical sciences is mainly consistent with E1. Some of the language Aristotle uses to discuss the objects the sciences study differs, but, in general, the categories of the three sciences and the objects’ defining characteristics remain unaltered. Concerning the differences between E1 and K7, in E1 Aristotle asserts that physical objects have in them a principle of motion and rest, but in K7 he states only that they have in them a principle of motion. More significantly, Aristotle does not hesitate in K7 to define mathematical objects as inseparable. Without any equivocation, he defines the three theoretical sciences as such:

Physics deals with things which contain a source (ἀρχή) of motion in themselves, and mathematics is theoretical and is a science which deals with permanent (μένοντα) things, but not with things which can exist separately. Hence there is a science distinct from both of these (ἐτέρα τούτων ἀμφοτέρων τῶν ἑπιστημῶν ἔστι τὰ), which deals with that which exists separately and is immovable; that is, if there really is a substance of this kind—I mean separately existent and immovable—as we shall endeavor to prove.

Note that Aristotle does not use the negative term ‘immovable’ (ἀκίνητα) for mathematical objects. Rather, he describes mathematical objects in terms of a positive characteristic; they remain in place, or are permanent (μένοντα). In addition, he admits that the existence of theological objects is not obvious, despite his belief in their existence and his aim to prove that they exist. Notwithstanding these minor differences between E1 and K7, the overarching categories and definitions of the three theoretical sciences presented in the two chapters are

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5 Ibid. 1025b19-21.
6 Aristotle *Metaphysics* 1064a15-16, 30-32, after Hugh Tredennick (1933).
7 Ibid. 1064a30-36.
consistent. Aristotle lists three theoretical sciences—physics, mathematics, and theology—and establishes the set of objects in the world that each science studies. Physical objects are separate and movable entities, mathematical objects are inseparable—abstracted from physical objects—and immovable, and theological objects are separate and immovable.

Significantly, Aristotle’s division of theoretical knowledge is purely ontological. He defines the three theoretical sciences only in terms of the characteristics of the objects that each science studies. No other aspect, such as epistemological criteria, plays a part in defining them. Furthermore, Aristotle forms a hierarchy of the three sciences founded solely on an ontological basis. As stated above, in *Metaphysics* E1, he calls theology “the most honorable (τιμωτάτη) science.” It is the characteristic of theological objects as divine, “the most honorable class of subject (τιμωτάτον γένος),” that establishes the science that studies them as most honorable.  

Similarly, in *Metaphysics* K7, Aristotle declares the following:

> Evidently, then, there are three kinds of theoretical science: the physical, mathematical, and theological. The highest class of science is the theoretical, and of the theoretical sciences themselves the highest (βέλτιστον) is the last named, because it deals with the most honorable (τιμωτάτον) side of reality; and each science is reckoned better (βέλτιων) or worse (χειριων) in accordance with the proper object of its study.

Aristotle ranks the three sciences according to the properties of the objects that each science studies. Theology is the highest, or most honorable (τιμωτάτη), science because theological objects are the most honorable. Correspondingly, physics and mathematics are ranked below theology, because their objects are less honorable than the divine, theological ones.

Aristotle does not, however, explicitly rank physics and mathematics in relation to one another. Because he labels mathematical objects as immovable and permanent, one might guess

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8 Aristotle *Metaphysics* 1026a21, after Hugh Tredennick (1933).
9 Aristotle *Metaphysics* 1064b1-6, after Hugh Tredennick (1933).
that he would have considered mathematics as intermediate between physics and theology. Nevertheless, in K7 he suggests that if objects that are both separate and immovable did not exist then physical objects, being separate and movable, would be primary: “If, then, natural substances are the first of existing things, physics will be the first of the sciences; but if there is some other nature and substance which exists separately and is immovable, then the science which treats of it must be different from and prior to physics, and universal because of its priority.”¹⁰ This passage indicates that Aristotle ranked physics as prior to and, consequently, more honorable than mathematics. Therefore, Aristotle considered separateness to be a more fundamental characteristic than movability, and, correspondingly, physics to be a more honorable science than mathematics. Again, theology is the most honorable of the three theoretical sciences, because divine entities are prior to physical and mathematical objects.

2.2 Ptolemy’s Definitions of Physics, Mathematics, and Theology

Ptolemy puts forward his own version of Aristotle’s division of theoretical knowledge in *Almagest* 1.1. As the introduction to Ptolemy’s astronomical compendium, this first chapter of the *Almagest* grounds his astronomy in a philosophical foundation. In the first sentence of the text, he presents the Aristotelian distinction between theoretical and practical philosophy. He declares, “The legitimate philosophers, Syrus, were, I think, quite right to distinguish the theoretical part of philosophy from the practical.”¹¹ In other words, according to Ptolemy, legitimate philosophers, past and contemporary, utilize the Aristotelian distinction between theoretical and practical knowledge. Ptolemy does not include productive knowledge as a division of philosophy, but even Aristotle contrasted only the theoretical and the practical on

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¹⁰ Ibid. 1064b9-14.
occasion, and the omission of the productive was common in post-Hellenistic philosophy.
Ptolemy goes on to call Aristotle by name as he divides the theoretical branch of philosophy into three categories: “For Aristotle divides theoretical philosophy too, very fittingly, into three primary genera, the physical, mathematical, and theological.”12 With this reference to Aristotle, Ptolemy indicates that he is purposefully appropriating Aristotle’s schema of the three theoretical sciences. The discussion of theoretical knowledge that follows, however, reveals substantial alterations to Aristotle’s definitions and objects of the three sciences.

Despite Franz Boll’s belief that Ptolemy used *Metaphysics* E when composing *Almagest* 1.1,13 further scrutiny suggests that Ptolemy did not directly refer to either *Metaphysics* E1 or K7 when composing the chapter. At the heart of Aristotle’s definitions of the three theoretical sciences is the pairing of the characteristics separate and inseparable with movable and immovable. Ptolemy, on the other hand, does not define the objects of the sciences according to a pairing of two fundamental contraries. Following the Aristotelian tradition, he recognizes that matter, form, and motion characterize all objects,14 but he does not apply a subset of these characteristics to the objects of each science. Instead, he identifies each science with a set of perceptible or imperceptible objects that exist in the cosmos. For example, Ptolemy asserts that theology investigates “the first cause of the first motion of the universe” (τὸ μὲν τῆς τῶν ὅλων πρώτης κινήσεως πρῶτον αἰτίαν).15 He most likely identified this first cause with Aristotle’s Prime Mover, portrayed in *Physics* 8 and *Metaphysics* Λ. While Ptolemy does not label this first cause as the Primer Mover in the *Almagest*, in the *Optics* he appeals to the Prime

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12 Ibid., H5.  
14 Ptolemy *Almagest* 1.1, H5.  
Mover as an exemplar of an unmoved entity. He calls it “that which moves first” (*quod primo mouet*). The Greek text of the *Optics* no longer exists, but the twelfth-century Latin translation, albeit of an Arabic translation, appears, at least in this case, to be literal. “That which moves first” clearly denotes the Prime Mover. Ptolemy’s reference to the Prime Mover in the *Optics* substantiates the identification of the ‘first cause’ in *Almagest* 1.1 with Aristotle’s notion of the Prime Mover. In *Almagest* 1.1, Ptolemy concentrates on two aspects of the Prime Mover. For Aristotle, the two defining attributes of theological objects are their separateness and immovability. For Ptolemy, the Prime Mover is distinctly motionless and invisible. It is the Prime Mover’s imperceptibility that Ptolemy highlights in his description of it as a theological object. He states the following:

> Now the first cause of the first motion of the universe, if one considers it simply, can be thought of as an invisible and motionless deity (θεόν ἀόρατον καὶ ἀκίνητον) and the division [of theoretical philosophy] concerned with investigating this [can be called] ‘theology’, since this kind of activity, somewhere up in the highest reaches of the universe, can only be imagined, and is completely separated from perceptible reality.

The only object Ptolemy explicitly defines as theological is this invisible and motionless deity. While he defines it as immovable, he does not state that it is an entity separate from all other entities; he only claims that it is separate from perceptible reality. Therefore, besides being motionless, the Prime Mover is characterized principally by its imperceptibility.

As in his portrayal of the Prime Mover, Ptolemy discusses how motion relates to physical and mathematical objects, but he does not mention whether these objects are separate or inseparable. Concerning physical objects, he calls them “ever-moving” (αἰεὶ κινούμενη) and

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16 Ptolemy *Optics* 2.103.
17 Ptolemy *Almagest* 1.1, H5, after G.J. Toomer. In the last clause of this passage, Ptolemy explains why he calls the first cause a god (θεόν) and the science of this first cause theology. It seems that, because the first cause is associated with the heavens and is imperceptible, it is like a god and therefore can be thought of as θεόν.
identifies them with perceptible characteristics of sublunary bodies: “The division [of theoretical philosophy] which investigates material and ever-moving nature, and which concerns itself with ‘white’, ‘hot’, ‘sweet’, ‘soft’ and suchlike qualities one may call ‘physics’; such an order of being is situated for the most part amongst corruptible bodies and below the lunar sphere.”

Ptolemy describes physical objects according to a sublunary framework. Physical objects are perpetually moving and, at least in the case of sublunary bodies, they are subject to changes, including corruption. Moreover, they are distinguished by perceptible qualities such as white, hot, sweet, and soft. As for mathematical objects, Ptolemy defines them as related to forms and movements from place to place, as well as some similar concepts: “That division [of theoretical philosophy] which determines the nature involved in forms and movements from place to place, and which serves to investigate shape, number, size, and place, time and suchlike, one may define as ‘mathematics’. “

Ptolemy mentions movements from place to place as a topic of mathematics, but he does not define mathematical objects as immovable. For Ptolemy, mathematics is simply the investigation of forms and movements from place to place as well as shape, number, size, place, time, etc.

Ptolemy ranks mathematics as intermediate between physics and theology, and he gives two reasons for this ranking. Firstly, while the Primer Mover is imperceptible and physical objects are perceptible, mathematical objects can be considered with and without the aid of the senses. Secondly, mathematical objects can be abstracted from all existing bodies, mortal and immortal, or, as is implied, physical and theological. Ptolemy presents these two arguments for the status of mathematics as follows:

18 Ibid.
19 Ibid., H5-6.
Its subject-matter falls as it were in the middle between the other two, since,
firstly, it can be conceived of both with and without the aid of the senses, and,
secondly, it is an attribute of all existing things without exception, both mortal
and immortal: for those things which are perpetually changing in their inseparable
form, it changes with them, while for eternal things which have an aethereal
nature, it keeps their unchanging form unchanged.\(^{20}\)

These two arguments give inconsistent accounts of what theological objects are. The first
argument implies that mathematics is intermediate because theological objects, specifically the
Prime Mover, are imperceptible, physical objects are perceptible, and mathematical objects are
conceivable with and without the aid of the senses. The second argument suggests that celestial
bodies, rather than the Prime Mover, are the theological objects under discussion, since Ptolemy
depicts mathematical objects as abstractions of both super- and sublunary objects.

It is possible that with these two arguments Ptolemy is broadening the scope of what
objects count as theological. When first defining theology in *Almagest* 1.1, he characterizes it as
the study of the Prime Mover, which, according to Ptolemy, is “completely separated from
perceptible reality.”\(^{21}\) In his second argument for the intermediate status of mathematics, he
includes the visible divine, aethereal bodies, as theological objects alongside the Prime Mover.
Yet, if Ptolemy were to include both visible and invisible divine entities as theological, then his
first argument for the intermediate status of mathematics would no longer be sound. If, as the
first argument implies, physical objects are perceptible and theological objects are
imperceptible—as Ptolemy has characterized them earlier in his accounts of physical qualities
and the Prime Mover—and objects that are mathematical are both perceptible and imperceptible,
then mathematics would indeed be intermediate. On the other hand, Ptolemy does not state that
mathematical objects are both perceptible and imperceptible. Rather, he claims that they can be

\(^{20}\) Ibid., H6, trans. G.J. Toomer.
\(^{21}\) Ibid., H5.
conceived of (νοεισθαν) both with and without perception. The meaning here is vague. Ptolemy may be suggesting that it is possible to observe mathematical objects, as one observes physical objects, but it is also possible to contemplate them as if they were immaterial, like theological objects. The argument, then, implies that mathematical objects are intermediate, as conceivable with and without the senses, because physical objects can be conceived of only with the aid of the senses, and theological objects can be conceived of only independently of the senses. If Ptolemy counted aethereal bodies as theological, it would be rather odd of him to imply that they can only be conceived of without the aid of sense perception. After all, the planets and stars are visible, even if the spheres that contain them are not perceptible from the earth. It seems, then, that Ptolemy broadens the definition of theological objects only in his second argument for the intermediate status of mathematics and that he does so for dialectical purposes. In this way, he can provide more than one argument for his ranking of the three theoretical sciences, even if the two arguments rely on incompatible premises.

In her book Ptolemy’s Universe: The Natural Philosophical and Ethical Foundations of Ptolemy’s Astronomy, Liba Taub observes that the language and concepts Ptolemy uses when defining the theoretical sciences differ from Aristotle’s descriptions in the *Metaphysics*. She discusses this variance between the texts as follows:

Ptolemy’s definitions of physics, mathematics, and metaphysics do not share much with the passage in Aristotle’s *Metaphysics* which Boll pointed to as having been so important to Ptolemy in his writing of the preface. But while these definitions were apparently not composed as Ptolemy stood over a copy of the *Metaphysics*, there is something about them which has a familiar ring, which suggests, broadly speaking, some “Aristotelian” influence. These definitions may represent Ptolemy’s interpretation of Aristotle’s division of philosophy, based on his own reading.

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22 Ibid., H6.
Taub highlights the discrepancy between Ptolemy’s and Aristotle’s definitions of the sciences, but she does not offer an explanation of why Ptolemy’s definitions are not those of Aristotle and what the “familiar ring” of Aristotelianism is in Ptolemy’s account.

Whether or not Ptolemy read Aristotle’s *Metaphysics* E1 and K7, his aim in *Almagest* 1.1 is not to provide a commentary on the *Metaphysics*. He seeks to ground his astronomy in the natural philosophy of Aristotle, but his method is an eclectic one. He derives his description of the three sciences from several of Aristotle’s texts. Identifying the objects that each of the sciences studies with actual objects in the cosmos, he draws his description of these objects from Aristotle’s corpus and categorizes the objects according to whether and how they are perceptible. In this way, Ptolemy incorporates epistemological criteria into his definitions of the three theoretical sciences at a fundamental level. For example, his identification of “the first cause of the first motion of the cosmos” as an object of theology alludes to the role of the Prime Mover in Aristotle’s cosmology, as represented in *Physics* 8 and *Metaphysics* Λ. In *Physics* 8, Aristotle puts forward the following argument for the existence of the Prime Mover:

We must consider whether it is or is not possible that there should be a continuous motion, and, if it is possible, which this motion is, and which is the primary motion; for it is plain that if there must always be motion, and a particular motion is primary and continuous, then it is this motion that is imparted by the first mover, and so it is necessarily one and the same and continuous and primary.\(^{24}\)

In other words, Aristotle argues that there is a primary and continuous motion and that this motion is caused by the first mover (τὸ πρῶτον κινοῦν). Ptolemy’s description of “the first cause of the first motion of the universe” (τὸ μὲν τῆς τῶν ὅλων πρῶτης κινήσεως πρῶτον

while it uses slightly different terms, such as ‘the universe’, recalls Aristotle’s account of the Prime Mover in Physica 8. In Metaphysics Λ, Aristotle identifies the continuous and primary motion caused by the first mover with the rotation of the sphere of fixed stars:

There is, then, something which is always moved with an unceasing motion, which is motion in a circle; and this is plain not in theory only but in fact. Therefore the first heavens must be eternal. There is therefore also something which moves them. And since that which is moved and moves is intermediate, there is a mover which moves without being moved, being eternal, substance, and actuality.26

If Ptolemy’s first cause is Aristotle’s Prime Mover, then the first motion of the universe imparted by the first cause is the diurnal rotation of the sphere of fixed stars.

As for physical and mathematical objects, Ptolemy derives his description of them from Aristotle’s De Anima, De Sensu, De Insomniis, and Metaphysics M. To begin with, Aristotle alludes to the tripartite division of theoretical philosophy in Book 1 of the De Anima:

The natural philosopher’s concern is with all the functions and affections of a given body, i.e., of matter in a given state; any attribute not of this kind is the business of another; in some subjects it is the business of the expert, the carpenter, it may be, or the physician; but inseparables in so far as they are not affections of the body in such a state, that is, in the abstract, are the province of the mathematician, and in so far as they are separate are the sphere of the first philosopher.27

Aristotle’s allusion to the three theoretical sciences in the De Anima could have drawn Ptolemy to the text when composing his definitions of the three theoretical sciences.

More significantly, the De Anima’s description of perceptible qualities undoubtedly influenced Ptolemy’s account of physical and mathematical objects. To reiterate, the qualities Ptolemy lists as exemplifying physical objects are white (λευκόν), hot (θερμόν), sweet (γλυκύ),

and soft (\(\alpha \pi \alpha \lambda \omicron\)). Each is perceptible by one sense only: white by sight, hot by touch, sweet by taste, and soft by touch. Because only one sense can perceive each of these qualities, according to Aristotle’s theory of perception they are ‘special-objects.’ Aristotle proclaims, “I call special-object whatever cannot be perceived by another sense, and about which it is impossible to be deceived, e.g. sight has color, hearing sound, and taste flavor, while touch has many varieties of object.”

For each sense, Aristotle lists at least one pair of contraries that exemplifies the sense’s special-object: “For every sense seems to be concerned with one pair of opposites, e.g. sight with white and black, hearing with high and low pitch, and taste with bitter and sweet; but in the object of touch there are many pairs of opposites, hot and cold, dry and wet, rough and smooth, and so on for the rest.” Among the contraries, Aristotle includes white (\(\lambda \epsilon \upsilon \kappa \omicron\)), hot (\(\theta \epsilon \rho \mu \omicron\)), and sweet (\(\gamma \lambda \upsilon \kappa \omicron\)), each of which Ptolemy lists among the objects of physics. While Aristotle does not mention softness (\(\alpha \pi \alpha \lambda \omicron\)), he would no doubt have considered it a special-object, as it is perceptible only by the sense of touch. Even more, Alexander of Aphrodisias includes softness, albeit by another term, \(\mu \alpha \lambda \alpha \kappa \omicron \tau \omicron \tau \omicron\), as a special sensible in his *De Anima* 55.23. Consequently, while Ptolemy’s list of physical qualities does not exactly match Aristotle’s examples in the *De Anima*, the four qualities he lists are classifiable as special-objects in Aristotle’s theory of perception.

The objects Ptolemy counts as mathematical are common-objects in Aristotle’s schema. They are perceptible by more than one sense. Again, Ptolemy provides the following examples of mathematical objects: forms (\(\epsilon \iota \delta \eta\)), movements from place to place (\(\mu \epsilon \tau \sigma \beta \alpha \tau \iota \kappa \alpha \iota \ \kappa \iota \eta \sigma \varepsilon \varepsilon \iota\)), shape (\(\sigma \chi \hat{\eta} \mu \iota \alpha\)), number (\(\pi \omicron \omicron \omicron \omicron\)), size (\(\pi \eta \lambda \iota \kappa \omicron\)), place (\(\tau \omicron \omicron \omicron \omicron\)), and time (\(\chi \rho \omicron \omicron \omicron\)). Aristotle provides two separate, but similar, lists of common-objects in the *De Anima*. In the first, he

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29 Ibid. 422b23-27.
includes movement (κίνησις), rest (ἡρεμία), number (ἀριθμός), shape (σχῆμα), and magnitude (μέγεθος).\(^{30}\) In the second, he includes all of the same terms, except, instead of using the term ἡρεμία for rest, he uses στάσις.\(^{31}\) Ptolemy’s list of mathematical objects in *Almagest* 1.1 does not completely coincide with Aristotle’s list, as only two of the terms are identical. Like Aristotle, Ptolemy includes both movements (κίνησις) and shape (σχῆμα) among other mathematical entities. It is most likely that Ptolemy was not using the *De Anima* as a direct guide to writing *Almagest* 1.1; however, his lists of physical and mathematical objects incorporate terms from Aristotle’s lists of special- and common-objects, respectively. Ptolemy includes these terms among others, which, while not in Aristotle’s lists, are still classifiable as common-objects.

The *De Anima* undoubtedly influenced Ptolemy’s analysis of perception in *On the Kritêrion and Hégemonikon*. As the title indicates, *On the Kritêrion* examines the criterion of truth, the method by which one gains knowledge, and the nature and parts of the human soul. I argued in the introductory chapter that *On the Kritêrion* is one of the earliest—perhaps the earliest—of Ptolemy’s extant texts. Therefore, one might suppose that Ptolemy’s epistemic investigations as described in *On the Kritêrion* influenced the epistemic foundation of his division of theoretical philosophy in *Almagest* 1.1. In *On the Kritêrion*, Ptolemy asserts that each perceptual faculty has one object proper to it and, concerning this object, the faculty does not err. Recalling Aristotle’s discussion of special-objects in the *De Anima*, Ptolemy explains, “On its own each of these faculties naturally tells the truth. This is the case whenever it is concerned with its own proper object without being distracted by complications involving other faculties. It happens when, for example, sight is concerned with colors, touch with [lacuna]

\(^{30}\) Ibid. 418a17-18.

\(^{31}\) Ibid. 425a16.
qualities….” Moreover, Ptolemy recognizes that some objects are perceptible by many senses. These common-objects include bulk (οὐγκὸς), magnitude (μέγεθος), number (πλῆθος), shape (σχῆμα), position (θέσις), arrangement (τάξις), and movement (κίνησις). While the list of common-objects in Almagest 1.1 matches Aristotle’s in the De Anima only in regard to two terms, the list in On the Kritêrion contains three of Aristotle’s terms: magnitude (μέγεθος), shape (σχῆμα), and movement (κίνησις). The similarity in the descriptions of special-objects and the lists of common-objects in Aristotle’s De Anima and Ptolemy’s On the Kritêrion indicates that Ptolemy appropriated the Aristotelian distinction between special- and common-objects.

Aristotle provides slightly different accounts of common-objects in the De Insomniis and De Sensu et sensibilibus, which may have influenced Ptolemy’s list of common-objects in On the Kritêrion. The De Insomniis lists only three common-objects, each of which Aristotle includes in the De Anima: shape (σχῆμα), magnitude (μέγεθος), and motion (κίνησις). Notably, these three terms are the three that On the Kritêrion shares with the De Anima. In the De Sensu, Aristotle provides two distinct lists of common-objects. In the first, he includes only four examples: magnitude (μέγεθος), shape (σχῆμα), movement (κίνησις), and number (όριθμός). Again, Ptolemy’s list in On the Kritêrion overlaps with respect to the first three terms. More interesting is the second account of common-objects in the De Sensu. Aristotle states, “For magnitude (μέγεθος) and figure (σχῆμα), roughness (τραχύς) and smoothness (λειόν), and, moreover, the sharpness (ὀξύ) and bluntness (ἀμβλύ) found in solid bodies (ὀγκοι), are percepts.

32 Ptolemy On the Kritêrion, La16, after Liverpool/Manchester Seminar on Ancient Philosophy (Liverpool: Liverpool University Press, 1989).
33 Ibid., La17.
34 Aristotle De Insomniis 458b5.
35 Aristotle De Sensu 437a9.
common to all the senses, or if not to all, at least to sight and touch." Not only does Aristotle add two new dichotomies—roughness and smoothness as well as sharpness and bluntness—but he also specifies that the latter dichotomy is found in objects that are solid, or have bulk. In *On the Kritêrion*, Ptolemy includes bulk (ὀγκος) as a common-object. This inclusion may stem from an Epicurean influence on Ptolemy’s conception of matter, or, while the comparison is a loose one—as Aristotle mentions solid bodies but does not call solidity itself a common-object—it is possible that Aristotle’s discussion of common-objects in the *De Sensu*, like the *De Anima* and *De Insomniis*, could have influenced Ptolemy’s account of common-objects in *On the Kritêrion*. Hence, Ptolemy’s discussion of common-objects in *On the Kritêrion* demonstrates his familiarity with an Aristotelian theory of special- and common-objects. The lists of common-objects in *On the Kritêrion* and *Almagest* 1.1 overlap only with respect to two terms, shape (σχήμα) and movements (κίνησις), but the similarity of scope between the lists is obvious. Ptolemy’s familiarity with an Aristotelian theory of sense perception, as demonstrated in *On the Kritêrion*, confirms that in *Almagest* 1.1 he purposefully distinguishes physical from mathematical objects based on their fit to special- and common-objects.

Like *On the Kritêrion*, Ptolemy’s *Optics* provides a theory of visual perception similar to Aristotle’s accounts of special- and common-objects. As I stated in the introductory chapter, it is reasonable to suppose that the *Optics* is a comparatively late work, probably written after the *Almagest*. In the *Optics*, Ptolemy explains that, through the sense of sight, one apprehends corporeity, size, color, shape, place, movement, and rest (*corpus*, *magnitudo*, *color*, *figura*, *situs*,

37 This influence becomes apparent in *On the Kritêrion* and the *Tetrabiblos* wherein Ptolemy portrays the soul as consisting of particles finer than the constituents of body. I discuss this distinction in detail in Chapter 4.
motus et quies). Ptolemy adds that sight is the only faculty that perceives color, while the other objects perceptible by sight are perceptible by the faculty of touch as well. As the original Greek text of the *Optics* is now lost, it is impossible to compare the Greek terms in the *Optics* to Aristotle’s lists of common-objects, but—as noted above in regard to the Prime Mover—the twelfth-century Latin translation is sufficiently revealing. Aristotle’s list in *De Anima* 2.6.418a17-18 overlaps with the *Optics*’ list of common-objects with respect to movement, rest, shape, and magnitude. Moreover, Ptolemy’s list in *Almagest* 1.1 overlaps with the list in the *Optics* more than with any other text. Both contain movement, shape, size, and place. As a point of interest, Ptolemy explains in the *Optics* how the visual faculty perceives common-objects:

For the visual faculty apprehends shapes and dimensions by means of the boundaries of the colored object, while place is apprehended by means of its location. The visual faculty also apprehends the motion or rest of these same colors by means of their change or lack thereof. And the motion or rest of shapes, dimensions, and location is perceived by means of the motion or rest of the boundaries or places of the colored object.

In other words, boundaries of color reveal an object’s shape and dimensions, the location of its boundaries reveals its place, and the (lack of) change in an object’s boundaries and place reveals its movement and rest. Nevertheless, if the *Optics* is a comparatively late work, then Ptolemy may not have yet elaborated his theory of optics and the mechanism by which one perceives common-objects when he composed *Almagest* 1.1.

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38 Ptolemy *Optics* 2.2.
41 Ptolemy *Optics* 2.7, trans. A. Mark Smith.
In addition to the *Almagest*, the *Harmonics*—Ptolemy’s text on the mathematical relations between musical pitches—mentions the tripartite division of theoretical philosophy. Again, the relation of the lost chapters of the *Harmonics* to the *Canobic Inscription* provides evidence for its early dating, before the *Almagest*. Perhaps because it is an early work of Ptolemy, the discussion in the *Harmonics* of the three theoretical sciences is less nuanced than in the *Almagest*. Nevertheless, it contains similar emphases to the division of theoretical knowledge in *Almagest* 1.1. For example, in the *Harmonics*, Ptolemy states that all entities are characterized by matter, form, and motion: “Since all things, then, have as their first principles \( \alpha \rho \chi \sigma \iota \zeta \) matter and movement and form \( \upsilon \lambda \eta \kappa \alpha \iota \kappa \psi \eta \sigma \epsilon \iota \kappa \alpha \iota \epsilon \iota \delta \epsilon \iota \), matter corresponding to the underlying and the out of which, movement to the cause and the by which, and form to the end and the for the sake of which….”

Likewise recalling *Almagest* 1.1, in the *Harmonics* Ptolemy distinguishes theoretical from practical philosophy, but he does not mention productive knowledge. He divides theoretical and practical philosophy into three subdivisions each: “For each of the two kinds of principle \( \alpha \rho \chi \eta \nu \), that is, the theoretical and the practical, there are three genera, physical, mathematical and theological in the case of the theoretical, and ethical, domestic and political in that of the practical.”

Ptolemy does not define the three theoretical sciences here; he only ranks them. As in *Almagest* 1.1, mathematics is intermediate between physics and theology:

Thus the enharmonic is to be compared to the natural and the ethical, because of its decrease in magnitude by comparison with the others; the diatonic to the theological and the political, because of the similarity of its order and its majesty to theirs; and the chromatic to the mathematical and the domestic, because of the shared nature of what is intermediate in relation to the extremes. For the mathematical genus is involved to a high degree both in the natural and in the

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43 Ibid. 3.6, D98.6-9.
While in the *Almagest* Ptolemy provides two arguments for the intermediate status of mathematics, he does not elucidate in the *Harmonics* what qualities mathematics shares with physics and theology that make it intermediate between the two others.

Ptolemy may have derived his first argument in *Almagest* 1.1 for mathematics’ intermediate status—that mathematical objects are conceivable with and without the aid of the senses—from Book M of Aristotle’s *Metaphysics*. In offering a polemic against the Platonic concept that numbers are separate, incorporeal entities, Aristotle elaborates on the description of mathematics in *Metaphysics* E and K. As in *Physics* 1 and 2, in *Metaphysics* M he claims that mathematical objects are perceptible but that they are not treated as perceptible in the study of mathematics. He explains, “And likewise with geometry: the mathematical branches of knowledge will not be about perceptible objects just because their objects happen to be perceptible, though not <studied> as perceptible; but nor will they be about other separate objects over and above these.”

Aristotle asserts that mathematical objects are perceptible but are not studied *qua* perceptible. This same understanding seems to underlie Ptolemy’s argument that mathematics is intermediate between physics and theology because mathematical objects can be conceived of with and without the senses.

On the whole, Ptolemy’s texts are consistent in their definitions of physics, mathematics, and theology. Attributing the tripartite division of theoretical philosophy to Aristotle, Ptolemy appropriates Aristotle’s ontological framework. While his account of physical, mathematical, and theological objects in *Almagest* 1.1 does not adopt all of the terms of *Metaphysics* E1 and

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44 Ibid., D98.17-24.
K7, the definitions are still Aristotelian. When Ptolemy describes theology, he identifies the first cause of the first motion of the cosmos as a theological object. This motionless and invisible deity recalls Aristotle’s Prime Mover of *Physics* 8 and *Metaphysics* Λ. Ptolemy derives his descriptions of physical and mathematical objects from Aristotle’s distinction between special- and common-objects in the *De Anima*, *De Insomniis*, and *De Sensu*. The examples he gives of physical objects are special-objects in Aristotle’s schema, as they are perceptible by only one sense. His mathematical objects, on the other hand, evoke Aristotle’s common-objects, as they are perceptible by more than one sense.

While Aristotle defines each set of theoretical objects according to their share in the dichotomies separate and inseparable and movable and immovable, Ptolemy defines the objects of the theoretical sciences according to whether and how they are perceptible. The Prime Mover is imperceptible, physical objects are perceptible by only one sense, and mathematical objects are perceptible by more than one sense. In this way, Ptolemy uses epistemological criteria to determine an object’s ontological category—whether it is theological, physical, or mathematical. In addition, Ptolemy bases one of his arguments for the ranking of the three theoretical sciences on the (im)perceptibility of the objects each of the sciences studies. While the Prime Mover is imperceptible and physical objects are perceptible, mathematical objects can be conceived of both with and without the aid of sense perception. In other words, even though mathematical objects are perceptible as common-objects, they can be conceived of independently of perception, as Aristotle indicates in *Metaphysics* M. Thus, Ptolemy reformulates Aristotle’s ontology by defining the sciences and their objects of study in relation to epistemic criteria. His description of scientific objects differs from the accounts in *Metaphysics* E1 and K7, because the underlying dichotomies he and Aristotle use are different. While Aristotle defines the sciences
in relation to two pairs of contraries—whether the objects are separate or inseparable and movable or immovable—Ptolemy defines them according to a spectrum of perceptibility. The Prime Mover, a theological object, is imperceptible, mathematical objects can be conceived of both with and without the aid of perception, and physical objects are perceptible. Nonetheless, the spectrum Ptolemy utilizes to define physics, mathematics, and theology is entirely consistent with Aristotle’s examination of perception as exemplified in the De Anima.

2.3 Knowledge and Conjecture: The Epistemic Value of Physics, Mathematics, and Theology

After defining the three theoretical sciences and their objects of study, Ptolemy comments on whether each of the sciences produces knowledge. As stated above, Aristotle’s division and ranking of the three sciences in Metaphysics E1 and K7 are purely ontological. When defining physics, mathematics, and theology, he does not mention whether these sciences lead to knowledge, perhaps because the same term applies to both science and knowledge: ἐπιστήμη. Ptolemy, on the other hand, uses the term ἐιδήσις, in addition to ἐπιστήμη, to signify knowledge when delineating the sciences’ epistemic success:

From all this we concluded: that the first two divisions of theoretical philosophy should rather be called guesswork (ἐἰκασία) than knowledge (κατάληψιν ἐπιστημονική), theology because of its completely invisible (ἀφανείς) and ungraspable (ἀνεπίληπτον) nature, physics because of the unstable (ἀστάτον) and unclear (ἀδήλον) nature of matter; hence there is no hope that philosophers will ever be agreed about them; and that only mathematics can provide sure (βεβαία) and incontrovertible (ἀμεταπίστον) knowledge (ἐιδήσιν) to its devotees, provided one approaches it rigorously. For its kind of proof proceeds by indisputable methods, namely arithmetic and geometry. Hence we were drawn to the investigation of that part of theoretical philosophy, as far as we were able to the whole of it, but especially to the theory concerning divine and heavenly things. For that alone is devoted to the investigation of the eternally unchanging. For that reason it too can be eternal (αἰεί) and unchanging (ὅσοντος ἔχειν).
Ptolemy claims that both theology and physics are conjecture (ἐικασία) and that mathematics alone yields sure and incontrovertible knowledge (ἐπίθεσις).

Ptolemy’s description of physics as conjectural is only slightly unconventional. After all, in *Almagest* 1.1 he defines physics as the study of mainly sublunary bodies. As stated above, according to Aristotelian physics, sublunary bodies undergo changes such as generation and corruption, growth and diminution, alteration, and mixture. Ptolemy explains that one cannot have knowledge of physical bodies because they are unstable (ἄστατος) and unclear (αδηλος).

While in Aristotle’s cosmology sublunary bodies are unstable, it does not follow that the instability of a body prevents one from obtaining knowledge of the universals that enform it. Indeed, for Aristotle, these universals are knowable and unchanging despite their abstraction from changeable bodies. For Ptolemy, however, the unstable nature of sublunary bodies seems in itself a sufficient reason to conclude that physics is conjectural.

On the other hand, Ptolemy’s representation of theology as conjectural is utterly unaristotelian. For both Aristotle and Plato, theology yields knowledge because it deals with the highest ontological order. In *Metaphysics* M, Aristotle depicts an epistemological hierarchy wherein the ontological priority of an object determines human beings’ success at understanding it:

> The more that what is known is prior in definition, and the simpler, the greater the accuracy (ἀκριβές) (i.e. simplicity (ἀπλούς)) obtained. So there is more accuracy where there is no magnitude (μεγέθους) than where there is, and most of all where there is no movement (κίνησις); though if there is movement

46 Ptolemy *Almagest* 1.1, H6-7, after G.J. Toomer.
accuracy is greatest if it is primary movement, this being the simplest, and uniform movement the simplest form of that.\textsuperscript{48}

Considering that Aristotle places this argument in his chapter on mathematical objects, he is most likely discussing the relationship of mathematics to theology and physics. After all, he maintains that the most accurate knowledge is of an entity that is unmoved and without magnitude. The only objects in Aristotle’s cosmology that match this description is the Prime Mover or the many unmoved movers of \textit{Metaphysics} Lambda. The next most accurate science is of something with a primary movement. Aristotle explains in the \textit{Physics} that the most primary type of movement is motion from place to place, and, according to the \textit{De Caelo}, it is aether, Aristotle’s fifth element, that experiences only this movement. After theology, then, astronomy, a branch of mathematics, is the most accurate field of inquiry.\textsuperscript{49} While theology ranks first and mathematics second, physics lies at the bottom of the epistemology ladder. Physical bodies have magnitude and experience many changes, in addition to motion from place to place.

Like Aristotle, Plato praises metaphysics as superior to the study of the mundane. In Book 7 of the \textit{Republic}, when outlining the education of the philosopher-king, Socrates contrasts knowledge with opinion. The former concerns true being, while the latter concerns its derivative, the world of becoming:

\begin{quote}
Therefore, dialectic is the only inquiry that travels this road, doing away with hypotheses and proceeding to the first principle itself, so as to be secure. And when the eye of the soul is really buried in a sort of barbaric bog, dialectic gently pulls it out and leads it upwards, using the crafts we described to help it and cooperate with it in turning the soul around. From force of habit, we’ve often called these crafts sciences or kinds of knowledge, but they need another name, clearer than opinion, darker than knowledge…It will therefore be enough to call the first section knowledge, the second understanding, the third belief, and the fourth conjecture, just as we did before. The last two together we call opinion, the
\end{quote}

\textsuperscript{48} Aristotle \textit{Metaphysics} 1078a9-13, trans. Julia Annas.
\textsuperscript{49} In \textit{Metaphysics} 1077a2-7, Aristotle counts astronomical objects as mathematical when he compares them to geometrical objects and the objects of optics and harmonics.
other two, intellection. Opinion is concerned with becoming, intellect with being. And as being is to becoming, so intellection is to opinion, and as intellection is to opinion, so knowledge is to belief and understanding to conjecture.  

In the Republic, Socrates states that the study of metaphysical reality yields secure knowledge, while the study of becoming, the physical, visible world, is mere opinion.

Hence, Ptolemy’s description of theology as conjecture is neither Aristotelian nor Platonic. Liba Taub recognizes that Ptolemy’s assertion is not Aristotelian in Ptolemy’s Universe:

He made the rather radical, and certainly non-Aristotelian, statement that both theology and physics should be called conjecture (εἰκασία) rather than knowledge (κατάληψις ἐπιστημονική). He reasoned that theology should not be called knowledge because of the invisibility and ungraspability (διὰ τὸ παντελῶς ἀφανὲς αὐτοῦ καὶ ἀνεπιλήπτον) of its subject; physics should not, because of the instability and lack of clarity of matter (διὰ τὸ τῆς ὑλῆς ἀστατον καὶ ἀδηλον). The reader is left with the clear impression that, so far as Ptolemy was concerned, mathematics represents the only true kind of knowledge.

While Taub recognizes the unaristotelian nature of Ptolemy’s claim, she offers no explanation of why it is that Ptolemy casts physical and theological objects in such a negative light; she only asserts Ptolemy’s preference for mathematics. Moreover, Taub takes Ptolemy’s preference to mean that, for Ptolemy, mathematics is a type of theology: “Ptolemy regarded mathematical astronomy as the best kind of theology which is available to man.”

Identifying mathematics with theology is clearly not what Ptolemy does in the Almagest, and even heuristically it does not explain why Ptolemy believed mathematics yields knowledge while theology is merely conjectural.

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51 Taub, 26.
52 Taub, 29.
I would argue that Ptolemy’s appraisal of mathematics as knowledge and physics and theology as conjecture is ultimately based on his application of Platonic epistemology to an Aristotelian form of empiricism. At the root of Ptolemy’s distinction between conjecture and knowledge is the Platonic dichotomy between δόξα and ἐπιστήμη. Plato’s distinction between opinion and knowledge was still a concern within Platonic circles at the time of Ptolemy’s writing. While the Stoics also contrasted opinion with knowledge, as Sextus Empiricus asserts in Adversus mathematicos 7.151, the similarity in concepts and interpretation between Ptolemy’s texts and Alcinous’ Didaskalikos situates Ptolemy more firmly within the Platonic tradition. The identity of Alcinous has been debated for centuries, but scholars have narrowed his identity down to a Middle-Platonist philosopher living, most likely, in the first or second century C.E., in other words, roughly contemporarily with Ptolemy. In the Didaskalikos, Alcinous endeavors to summarize the principles of Plato’s philosophy. As was common with Middle Platonic writers, he blends several philosophical influences: Platonism, of course, as well as Aristotelianism and Stoicism.

To begin with, in chapter 3 of the Didaskalikos, Alcinous presents the Aristotelian distinction between theoretical and practical knowledge. Like Ptolemy, he does not contrast productive knowledge with the theoretical and the practical. He states, “There are two types of life, the theoretical and the practical. The summation of the theoretical life lies in the knowledge of the truth, while that of the practical life lies in the performance of what is counseled by reason. The theoretical life is of primary value; the practical of secondary, and involved with necessity.”

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introduces Aristotle’s tripartite division of theoretical knowledge. Like Ptolemy, he identifies each of the sciences with a class of entities in the cosmos:

Of theoretical philosophy, that part which is concerned with the motionless and primary causes and such as are divine is called theological; that which is concerned with the motion of the heavenly bodies, their revolutions and periodic returns, and the constitution of the visible world is called physical; and that which makes use of geometry and the other branches of mathematics is called mathematical.\(^\text{55}\)

The most similar aspect to Ptolemy’s account is Alcinous’ description of theology. Causes that are motionless, primary, and divine are, according to Alcinous, theological. These characteristics of theological entities could be attributed to an Aristotelian Prime Mover, such as described by Ptolemy in *Almagest* 1.1. The most dissimilar aspect of Alcinous’ definitions of the sciences as compared to Ptolemy’s is the former’s description of physics. While Ptolemy mainly associates physics with the study of the sublunar realm, Alcinous includes cosmological and astronomical concepts as physical. In particular, the movement of the stars (τὴν τῶν ἀστρων φορὰν) is a cosmological phenomenon, and the physical constitution of the cosmos (τοῦτοῦ κόσμου τὴν σύστασιν), while it may include the sublunar realm, emphasizes the composition of the superlunar region. John Dillon has observed that Alcinous borrows the phrases “the motion of the heavenly bodies” and “the constitution of this world” from Plato’s *Republic* 530a and *Timaeus* 32c, respectively.\(^\text{56}\) No doubt, Alcinous’ inclusion of cosmological concepts in his definition of physics stems from a Platonic tradition of amalgamating the two fields. More striking, however, is Alcinous’ portrayal of the revolutions and periodic returns (τὰς τούτων περιόδους καὶ ἀποκαταστάσεις) of heavenly bodies as the subject of physics. One would expect that these concepts would fall under the category of mathematics, as they concern the

\(^{55}\) Ibid. 3.4, H153-154, after John Dillon.

\(^{56}\) Dillon, 60.
mathematically measured movements of heavenly bodies, or astronomical phenomena. Yet, Alcinous offers a very limited account of mathematics in this chapter of the *Didaskalikos*. Indeed, he names only geometry as a branch of mathematics.

In chapter 7 of the *Didaskalikos*, Alcinous again defines the three theoretical sciences, but in this chapter he offers a more nuanced definition of mathematics and a slightly altered account of physics:

> Next let us discuss theoretical science. We have said earlier that the divisions of this are the theological, physical, and mathematical. The aim of the theological is knowledge (γνῶσις) of the primary, highest, and originative causes. The aim of the physical is to learn what is the nature of the universe, what sort of an animal is man, and what place he has in the world, if God exercises providence over all things, and if other gods are ranked beneath him, and what is the relation of men to the gods. The aim of the mathematical is to examine the nature of plane and three-dimensional being, and the phenomena of change and motion from place to place.57

The account of theology here resembles Alcinous’ earlier description in chapter 3. Theology concerns primary causes. Physics, on the other hand, studies the nature of the universe (ἡ τοῦ παντὸς φύσις), the nature of human beings, and the relationship between gods and human beings. As in chapter 3, physics includes cosmological matters, such as the nature of the universe. Astronomical concepts, however, do not fall under physics. Instead, Alcinous frames theological questions, such as the activity of God and the existence of other gods, as pertaining to the study of physics. Concerning mathematics, Alcinous again includes geometry as a branch of mathematics, but he adds the study of two-dimensional objects, motion from place to place (κίνησις), and change in general (φωρα), as mathematical. Considering that Alcinous includes motion from place to place as a mathematical concept in chapter 7, it is curious that in chapter 3 he portrays the revolutions and periodicities of heavenly bodies as falling within the scope of

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57 Alcinous *Didaskalikos* 7.1, H160-161, after John Dillon.
One possible explanation for this discrepancy is Alcinous’ emphasis in chapter 7. Dillon highlights the influence of Plato’s *Republic* 7 on Alcinous’ definition of mathematics in this chapter: “His treatment of it is heavily dependent on *Republic* 7. 524d-533d, as we shall see, and betrays no independent interest in mathematics on the part of A.”58 After defining mathematics in chapter 7, Alcinous proceeds to delineate the role of mathematics in the education of the philosopher-king. In this context, astronomy, along with arithmetic, geometry, stereometry, and harmonics, counts as a branch of mathematics. Alcinous defines astronomy as the “means of which we will study in the heaven the motions of the stars and the heaven, and the creator of night and day, the months and the years.”59 While Alcinous discusses the periodic revolutions of heavenly bodies as if they are the concern of physics in chapter 3, he treats astronomy as a branch of mathematics when describing the proper education of a philosopher. As a result, one is left with the distinct impression that Alcinous did not maintain a consistent definition of astronomy, as either physical or mathematical.

More significant for our purposes is Alcinous’ concern with the dichotomy between δόξα and ἐπιστήμη. In chapter 4 of the *Didaskalikos*, he ascribes to Plato his own theory of the criterion of truth and the nature of knowledge. His account of the criterion contains some of the same concepts that Ptolemy utilizes in *On the Kritêrion*. Alcinous splits the criterion into three parts: that which judges (or the agent of judgment), that being judged, and the process of judgment. He identifies the agent with the philosopher and reason with the means, or instrument, by which the truth is judged.60 Ptolemy’s list of the criterion’s components includes two of these terms—that which judges (which Ptolemy identifies with the intellect) and that being judged. To

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58 Dillon, 86.
60 Ibid. 4.2, H154.
these two terms Ptolemy adds the goal of judgment (that for the sake of which it is judged, or truth) as well as a distinct instrument (sense perception) and means (reason). When refuting the criterion in *Adversus mathematicos* 7.35, Sextus Empiricus identifies three terms: the agent, that through which an object is judged, and the application. Consequently, in listing several components of the criterion, Ptolemy adheres to a contemporary trend evidenced by the texts of Alcinous and Sextus Empiricus.

After defining the criterion of truth, Alcinous portrays Plato’s distinction between knowledge and opinion. According to Alcinous, the objects of intellection yield knowledge (ἐπίστημη), and scientific reason (ἐπιστημονικός λόγος) is sure (βέβαιος) and stable (μόνιμος). Opinion (δόξα), on the other hand, derives from sense perception and, because it is concerned with unstable objects, it is only likely (ἐγκός). Alcinous explains this distinction in the following:

This latter, too, has two aspects: one concerned with the objects of intellection (νοητά), the other with the objects of sensation. Of these, the former, that concerning the objects of intellection, is science (ἐπίστημη) and scientific reason, while that concerning sense-objects is opinion, and reason based on opinion (δόξα). For this reason scientific reason possesses stability and permanence, inasmuch as it concerns principles which are stable and permanent, while the reason based on persuasion and opinion possesses a high degree of (mere) likelihood, by reason of the fact that it is not concerned with permanent objects.

Because the objects of intellection are permanent, the knowledge and reason associated with them are sure and permanent. Because the objects of sense perception are unstable, the reason associated with them is itself unstable, being opinion and only likely. The ontological status of

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61 Ptolemy *On the Kritêrion*, La4-5.


the object, stable or unstable, determines the epistemological security of human beings’ reasoning on the object. Plato makes a similar distinction between knowledge and opinion in Books 5 and 6 of the Republic. Whether a human being apprehends a Form or a likeness of a Form determines whether one has knowledge or opinion of it. Therefore, in his basic definitions of opinion and knowledge, Alcinous follows Plato.

Alcinous goes on to distinguish between two types of intellection. The first, he claims, exists before metempsychosis and the second applies after one’s soul has become embodied. He delineates these two types as follows: “Intellection is the activity of the intellect as it contemplates the primary objects of intellection. There seem to be two forms of this, the one prior to the soul’s coming to be in this body, when it is contemplating by itself the objects of intellection, the other after it has been installed in this body.”

Each type of intellection contemplates a different set of intelligible objects. The former understands the Ideas, or Plato’s Forms (ιδέας); the second comprehends enmattered forms (ὅσ τὰ ἐνυπολογητὰ συμβαίνουσα), an Aristotelian concept. Alcinous explains, “and since of intelligible objects some are primary, such as the (transcendent) Ideas, and others secondary, such as the forms in matter, which are inseparable from matter, so also intellection will be twofold, the one kind of primary objects, the other of secondary.” While intellect studies the Forms through direct thought or intuition (νόησις), enmattered forms are apprehended through scientific reasoning. The intellection of enmattered forms comes about through the remembrance of the intellection of the Forms before embodiment. Quoting Plato’s Phaedrus 246e, Alcinous portrays intellection of enmattered forms as such: “The natural concept (φυσικὴ ἔννοια) is called by him, ‘simple item of

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64 Ibid. 4.6, H155.
65 Ibid. 4.7, H155.
66 Dillon, 69.
knowledge’, ‘the wing of the soul’, and sometimes ‘memory’.”67 Alcinous elaborates this theory of learning through recollection in the following:

That learning is remembering we may infer as follows. Learning cannot arise in any other way than by remembering what was formerly known. If we had in fact to start from particulars in forming our conception of common qualities, how could we ever traverse the infinite series of particulars, or alternatively how could we form such a conception on the basis of a small number (for we could be deceived, as for instance if we came to the conclusion that only that which breathed was an animal); or how could concepts have the dominant role that they do have? So we derive our thoughts through recollection, on the basis of small sparks, under the stimulus of certain particular impressions remembering what we knew long ago, but suffered forgetfulness of at the time of our embodiment.68

Even though Alcinous accepts that some objects of intellection, namely the enmattered forms, are perceptible, he maintains an absolute distinction between opinion and knowledge. Apprehension of the intelligible world is knowledge obtained through recollection; cognition of the sensible world—albeit composed of both intelligible and unintelligible objects—is opinion. Alcinous explains this distinction accordingly: “Accepting that the intelligible world is the primary object of intellection, and that the sensible world is a composite, the intelligible world is judged by intellection along with reason, that is to say, not without the aid of reason, and the sensible world by opinion-based reason not without the aid of sense-perception.”69 While Alcinous incorporates Aristotelian and Stoic elements into his epistemology—such as enmattered forms and natural concepts, respectively—his overall understanding of opinion, knowledge, and, especially, the latter’s acquisition through recollection of the Forms is thoroughly Platonic.

In On the Kritêrion, Ptolemy appropriates the distinction between δόξα and ἐπιστήμη. How he defines these terms, however, is distinctive. For Ptolemy, an Aristotelian form of

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68 Ibid. 25.3, H178.
69 Ibid. 4.8, H156.
empiricism underlies the distinction. As in Aristotle’s *De Anima*,\(^{70}\) in *On the Kritērion* intellect is dependent upon the transmission of sense impressions by means of *phantasia*.\(^{71}\) Through memory, not of the Forms but of sense impressions and concepts developed in relation to them, intellect has the ability to pass judgment on both sense perception and the objects perceived.\(^{72}\) Intellect makes inferences about the perceived objects, and Ptolemy categorizes these inferences as either opinion (δόξα) or knowledge (ἐπιστήμη). He states, “Internal *logos* takes two forms. Its simple and unarticulated apprehension of conceptions is opinion (δόξα) and supposition (ὀίησις): when its apprehension is skillful (τεχνική) and firmly grounded, it is knowledge (ἐπιστήμη) and understanding (γνώσις).”\(^{73}\) According to Ptolemy, opinion and knowledge are of the same objects, but their inferences are at a different stage of development. Opinion concentrates on an immediate object, while knowledge judges the object in relation to remembered sense impressions. Ptolemy explains that the faculty of thought “exhibits a capacity for forming opinions (δοξαστική) through its connections with the senses, and a capacity for knowledge (ἐπιστημονική) through its independent re-examination of external objects.”\(^{74}\) Furthermore, knowledge depends on the skillful (τεχνική) judgment of sense impressions.

Ptolemy elucidates the distinction between δόξα and ἐπιστήμη in the following:

> When the internal *logos* of thought combines with these simple and non-inferential *kriteria*, even *logos* can still only form opinions (δοξαστική) if it concentrates exclusively on its immediate object. But when it makes clear skillful (τεχνική) distinctions, it at once enters the state of knowledge (ἐπιστημονική). This involves separating and combining the differences and non-differences between actual things, and moving up from particulars to universals and on to the genera and species of the objects before it.\(^{75}\)

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\(^{70}\) See Aristotle *De Anima* 427b-429a.

\(^{71}\) Ptolemy *On the Kritērion*, La13.

\(^{72}\) Ibid.

\(^{73}\) Ptolemy *On the Kritērion*, La6, after Liverpool/Manchester Seminar on Ancient Philosophy.

\(^{74}\) Ibid., La21, trans. Liverpool/Manchester Seminar on Ancient Philosophy.

\(^{75}\) Ibid., La18, after Liverpool/Manchester Seminar on Ancient Philosophy.
According to Ptolemy, opinion can be transformed into knowledge by means of skillful analysis.

The idea that opinion and knowledge can be of the same objects is not unique to Ptolemy. Indeed, even Plato suggests as much. In the *Meno*, for instance, Socrates converts the slave boy’s right opinion of a mathematical problem into knowledge. Socrates proclaims, “These opinions have now just been stirred up like a dream, but if he were repeatedly asked these same questions in various ways, you know that in the end his knowledge about these things would be as accurate as anyone’s.” For Plato, one transforms opinion into knowledge through recollection of the Forms from the time before embodiment. Ptolemy, on the other hand, does not portray a belief in the pre-existence of the soul in his texts. According to *On the Kritêrion*, knowledge is merely the skillful examination of perceived objects. It is because opinion and knowledge both interact with sense perception, and because, in the pursuit of knowledge, one may utilize skilled reasoning methods to transform opinion into knowledge, that opinion and knowledge may be different epistemic states related to the same object.

Ptolemy’s use of skillful (τεχνική) judgment to distinguish knowledge from opinion stems from an adaptation of Aristotelian empiricism. In *Metaphysics* A1, Aristotle declares that experience (ἐμπειρία) derived from sense impressions generates knowledge (ἐπιστήμη) and art (τέχνη). Like knowledge, art is a product of universal judgments. Aristotle portrays the relation of art to universals (καθόλου) in the following passage:

> It would seem that for practical purposes experience is in no way inferior to art; indeed we see men of experience succeeding more than those who have theory without experience. The reason of this is that experience is knowledge (γνώσις) of particulars, but art of universals (η δὲ τέχνη τῶν καθόλου); and actions and the effects produced are all concerned with the particular (καθ’ ἐκαστοῦ).  

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77 Aristotle *Metaphysics* 981a12-17, after Hugh Tredennick (1933).
Art is the apprehension of universals within a specific sphere, distinct from the domain of scientific knowledge (ἐπιστήμη). On the other hand, Aristotle describes τέχνη, in comparison to experience (ἐμπειρία), as ἐπιστήμη, presumably because both art and science deal with universals: “In general the sign of knowledge or ignorance (σημεῖον τοῦ ἐιδότος καὶ μὴ ἐιδότος) is the ability to teach, and for this reason we hold that art rather than experience is knowledge (ἐπιστήμην); for the artists can teach, but the others cannot.”78 Furthermore, Aristotle describes the development of various arts and includes among them mathematics: “Thus the mathematical arts originated in the neighborhood of Egypt, because there the priestly class was allowed leisure.”79 The relationships Aristotle outlines among τέχνη, ἐπιστήμη, and mathematics appears to have influenced Ptolemy’s interpretation of the distinction between δόξα and ἐπιστήμη. According to Ptolemy, the skillful (τεχνική) treatment of opinions, which deal with particulars, may be transformed into scientific knowledge, which concerns universals. Furthermore, considering that Aristotle portrays mathematics as an art (τεχνη), and mathematics for Ptolemy is knowledge (ἐπιστήμη), it is fitting that what distinguishes δόξα from ἐπιστήμη for Ptolemy is that the latter is τεχνική.

In the Harmonics, Ptolemy repeats this distinction between δόξα and ἐπιστήμη and elucidates the terms’ relationships to conjecture (ἐικασία) and skill (τέχνη). In particular, he describes τέχνη as a cause corresponding to reason (λόγος): “Of the cause that is in accordance with reason, one aspect is intelligence, corresponding to the diviner form, one is skill (τέχνη), corresponding to reason itself, and one is habit, corresponding to nature.”80 In the Harmonics Ptolemy associates skill with reason, and in On the Kritērion, as stated above, the application of

78 Ibid. 981b7-10.
79 Ibid. 981b24-25.
80 Ptolemy Harmonics 3.3, D92.24-26, trans. Andrew Barker.
skill or reason to sense perception yields knowledge. Moreover, in the Harmonics Ptolemy identifies opinion with conjecture. While listing the various parts of the soul, he states the following:

The intellectual part, finally, has at most seven different species, equal in number to the species of the octave: these are imagination, concerned with [the reception of] communications from perceptibles, intellect (νοῦς), concerned with the first stamping-in of an impression, reflection, concerned with the retention and memory of the stamped impressions, thought (διάνοιαν), concerned with recollection and enquiry, opinion (δόξα), concerned with superficial conjecture (ἐπιπολης ἐικασίαν), reason (λόγος), concerned with correct judgment, and knowledge (ἐπιστήμην), concerned with truth and understanding (κατάληψιν).81

Ptolemy clearly indicates in the Harmonics that opinion concerns conjecture. Therefore, when Ptolemy calls theology and physics conjecture in the Almagest, he associates them with opinion.

Ptolemy’s association of δόξα with ἐικασία has a precedent in Socrates’ discussion of the divided line in Republic 6 and his reiteration of the concept in Republic 7 with respect to the education of the philosopher-king.82 Socrates claims that there are two types of entities: the visible and the intelligible. In relation to these two types of entities, an individual may have different types, or levels, of comprehension. Of the intelligible, one may have knowledge (ἐπιστήμη) and understanding (διάνοια); of the visible, one may have belief (πίστις) and conjecture (ἐικασία). Socrates calls knowledge and understanding types of intellection (νόησις) and belief and conjecture, the types of cognition dealing with the visible world, opinion (δόξα).

He lists these types of cognition accordingly:

It will therefore be enough to call the first section knowledge, the second understanding, the third belief, and the fourth conjecture, just as we did before. The last two together we call opinion, the other two, intellection. Opinion is concerned with becoming, intellect with being. And as being is to becoming, so

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81 Ibid. 3.5, D96.21-27.
82 Plato Republic 509dff., 533c-534a.
intellection is to opinion, and as intellection is to opinion, so knowledge is to belief and understanding to conjecture.\textsuperscript{83}

Considering that Socrates characterizes conjecture as a type of opinion in the \textit{Republic}, Ptolemy’s description of δόξα as concerning ἐικοσία is entirely consistent with Plato’s philosophy. What is unique to Ptolemy’s account is his application of ἐικοσία. For Ptolemy, conjecture is not restricted to the visible realm. Physics and theology are conjectural.

Ptolemy’s association of physics and theology with conjecture and mathematics with knowledge ultimately hinges on an epistemic criterion, the (im)perceptibility of the objects that each field studies. If knowledge is the product of skilled inferences from observation, then theology and physics do not produce knowledge because they do not yield the correct type of cognition. In \textit{Almagest} 1.1, Ptolemy describes the Prime Mover as invisible (ἀορατὸς).\textsuperscript{84} Because knowledge is dependent upon sense perception, the invisible nature of this theological object prevents human beings from procuring knowledge of it. Physical objects, on the other hand, are perceptible. Yet, they cannot be the objects of knowledge, because their changeability prevents one from making skilled inferences from their sense impressions. Ptolemy implies that the unstable (ἀστατὸς) and unclear (ἀδηλος) nature of (sublunar) physical objects prevents the natural philosopher from making stable and clear inferences. As a result, he claims that in respect to theology and physics “there is no hope that philosophers will ever be agreed about them.”\textsuperscript{85} Because philosophers cannot make skilled inferences from theological and physical objects—the former because of their invisible nature, the latter because of their unstable and unclear nature—these fields of inquiry yield conjecture, a type of opinion, rather than knowledge. This conclusion combines an Aristotelian form of empiricism with the Platonic

\textsuperscript{83} Ibid. 533e-534a, after G.M.A. Grube.
\textsuperscript{84} Ptolemy \textit{Almagest} 1.1, H5.
\textsuperscript{85} Ibid., H6, trans. G.J. Toomer.
concern for categorizing the objects of opinion.

While philosophers are not able to agree on the nature of theological and physical objects, mathematicians are able to reach a consensus. Galen, a contemporary of Ptolemy, portrays mathematicians as reaching a consensus in his *De proprietum animi cuiuslibet affectuum dignotione et curatone*. While philosophers quibble among themselves, mathematicians, according to Galen, do not disagree with one another. Ptolemy, however, makes a further claim than Galen’s. He asserts that not only do mathematicians reach a consensus, but, even more, mathematics yields knowledge. It is the only science that utilizes his scientific method, as outlined in *On the Kritêrion* and elaborated in the *Harmonics*. In *Almagest* 1.1, Ptolemy proclaims that mathematics yields sure (βεβαίος) and incontrovertible (ἀμετάπιστος) knowledge (εἰδησις) when approached rigorously (ἐξεταστικῶς). In addition, mathematics proceeds by “indisputable methods” (ἀναμφίσβήτητος ὀδοί), such as arithmetic and geometry. In *On the Kritêrion*, Ptolemy defines knowledge (ἐπιστήμη) as an apprehension that is skillful and incontrovertible (ἀμετάπιστος), the same term he uses in the *Almagest*. Knowledge is produced through the skillful agency of intellect, which judges sense perceptions by means of reason. Ptolemy frames this process as the criterion of truth:

Since we observe, examine, and come to understand reality by sense perception, reasoning, and by discourse either in our own minds or with other people, it would be not unreasonable to match sense perception with the instrument with which the subject under judgment is judged, intellect with the agent of judgment, and logos with the means by which the agent judges. In other words, the intellect obtains knowledge through the judgment of sense perceptions by means of reason. Moreover, in *Almagest* 1.1, Ptolemy chooses to use the term εἰδησις for

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86 Galen *De propriorum animi cuiuslibet affectuum dignotione et curatone*, B42. Cf. ibid., B93.
87 Ptolemy *Almagest* 1.1, H6, trans. G.J. Toomer.
88 Ptolemy *On the Kritêrion*, La6.
89 Ibid., La5, after Liverpool/Manchester Seminar on Ancient Philosophy.
mathematical knowledge, as opposed to ἐπιστήμη. Considering that ἐπιστήμη derives from the verb ὁδός, literally meaning ‘to have seen’, it is fitting that the term Ptolemy uses for knowledge reflects the process by which one obtains that knowledge. According to Ptolemy’s epistemic system, all knowledge is based fundamentally on sense perception.

The scientific method Ptolemy uses in the *Harmonics* enhances the procedure introduced in *On the Critērion*. In the *Harmonics*, Ptolemy portrays the practice of harmonics and astronomy as a scientific interplay, back and forth, between observation and reason, and aimed at the construction of knowledge. After the senses perceive rough distinctions, reason analyzes these distinctions, determines what the accurate distinctions should be, and guides the senses towards more accurate perception. In relation to harmonics, Ptolemy explicates this process as follows:

Rather, hearing is concerned with the matter and the modification, reason with the form and the cause, since it is in general characteristic of the senses to discover what is approximate and to adopt from elsewhere what is accurate, and of reason to adopt from elsewhere what is approximate, and to discover what is accurate. For since matter is determined and bounded only by form, and modifications only by the causes of movements, and since of these the former [i.e., matter and modifications] belong to sense perception, the latter to reason, it follows naturally that the apprehensions of the senses are determined and bounded by those of reason, first submitting to them the distinctions that they have grasped in rough outline—at least in the case of the things that can be detected through sensation—and being guided by them towards distinctions that are accurate and accepted.90

Communication back and forth between the senses and reason produces rational postulates that save the phenomena. In the following passage, Ptolemy characterizes harmonics and astronomy as sciences that utilize this method:

The aim of the student of harmonics must be to preserve in all respects the rational postulates of the *kanon*, as never in any way conflicting with the perceptions that correspond to most people’s estimation, just as the astronomer’s aim is to preserve the postulates concerning the movements of the heavenly

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90 Ptolemy *Harmonics* 1.1, D3.4-14, trans. Andrew Barker.
bodies in concord with their carefully observed courses, these postulates themselves having been taken from the obvious and rough and ready phenomena, but finding the points of detail as accurately as is possible through reason.91

According to Ptolemy, harmonics and astronomy follow the method by which one obtains knowledge. Moreover, as in the *Almagest*, Ptolemy asserts in the *Harmonics* that astronomy and harmonics employ arithmetic and geometry “as indisputable instruments” (ἀργανά ἀναμφισβήτητα).92 Therefore, if branches of mathematics, such as harmonics and astronomy, exercise Ptolemy’s method for creating knowledge, and they utilize indisputable methods, such as arithmetic and geometry, then Ptolemy’s description of mathematics in *Almagest* 1.1 is entirely cogent. Mathematics provides sure and incontrovertible knowledge because the method by which one practices mathematics produces knowledge.

Ptolemy makes a further claim in *Almagest* 1.1 that mathematics can make a good guess at the nature of theology and contribute significantly to the study of physics. He presents this argument in his discussion of mathematics:

Furthermore it can work towards the other apprehensions [of the two other divisions of theoretical philosophy] no less than they do. For this is the best science to help theology along its way, since it is the only one which can make a good guess (καταστοχάζωθαί) at [the nature of] that activity which is unmoved and separated; [it can do this because] it is familiar with the attributes of those beings which are on the one hand perceptible, moving and being moved, but on the other hand eternal and unchanging, [I mean the attributes] having to do with motions and the arrangements of motions. As for physics, mathematics can make a significant contribution. For almost every peculiar attribute of material nature becomes apparent from the peculiarities of its motion from place to place.93

Besides being the only science productive of knowledge, mathematics has the further ability to contribute to the study of theology and physics, which, without the aid of mathematics, are mere conjecture.

91 Ptolemy *Harmonics* 1.2, D5.13-19, after Andrew Barker.
92 Ptolemy *Harmonics* 3.3, D94.16-17, trans. Andrew Barker
93 Ptolemy *Almagest* 1.1, H7, after G.J. Toomer.
In *Ptolemy’s Universe*, Liba Taub observes that while *Almagest* 1.1 does not borrow the exact phrasing of any of Aristotle’s texts, the idea of the contribution of mathematics to physics is consistent with Aristotle’s theory of motion in the *Physics*. Taub does not mention, however, how Ptolemy’s comments on motion from place to place reflect Aristotle’s description of natural motion in the *De Caelo*. In the *De Caelo*, Aristotle describes the natural, rectilinear motion of the four elements—earth, water, air, and fire. Fire, being light, naturally rises to the circumference of the sublunary realm. Earth, being heavy, naturally falls to the center of the cosmos. Water and air, as intermediate to earth and fire, rise or fall until they reach their respective natural places, in between the spheres of earth and fire. In addition, Aristotle ascribes a pair of basic qualities to each of the four elements. An element contains one permutation of two dichotomies: hot and cold, wet and dry. In *On Generation and Corruption*, Aristotle identifies the hot and cold as active principles. The addition of either heat or coldness leads to the generation and corruption of the elements, or the transmutation of the elements into one another. Conversely, Aristotle’s fifth element, the aether, does not undergo generation or corruption. Characterized by neither heaviness nor lightness, it moves eternally in a circular manner. In this way, aether is always active. Ptolemy’s assertion, then, that the movement of an object reveals its physical nature is consistent with the ideas present in Aristotle’s *Physics*, *De Caelo*, and *On Generation and Corruption*. If a body naturally moves in a circle, it is aethereal. If it naturally moves rectilinearly, it is composed of one or more of the four sublunary elements. Hence, the observation of a body’s motion from place to place—which Ptolemy calls

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94 Taub, 28.
mathematical in *Almagest* 1.1—and the application of geometry, an indisputable method, allows one to make skilled inferences and determine the physical composition of a body.

Concerning mathematics’ ability to shed light on theology, Taub discerns that Ptolemy’s claim is coherent with his description of the sciences earlier in the chapter. She draws on Ptolemy’s second argument for the intermediate status of mathematics:

> Earlier he stated that what is mathematical preserves the divine nature which is the subject matter of theology. Thus, the unchanging form of those things which are eternal and have an aethereal nature, those things which are the subject matter of theology, relies on the ὀυσία (essence) of mathematics for its preservation. In order to understand what is eternal and divine, one must also understand that which keeps the divine eternal and unchanging. Therefore, there is an intimate and necessary connection between theology and mathematics.97

According to Taub, mathematics can make a guess at the nature of theological objects for Ptolemy, because mathematical objects underlie entities that are eternal and divine. This explanation, however, fails to recognize that when Ptolemy proposes his second argument for the intermediate position of mathematics—wherein he portrays mathematical objects as attributes of all existing things—the entities he describes as eternal and unchanging are aethereal. When Ptolemy calls theology conjectural, on the other hand, he identifies it with the study of the invisible, namely the Prime Mover.98 Therefore, acknowledging that mathematical objects can be abstracted from aethereal bodies does not explain why mathematics can make a good guess at the nature of the Prime Mover. Taub repeats this identification of the aethereal with the theological in the following passage:

> Ptolemy had already located that activity which is the subject of theology in the upper regions of the cosmos. The mathematical attributes of the perceptible, but nevertheless eternal, moving things (presumably, but unnamed by Ptolemy, the heavenly bodies) are akin to that divine activity and can be studied by mathematicians. Therefore, mathematics is the surest path to knowledge of that

97 Taub, 26-27.
which is divine and eternal; however, it cannot give true knowledge of the divine, since it does not study the divine activity, but only those kindred attributes which are perceptible.  

Despite her neglect of the Prime Mover, Taub recognizes that it is because aethereal bodies are divine and eternal that mathematics can make a good guess at the nature of theological objects.

It is because mathematical objects have certain characteristics in common with theological objects that mathematics can make a good guess at the nature of theological objects. Ptolemy explains in *Almagest* 1.1 that astronomy studies mathematical objects that are divine, eternal, and unchanging. It is because these objects are eternal and unchanging that the mathematical knowledge associated with them is itself eternal and unchanging. Ptolemy relates his preference for studying astronomy in the following:

> Hence we were drawn to the investigation of that part of theoretical philosophy, as far as we were able to the whole of it, but especially to the theory concerning divine and heavenly things. For that alone is devoted to the investigation of the eternally unchanging. For that reason it too can be eternal and unchanging (which is a proper attribute of knowledge) in its own domain, which is neither unclear nor disorderly.

Astronomy can make a guess at the nature of theological objects because theological objects, like astronomical objects, are eternal and (mostly) unchanging. When defining the Prime Mover, Ptolemy calls it motionless and thereby indicates that it is unchanging and eternal. While aethereal bodies are dissimilar to the Prime Mover in that they are perceptible, they are eternal and unchanging, inasmuch as the only change they experience is motion from place to place. Consequently, mathematics can make a good guess at the attributes of theological objects, because astronomical and theological objects have certain characteristics in common.

When Ptolemy makes the claim that theology is conjectural, he bases this statement not

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99 Taub, 29.
100 Ptolemy *Almagest* 1.1, H6-7, trans. G.J. Toomer.
only on the invisibility of the Prime Mover but on its ungraspable (ἄνεπιληπτος) nature as well. The question arises, how useful is the good guess that mathematics can make if theology is ultimately ungraspable? Ptolemy seems to suggest that the guess that mathematics makes is at least well reasoned. After all, mathematics utilizes a rational method, and mathematical objects, which are perceptible, have certain attributes in common with the Prime Mover that allow for skilled inferences. On the other hand, Ptolemy also seems to imply that, beyond knowing that the Prime Mover exists, one cannot know for certain whether the guess that mathematics makes at the characteristics of the Prime Mover applies. In other words, as Ptolemy maintains, concerning theology and physics "there is no hope that philosophers will ever be agreed about them…" Alcinous makes a similar remark when he distinguishes between divine and human reason in the Didaskalikos. He argues, "Reason in turn takes two forms: the one is completely ungraspable (ἄληπτος) and unerring (ἄτρεχτος), while the other is only free from error when it is engaged in the cognition of reality. Of these the former is possible for God, but impossible for men, while the second is possible also for men." According to Alcinous, divine reason is ungraspable by human beings; however, human beings can still have unerring knowledge of the Forms. For Ptolemy, the ungraspable nature of the Prime Mover rests on its imperceptibility; one can never corroborate his guess at the nature of the Prime Mover because it is imperceptible.

Nevertheless, Ptolemy suggests that mathematics can produce valid results in the field of physics. To reiterate, Ptolemy asserts, "As for physics, mathematics can make a significant contribution. For almost every peculiar attribute of material nature becomes apparent from the peculiarities of its motion from place to place." Ptolemy echoes this sentiment in Geography

1.1, wherein he asserts that mathematics reveals the nature of the heavens and earth:

These things belong to the loftiest and loveliest of intellectual pursuits, namely to exhibit to human understanding through mathematics [both] the heavens themselves in their physical nature (since they can be seen in their revolution about us), and [the nature of] the earth through a portrait (since the real [earth], being enormous and not surrounding us, cannot be inspected by any one person either as a whole or part by part).

In *Almagest* 1.1, Ptolemy gives an example of this application of mathematics to physics. He explains that observation of the movements of bodies divulges their elemental composition. Whether a body moves rectilinearly or circularly reveals whether it consists of corruptible or incorruptible elements, and, if it moves rectilinearly, whether it moves towards or away from the center of the cosmos indicates whether the elements composing it are heavy and passive or light and active, respectively. As stated above, this geometrical account of natural motion is consistent with Aristotle’s exposition in *On Generation and Corruption*.

Ptolemy again applies geometry to element theory in *Almagest* 1.7, *Planetary Hypotheses* 2.3, and two of his lost works, *On the Elements* and *On Weights*. In *Almagest* 1.7, he depicts the motion of the four elements in geometrical terms in order to situate natural rectilinear motion within a spherical cosmos:

For there is no up and down in the universe with respect to itself, any more than one could imagine such a thing in a sphere: instead the proper and natural motion of the compound bodies in it is as follows: light and rarefied bodies drift outwards towards the circumference, but seem to move in the direction which is ‘up’ for each observer, since the overhead direction for all of us, which is also called ‘up’, points towards the surrounding surface; heavy and dense bodies, on the other hand, are carried towards the middle and the centre, but seem to fall downwards, because, again, the direction which is for all us towards our feet, called ‘down’, also points towards the centre of the earth.

In *Planetary Hypotheses* 2.3, Ptolemy also describes the sublunary elements as rising and falling.

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The four elements move rectilinearly, while the fifth element, the aether, moves uniformly and circularly. Ptolemy is said to have applied geometry to element theory in *On the Elements* and *On Weights* as well. These two books are no longer extant, but, in his commentary on the *De Caelo*, Simplicius attests to Ptolemy’s theory of natural motion. Whereas Ptolemy asserts in *Planetary Hypotheses* 2.3 that the four elements rest in their natural places, according to Simplicius, in *On the Elements* Ptolemy argues that elements either rest or move circularly when in their natural places and move rectilinearly only when displaced from their natural places.\(^{106}\) Xenarchus puts forward this same argument in his *Against the Fifth Substance*, also cited by Simplicius.\(^{107}\) In *On Weights*, so Simplicius maintains, Ptolemy adds that neither air nor water has weight in its natural place.\(^{108}\) Because the subject matter of *On the Elements* and *On Weights* is similar, it is possible that they were originally one text, later referred to by two names.\(^{109}\) Either way, what is significant is that Ptolemy consistently describes his element theory in geometrical terms, even if the extant accounts of his element theory differ. I will continue this examination of Ptolemy’s element theory in Chapter 4.

Ptolemy applies mathematics to composite bodies in the *Harmonics*, *Tetrabiblos*, and *Planetary Hypotheses*. In the *Harmonics* he applies the branch of mathematics which investigates the relations between musical pitches, or harmonics, to astrology and psychology; in the *Tetrabiblos* he applies astronomy to astrology; in the *Planetary Hypotheses* he applies astronomy to cosmology. I will discuss these applications of mathematics in Chapter 3 and 4 and thereby demonstrate that in his natural philosophical corpus Ptolemy substantiates his claim


\(^{107}\) See Simplicius in *Cael*. 1.2.21-22.

\(^{108}\) Heiberg, 263-264.

in Almagest 1.1 that mathematics contributes significantly to the study of physics.

2.4 The Contribution of Astronomy to the Study of Theology

The structure of Ptolemy’s argument for the applicability of astronomy to theology is thoroughly Platonic. In Republic 7, Plato constructs a similar argument. In framing the education of the philosopher-king, Socrates makes the claim that the study of astronomy is necessary because it guides one’s mind toward metaphysical reality. Astronomical objects are, according to Socrates, the most beautiful and exact of visible entities. They imitate the Forms to a more perfect degree than any other component of the physical world and, in this manner, have attributes similar to the Forms. Socrates portrays heavenly bodies as relatively perfect in the following passage:

> It’s like this: We should consider the decorations in the sky to be the most beautiful and most exact of visible things, seeing that they’re embroidered on a visible surface. But we should consider their motions to fall far short of the true ones—motions that are really fast or slow as measured in true number, that trace out true geometrical figures, that are all in relation to one another, and that are the true motions of the things carried along in them. And these, of course, must be grasped by reason and thought, not by sight.\(^{110}\)

Even though heavenly bodies are not as perfect as the Forms, they are useful in gaining understanding of the Forms. Because astronomical objects are beautiful and relatively perfect, they serve as a model of the Forms. Socrates proclaims, “Therefore, we should use the embroidery in the sky as a model in the study of these other things.”\(^{111}\) While for Plato, astronomical bodies are rather good images of the Forms and, in this way, lead to knowledge of metaphysical entities, the case for Ptolemy is slightly different. After all, Ptolemy adheres to an Aristotelian ontology. Mathematical objects are not images of theological ones. The

\(^{110}\) Plato Republic 529c-d, trans. G.M.A. Grube.

\(^{111}\) Ibid. 529d.
characteristics that astronomical and theological objects share are not differentiated by an ontological hierarchy. Heavenly bodies and the Prime Mover are eternal in exactly the same way. Concerning their unchanging nature, however, heavenly bodies are secondary to the Prime Mover. The Prime Mover is completely motionless; it does not experience any type of change. Conversely, aethereal bodies experience change insofar as they undergo motion from place to place. Nevertheless, they do not experience any other type of change, and motion from place to place is, according to Aristotle’s *Physics*, the primary type of motion. Hence, Ptolemy adapts the Platonic argument for gaining metaphysical knowledge by means of astronomy to a framework of Aristotelian ontology and empiricism. According to Ptolemy, one can make a guess at the nature of the Prime Mover by perceiving and making inferences from astronomical objects. The astronomer studies aethereal bodies, which are eternal and relatively unchanging, and, by abstracting from them their eternality and unchangingness, he can make a good guess at the characteristics of the Prime Mover.

Recalling Plato’s *Republic*, Alcinous discusses the propaedeutic value of mathematics in chapter 7 of the *Didaskalikos*. After listing each of the divisions of mathematics that Plato sets out in *Republic* 7—arithmetic, geometry, stereometry, astronomy, and harmonics—he discusses the merits of astronomy and harmonics:

> We will pay attention also to music, relating the sense of hearing to the same objects; for even as the eyes are naturally suited to astronomy, so is the sense of hearing to harmony; and even as in applying our minds to astronomy we are led from visible objects to invisible and intelligible essence, so in listening to harmonious sound we in the same way transfer our attention from things audible to what is contemplated by the mind itself; whereas if we do not approach these studies in this way, our view of them will be imperfect and unproductive and of no account. For one must pass swiftly from what is visible and audible to those things which may be seen only by the rational activity of the soul.112

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Alcinous describes the contribution of mathematics, especially astronomy and harmonics, to the understanding of metaphysical reality. Considering that Alcinous, a Middle Platonist philosopher roughly contemporary with Ptolemy, discusses the merits of mathematics and the ability of astronomy to guide one’s mind towards metaphysical knowledge, it is not surprising that Ptolemy should adopt a similar argument in the Almagest for the contribution of mathematics to the study of theology.

2.5 Conclusion

While Ptolemy preferred the study of mathematics to other fields of inquiry, his claim that mathematics alone produces knowledge derives from more than a mere preference. Pursuing an eclectic method in his texts, Ptolemy blends the ontology and empiricism of Aristotle with Platonic and Stoic epistemological concerns. He distinguishes the three theoretical sciences—physics, mathematics, and theology—according to whether and how their objects of inquiry are perceptible. Physical objects are special-objects, perceptible by only one sense; mathematical objects are common-objects, perceptible by more than one sense; the Prime Mover, the only unequivocally theological object in Ptolemy’s ontology, is imperceptible. Furthermore, the ability of the three theoretical sciences to yield skilled inferences based on sense impressions determines their epistemic success. Because the Prime Mover is imperceptible and physical objects are unstable and unclear, theology and physics amount to conjecture. Mathematics, on the other hand, yields sure and incontrovertible knowledge. Through the skillful and rigorous pursuit of mathematics, the interplay of observation and reason, and the application of arithmetic and geometry, which are indisputable methods, the mathematician produces knowledge. Ptolemy’s mixture of philosophical influences—
Aristotelian, Platonic, and, to a lesser extent, Stoic—reflects the practice of contemporary Middle Platonists, such as Alcinous. Whether Ptolemy applies this scientific method for the production of knowledge in his texts, and whether he characterizes his mathematical and physical hypotheses as knowledge and conjecture, respectively, I will investigate in the following chapters.
Chapter 3

Ptolemy’s Epistemology and Ontology of Mathematics

In the previous chapter, I argued that Ptolemy accepted Aristotle’s ontological schema. Like Aristotle, Ptolemy divides theoretical philosophy into the physical, the mathematical, and the theological. Each of these fields, according to both Aristotle and Ptolemy, studies one type of entity in the cosmos. In *Metaphysics* E1 and K7, Aristotle defines the set of objects each field studies according to two dichotomies: whether the objects are separate or inseparable from matter, and whether they are movable or immovable. Unlike Aristotle, Ptolemy associates each theoretical science with not a class of objects but rather particular objects, existing in the cosmos and distinguished by how and whether they are perceptible. Ptolemy’s description of these objects is still Aristotelian. According to *Almagest* 1.1, physics examines qualities such as white, hot, sweet, and soft, which, like Aristotle’s special-objects in the *De Anima*, are each perceptible by one sense only;\(^1\) mathematics studies forms and motion from place to place as well as shape, number, size, place, and time, which, like Aristotle’s common-objects, are perceptible by more than one sense;\(^2\) theology studies the Prime Mover, which is imperceptible.\(^3\)

This chapter will further investigate how Ptolemy defines mathematical objects, how he describes the relationships between the tools and branches of mathematics, and whether he

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\(^1\) Ptolemy *Almagest* 1.1, H5; see Aristotle *De Anima* 418a11-14.
\(^2\) Ptolemy *Almagest* 1.1, H5-6; see Aristotle *De Anima* 418a17-20.
\(^3\) Ptolemy *Almagest* 1.1, H5.
demonstrates in the *Harmonics* and *Almagest* that he believed mathematics yields sure and incontrovertible knowledge, as he claims in *Almagest* 1.1. This investigation begins with a close philological examination of Ptolemy’s theory of causation as applied to harmonics. Thereafter, I situate Ptolemy’s description of mathematical objects as beautiful—and the ability of sight and hearing to perceive these beautiful objects—in the Platonic and Aristotelian traditions. According to Ptolemy, these beautiful objects exist in music, the heavens, and the human soul. As a result, I go on to analyze Ptolemy’s application of harmonics to psychology, astrology, and astronomy. The chapter culminates with an analysis of Ptolemy’s method and epistemology of harmonics and astronomy, and it closes with some comments on mathematics’ contribution to physics.

### 3.1 Harmonia

In the *Harmonics*, Ptolemy elaborates on the objects, science, and practice of mathematics. Harmonics, specifically, is the science of the relations existing between musical pitches. Ptolemy defines harmonics as such: “…the theoretical science of *harmonia* (ἡ θεωρητικὴ ταύτης ἐπιστήμη) is a form of mathematics, the form concerned with the ratios of differences between things heard, this form itself contributing to the good order that comes from theoretical study and understanding to people habituated in it.”

The technical term that Ptolemy uses when discussing the science, causes, and objects of harmonics is *harmonia*. The few historians of science who have studied the *Harmonics* have identified *harmonia* with the power or function of *harmonia*, which Ptolemy calls the *dynamis harmonikê*. For instance, Andrew Barker, in his *Scientific Method in Ptolemy’s Harmonics*, defines the *dynamis harmonikê* as the

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power human beings have to understand harmonic relations, which they abstract from perceptible objects. Barker states the following:

The expression *dunamis harmonikê*...has already appeared in the *Harmonics*, in the very first line of the treatise. In that context, it is ‘that which grasps the distinctions related to high and low pitch in sounds’ (3.1-2). It is this *dunamis* whose ‘criteria’ are hearing and reason; and it is very clearly a power or capacity which we ourselves possess, whether as scientists or as musicians or simply as human beings. It is, in fact, the capacity which Ptolemy has been exercising throughout his investigation.5

Barker recognizes that, according to Ptolemy, human beings have a power, or capacity, to grasp formal relations between pitches. Yet, he errs in his analysis of *Harmonics* 1.1. In the first line of the chapter, Ptolemy does not use *dynamis harmonikê* as the subject of the sentence. Rather, it seems that *harmonikê* is the subject while *dynamis* is the predicate. The text reads, ‘Ἀρμονική ἐστι δύναμις καταληπτική τῶν ἐν τοῖς ψόφοις περὶ τὸ ἥξυ καὶ βαρύ διαφορῶν….’6 In his 1989 translation of the text, Barker distinguishes ‘Ἀρμονική’—the subject, modifying the implied noun ἐπιστήμη—from δύναμις, the predicate: “Harmonic knowledge is the power that grasps the distinctions related to high and low pitch in sounds….” Yet, in his 2000 analysis, Barker identifies τὴν ἀρμονικὴν δύναμιν of *Harmonics* 3.3,7 where ἀρμονικὴν is used attributively, with ‘Ἀρμονική ἐστι δύναμις of *Harmonics* 1.1,8 where δύναμις is the predicate of ‘Ἀρμονική. Not only is this identification of the phrases τὴν ἀρμονικὴν δύναμιν and ‘Ἀρμονική ἐστι δύναμις misleading, but I will argue below that the text implies a more subtle distinction between the *dynamis harmonikê* and harmonic knowledge than Barker allows.

6 Ptolemy *Harmonics* 1.1, D3.1-2.
7 Ibid. 3.3, D92.2.
8 Ibid. 1.1, D3.1.
In general, Barker conflates Ptolemy’s usage of the terms *harmonia* and *dynamis harmonikē*. Elaborating on the meaning of the *dynamis harmonikē*, he asserts the following in *Scientific Method in Ptolemy’s Harmonics*:

> The power we are considering, which is now called simply *harmonia*, is not, Ptolemy says, to be conceived as the matter which is moulded to produce something, ‘for it is something active, not passive’ (92.12-13). Nor is it the end or purpose, that which constitutes an actualisation of completed form. What count as ‘ends’ in connection with *harmonia* are such things as ‘good melody, good rhythm, good order and beauty’; and these are not identical with *harmonia* or the *dunamis harmonikē*, but are things brought into being through its agency. This *dunamis*, then, is to be understood as ‘the cause, which imposes the appropriate form on the underlying matter’ (93.13-16). Despite the high level of abstraction, this passage again is readily understood if we identify the *dunamis harmonikē* with a kind of power or capacity which we ourselves possess, in so far as we are capable of bringing certain kinds of ‘material’ into good harmonic order. It is broadly analogous to our capacity to mould sounds into significant speech, or to conduct mathematical calculations; and it is no more (though no doubt also no less) ontologically puzzling than they are.  

Barker argues that the *dynamis harmonikē* has a narrow meaning for Ptolemy. According to Barker, it is a power that only human beings possess that enables them to grasp specific formal relations in the cosmos. At the same time, Barker identifies *harmonia* with the *dynamis harmonikē* and, therefore, treats *harmonia* as a *dynamis* that human beings possess. I will argue below that the text of the *Harmonics* suggests a larger range of meanings for these terms than Barker indicates.

In his article “Ptolemy’s *Harmonics* and the ‘Tones of the Universe’ in the Canobic Inscription,” Noel Swerdlow, like Barker before him, identifies *harmonia* with the *dynamis harmonikē*. At the same time, however, he introduces an additional meaning for the terms. He describes the *dynamis harmonikē* not only as a power human beings have to discover and

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9 Barker, 2000, 260-261.
demonstrate the formal relations existing between pitches but also as the formal relations
themselves:

Ptolemy begins with a new introduction in 3.3-4. Having shown that the power or
function (dynamis) of harmonia, tuning and music in various tunings, can be
reduced to proper ratios, that music itself is a rational science, a science of ratios,
it remains to show the same power of harmonia, of tuning, in the world, where it
is the cause which gives the proper form to underlying matter. This power lies in
that kind of reason, concerned with movement, that causes and discovers what is
ordered, good, and beautiful. It utilizes the highest senses, sight and hearing,
which judge their objects not only as agreeable or disagreeable, as do the other
senses, but according to their beauty, and these senses assist each other, as when
speech is enhanced by diagrams or sight by poetic description…The power of
harmonia is present in all things that have their own source of movement,
especially in those of a more perfect and rational nature, not however in their
matter because of its inconsistency, but in their forms. These more perfect and
rational natures are found, among the divine, in the movements of the heavenly
bodies, and among the mortal, in the movements of the human soul, both of which
are rational and have movement in position.10

Swerdlow describes the dynamis harmonikê as a power that human beings have to discover and
cause harmonic ratios as well as the formal cause of these ratios, which exist in the movements
of certain entities in the cosmos, such as in music, the heavens, and the human soul. While
Swerdlow’s treatment of these terms is rather brief, he is correct in applying more than one
meaning to them.

In the Harmonics, Ptolemy uses the terms harmonia, its adjective, harmonikê, and
dynamis (when used as a technical term pertaining to harmonics) rather fluidly. The range of
their meanings, however, is fixed. He uses them to convey four sets of meanings: (1) The power,
or capacity, of an object to have certain formal characteristics, namely harmonic ratios, (2) The
formal characteristics or function of physical objects that are characterized by these ratios, (3)
The power, or capacity, of human beings to grasp and demonstrate these formal characteristics,

10 N. M. Swerdlow, "Ptolemy's Harmonics and the 'Tones of the Universe' in the Canobic
Inscription." In Studies in the History of the Exact Sciences in Honour of David Pingree, ed. C.
and (4) The science and discourse of these ratios that the student of harmonics studies and practices. Ptolemy uses the term *dynamis* to communicate meanings 1, 2, and 3; he uses *harmonia* to convey meanings 2, 3, and 4; and, he uses *harmonikê* to indicate meanings 2 and 4. Therefore, the *dynamis* relevant to harmonics is a capacity of not only human beings but inanimate objects as well. Furthermore, it will become evident that *harmonia* is not entirely synonymous with Barker’s definition of the *dynamis harmonikê* as a power of human beings. The term *harmonia* encompasses a range of meanings, including this capacity of human beings but also the formal characteristics of objects—which Swerdlow implies is a meaning of the term—as well as the science of these formal characteristics.

To begin with, Ptolemy uses *dynamis* to indicate (1) The capacity of objects to have the formal characteristics of harmonic ratios, (2) The function of objects when characterized by these ratios, and (3) The capacity human beings have to understand and impose these ratios on physical objects. Despite Barker and Swerdlow’s emphasis on the *dynamis harmonikê* as a capacity that human beings possess, Ptolemy more often describes *dynamis* as a property of inanimate objects. He applies the first definition two times, the second definition twenty times, and the third definition only six times. Beginning with the second definition, Ptolemy portrays *dynamis* as the function musical pitches have in relation to one another. In *Harmonics* 2.5, a chapter called “How the names of the notes are understood in relation to position (\(\theta\varepsilon\iota\nu\)) and to function (\(\delta\upsilon\sigma\alpha\omicron\mu\iota\nu\)),”¹¹ Ptolemy states the following:

…we give the following names, sometimes with respect to their actual position (\(\theta\varepsilon\iota\nu\)), that is, to their being higher or lower absolutely…Sometimes we name them with respect to function (\(\delta\upsilon\sigma\alpha\omicron\mu\iota\nu\)), that is, to the way in which they are related to something else (\(\tau\omicron\ \pi\rho\omicron\\ \tau\iota\ \pi\omicron\omicron\\ \epsilon\chi\omicron\omicron\nu\)). Here we first adjust to their positions (\(\theta\varepsilon\sigma\varepsilon\iota\)) the functions (\(\delta\upsilon\sigma\alpha\omicron\mu\epsilon\iota\varsigma\)) that they have…¹²

¹¹ Ptolemy *Harmonics* 2.5, D51.17-18, after Andrew Barker.
¹² Ibid., D52.1-12.
In this passage, Ptolemy defines *dynamis* as a relation between notes. He repeats this association between *dynamis* and the relations between notes in *Harmonics* 3.8. Explaining the features of the harmonic *systêmata*, Ptolemy states the following:

…for the order and pitch of the notes apparently advances, as it were, along a straight line, but their function and their relation to one another (*ἡ δὲ δύναμις καὶ τὸ πῶς ἔχειν πρὸς ἀλλήλους*), which constitutes their special character, is determined and enclosed within one and the same circuit, since in their nature there is no starting point among them, and their starting point in respect of position (*θέσει*) is shifted in different ways at different times to the various successive places in the series.\(^\text{13}\)

The καὶ that joins δύναμις with the following phrase, τὸ πῶς ἔχειν πρὸς ἀλλήλους, may indicate either that the two ideas are identical in meaning or disparate. Either way, Ptolemy clearly associates the two and, in *Harmonics* 2.5, he defines the *dynamis* as a relation.

Ptolemy uses the term *dynamis* throughout the text to represent a function of musical pitches. He contrasts *dynamis* to *thesis*, the position of notes, not only in *Harmonics* 2.5 and 3.8, quoted above, but in 3.6 as well. While comparing the genera in music to the genera of human virtues, Ptolemy mentions the *dynamis* and *thesis* of musical notes:

Hence one might appropriately compare with each of these three genera the three items called by the same name, ‘genera’, in the field of *harmonia*—I mean the enharmonic, the chromatic and the diatonic—since these also differ from one another in magnitude, and in the bulk that corresponds to their expansion and contraction: for in these genera both the *pyknon* and the *apyknon* undergo that sort of modification, both in position and in function (*καὶ θέσει καὶ δυνάμει*).\(^\text{14}\)

As stated above, in *Harmonics* 2.5 Ptolemy uses *thesis* and *dynamis* as distinguishing properties, which serve to name individual notes. He applies this system of nomenclature in naming, for example, the *mesê*. He explains, “We then give the name ‘*mesê* by function’ (*μέσην μὲν τῆ*...\)

\(^{13}\) Ibid. 3.8, D101.1-6.

\(^{14}\) Ibid. 3.6, D98.11-16.
δυνάμει), from its positioning here, to the lower note of the higher disjunction….” 15 Thereafter, in Harmonics 2.11, Ptolemy treats the dynamis of the mesê as definitional. He states, “It is clear that in these tonoi that we have set out there will be, peculiar to each of them, a specific note of the octave that belongs to the dynamic mesê (τὴ δυνάμει μέσης), since the tonoi are equal in number to the species.” 16 Ptolemy repeats this emphasis on the dynamis of mesê at D65.6, 25, and 33. Thus, the dynamis of a note signifies its relation with other notes and this relation, in conjunction with thesis, provides the names of musical pitches, such as the dynamic mesê.

Ptolemy uses the term dynamis throughout the text to demarcate the function of pitches and their modulations. For instance, in Harmonics 1.6, he refers to the dynamis of the notes of the octave, 17 and in Harmonics 3.8 he discusses the dynamis of the double octave. 18 Similarly, in Harmonics 2.8, he discusses the functions, dynameis, of the octave:

Further, the functions (δυνάμεις) in the octave should not be measured by the quantity of its terms, but by the quantity of the ratios that jointly constitute it; and we have here the most apt exemplification of this, in the species that are contained by it. For we all assume quite unambiguously that these are just seven, while the notes that constitute them are eight, and no one would say that the one taken downwards from the lowest note, for example, makes a different species from the first—the one in the same direction from the highest note—because it is true in general that any species taken in the same direction, beginning from each of the extremes of the octave, produces the same function (δυνάμιν). 19

In the same way, in Harmonics 2.6 Ptolemy discusses the dynamis of a single tonos 20 as well as a modulation in tonos. 21 In Harmonics 2.11, Ptolemy explains that different tonoi have diverse dynameis: “Thus it is possible to maintain some notes in the systêma unchanged in alterations

15 Ibid. 2.5, D52.18-19.
16 Ibid. 2.11, D64.16-18.
17 Ptolemy Harmonics 1.6, D13.5, 10.
18 Ibid. 3.8, D101.13.
19 Ibid. 2.8, D59.20-29, after Andrew Barker.
20 Ptolemy Harmonics 2.6, D54.11.
21 Ibid., D55.8, 23.
between *tonoi*, keeping the range of the voice constant, because in different *tonoi* the same functions (δυνάμεις) never fall on the positions of the same notes.”22 Ptolemy also uses *dynamis* as a function of relations when examining zodiacal phenomena in *Harmonics* 3.9. I will explain below how and why Ptolemy associates the zodiacal circle with musical pitches. For now what is significant is Ptolemy’s use of the term *dynamis* to signify the function of a zodiacal sign in relation to other signs: “In a marvelous way, too, those of the points on the zodiac that are separated by one twelfth part are not concordant, but are only in the class of the melodics, while those separated by five twelfth parts are in that of the unmelodics; they are called ‘uncoordinated’, and are so too in function (δύναμις).”23 Therefore, Ptolemy uses the term *dynamis* to indicate the function a physical body—a musical pitch or region of the zodiac—has in relation to other physical bodies, whether they be other pitches, such as within an octave, or other zodiacal signs.

Moreover, Ptolemy uses *dynamis* to indicate the capacity, or power, of physical objects to have this function in relation to other like objects. In *Harmonics* 3.4, when discussing the power of *harmonia* (τὴν ἀρμονίαν δύναμιν), Ptolemy explains that all physical objects have this power to some degree:

> We must also insist that this sort of power (τὴν τοιαύτην δύναμιν) must necessarily be present to some extent in all things that have in themselves a source of movement, just as must the other powers, but especially and to the greatest extent in those that share in a more complete and rational nature, because of the suitability of the way in which they were generated.24

Despite Barker’s emphasis on the definition of the *dynamis harmonikê* as a power that human beings possess, Ptolemy clearly states in *Harmonics* 3.4 that the power of *harmonia*, which may

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22 Ibid. 2.11, D65.15-19, after Andrew Barker.
23 Ibid. 3.9, D104.2-5.
24 Ptolemy *Harmonics* 3.4, D95.4-8, trans. Andrew Barker.
be a periphrasis of dynamis harmonikê, is present in all things that have within them a source of movement. Furthermore, he explains which physical bodies have this power to the greatest extent in the title of the chapter: “That the power of attunement (Ὁτι ἦ τοῦ ἕρμομένου δύναμις) is present in all things that are more perfect in their natures, but is revealed most fully through human souls and through the movements in the heavens.” If the power of harmonia is present most fully in human souls and in the movements of the heavens, then it is irrefutably a power that inanimate, as well as animate, objects possess.

In the first sentence of Harmonics 3.4, Ptolemy summarizes the content of the previous chapter. Despite his use of the phrase ‘the dynamis of harmonia’—in the title as well as in the content of the chapter—to mean a power possessed to some extent by all objects with a source of movement, when he discusses Harmonics 3.3, he depicts the dynamis of harmonia as a capacity of human beings: “Let this be enough to show that the power of harmonia (ἡ αρμονίας δύναμις) is a form of the cause corresponding to reason, the form that concerns itself with the proportions of movements, and that the theoretical science of this (ἡ θεωρητική ταύτης ἐπιστήμη) is a form of mathematics, the form concerned with the ratios of differences between things heard…” Ptolemy has already indicated in Harmonics 1.7 that reason has a dynamis: “It would not be right to attribute these errors to the power of reason (ἡ δυνάμει τοῦ λόγου), but to those who ground reason in faulty assumptions…. As a cause corresponding to reason, the power of harmonia, at least in the first sentence of Harmonics 3.4, is a capacity that human beings possess and employ in the theoretical study of harmonics. Ptolemy seems to portray the dynamis of harmonia as a power of human beings here because he is summarizing the content of

25 Ptolemy Harmonics 3.4, D94.21-23, after Andrew Barker.
26 Ibid., D94.24-95.2.
27 Ptolemy Harmonics 1.7, D15.3-4, trans. Andrew Barker.
Harmonics 3.3. In this chapter, titled “In what class the power of harmonia (τὴν ὀρμονικήν δύναμιν) and the science of it are to be located,” Ptolemy consistently portrays the dynamis harmonikē as the power human beings possess to study and demonstrate harmonic ratios.28 He discusses this double task of the science of harmonics, to study and demonstrate, in the following passage: “Since it is natural for a person who reflects on these matters to be immediately filled with wonder—if he wonders also at other things of beauty—at the extreme rationality of the power of harmonia (τὴν ὀρμονικὴν δύναμιν), and at the way it finds and creates with perfect accuracy the differences between the forms that belong to it….“29 Later in the chapter, Ptolemy explains that human beings employ this power by using the criteria of sight and hearing, in conjunction with reason: “This sort of power (ἡ τοιαύτη δύναμις) employs as its instruments and servants the highest and most marvelous of the senses, sight and hearing, which, of all the senses, are most closely tied to the ruling principle….“30 What is interesting, for the moment, is that Ptolemy uses the phrase dynamis harmonikē so fluidly between Harmonics 3.3 and 3.4. In the latter chapter, he portrays it mainly as a capacity that all objects with a source of movement possess, but he lets the usage of 3.3—wherein the dynamis harmonikē is a power of human beings—seep into 3.4 when summarizing the content of 3.3 in the first line. Thus, Ptolemy has three fixed meanings for the dynamis harmonikē: (1) A function of objects in relation to one another, (2) The capacity of objects to have this function, and (3) The capacity of human beings to grasp and demonstrate the objects’ relations. Ptolemy applies these definitions fluidly, even within a single chapter, such as Harmonics 3.4.

While Ptolemy uses harmonikē as an attributive adjective for dynamis, as in the dynamis

28 Ptolemy Harmonics 3.3, D91.20-21, after Andrew Barker.
29 Ibid., D92.1-4.
30 Ibid., D93.11-13.
harmonikê, he mainly utilizes harmonikê as a substantive signifying the science (ἐπιστήμη) of harmonics. For instance, in the first sentence of Harmonics 1.1—which Barker utilizes when defining the dynamis harmonikê as a power possessed by human beings—Ptolemy states, “Harmonic knowledge is a power that grasps (‘Ἀρμονικὴ ἐστι δύναμις καταληπτικὴ) the distinctions related to high and low pitch in sounds….“31 Ἀρμονικὴ is a substantive, which modifies the implied noun ἐπιστήμη. Ptolemy continues this association, between the power, or dynamis, human beings have to grasp harmonic ratios and the science, which results from the grasping, in Harmonics 3.3. Again the chapter is called “In what class both the power of harmonia and the science of it (τὴν τε ὀρμονικὴν δύναμιν καὶ τὴν ἐπιστήμην σύντῆς) are to be located.”32 Therefore, Ptolemy associates the science of harmonics with the power, or dynamis to study it.

This identification of a science or an art with a dynamis seems to have been common in antiquity. For instance, in Rhetoric 1.2, Aristotle provides the following definition of rhetoric: “Rhetoric may be defined as the faculty (˝Εστω δὴ ἡ ῥητορικὴ δύναμις) of observing in any given case the available means of persuasion. This is not a function of any other art (τέχνη).”33 According to Aristotle, rhetoric (ῥητορικὴ) is an art (τέχνη) that is definable as a dynamis. This definition of rhetoric—as a substantive identified with a dynamis—became standard in antiquity.34 Dionysius Thrax, a second-century B.C.E. grammarian, defines rhetoric with the

31 Ibid. 1.1, D3.1-2.
32 Ibid. 3.3, D91.20-21.
34 I must thank Alexander Jones for doing the Thesaurus Linguae Graecae search that yielded this research on the definitions of sciences and arts, expressed as substantives and identified with dynamis.
following formulation: ῥητορική ἐστὶ δύναμις τεχνικῆ…\textsuperscript{35} Dionysius Halicarnassensis, the first-century B.C.E. historian and rhetorician, uses the same exact formulation in his \textit{De imitatione},\textsuperscript{36} as do later writers, including the author of the \textit{Prolegomena in artem rhetoricam},\textsuperscript{37} Troilus, in his \textit{Prolegomena in Hermogenis artem rhetoricam},\textsuperscript{38} Ammonius, in his \textit{In Porphyrii isagogen sive quinque voces},\textsuperscript{39} Joannes Doxapatres, in his \textit{Prolegomena in Aphthonii progymnasmata},\textsuperscript{40} and the authors of \textit{Prolegomena in librum περὶ στάσεων},\textsuperscript{41} \textit{Introductio in prolegomena Hermogenis artis rhetoricae},\textsuperscript{42} \textit{Prolegomena in artem rhetoricam},\textsuperscript{43} and \textit{Synopses artis rhetoricae}.\textsuperscript{44} With this formulation, ῥητορική ἐστὶ δύναμις τεχνικῆ, these writers indicate that rhetoric is an art (τέχνη), just as Aristotle does in the \textit{Rhetoric}; however, unlike Aristotle, they do so by means of an adjectival construction. Rhetoric (a substantive) is a power (δύναμις) that operates as an art (τεχνική). Ptolemy uses this same formulation when defining harmonics. Again, he states, ‘Ἀρμονικῇ ἐστὶ δύναμις καταληπτικῆ…’\textsuperscript{45} Just as these other writers indicate that rhetoric is a \textit{technē} by means of the formulaic construction, Ptolemy, employing this same formula, indicates that harmonics is a \textit{katalēpsis}, a type of apprehension or, more specifically in this case, a science (ἐπιστήμη).\textsuperscript{46}

\begin{itemize}
\item \textsuperscript{35} Dionysius Thrax \textit{Fragmenta}, Fragment 53.2.
\item \textsuperscript{36} Dionysius Halicarnassensis \textit{De imitatione}, Fragment 26.1.
\item \textsuperscript{37} Rhetorica Anonyma \textit{Prolegomena in artem rhetoricam} 3.611.5-5, 14.29.7-8, 14.30.12-13.
\item \textsuperscript{38} Troilus \textit{Prolegomena in Hermogenis artem rhetoricam} 52.26-27.
\item \textsuperscript{39} Ammonius \textit{In Porphyrii isagogen sive quinque voces} 1.14.
\item \textsuperscript{40} Joannes Doxapatres \textit{Prolegomena in Aphthonii progymnasmata} 14.106.22.
\item \textsuperscript{41} Anonymi in Hermogenem \textit{Prolegomena in librum περὶ στάσεων} 14.199.23.
\item \textsuperscript{42} Anonymi in Hermogenem \textit{Introductio in prolegomena Hermogenis artis rhetoricae} 14.283.14.
\item \textsuperscript{43} Anonymi in Hermogenem \textit{Prolegomena in artem rhetoricam} 14.349.9.
\item \textsuperscript{44} Anonymi in Hermogenem \textit{Synopses artis rhetoricae} 3.461.19.
\item \textsuperscript{45} Ptolemy \textit{Harmonics} 1.1, D3.1-2.
\item \textsuperscript{46} Other ancient authors used this formulation to define additional fields of inquiry and practice. For instance, in the first line of \textit{Outlines of Pyrrhonism} 1.8, Sextus Empiricus, a contemporary of Ptolemy, defines skepticism: ” Ἐστι δὲ ἡ σκέπτικὴ δύναμις ἀντιθετικῆ…”\textsuperscript{46} Aristides
\end{itemize}
Ptolemy uses the term *harmonikê* to represent the science of harmonics elsewhere in the text. In *Harmonics* 3.3, for instance, he states, “Related to sight, and to the movements in place of the things that are only seen—that is, the heavenly bodies—is astronomy (ἀστρονομία); related to hearing and to the movements in place, once again, of the things that are only heard—that is, sounds—is harmonics (ἀρμονική).” The substantive ἀρμονική is parallel to the noun ἀστρονομία, both of which Ptolemy treats as branches of mathematics. The student of harmonics uses the criteria of hearing and reason in order to grasp the distinctions between pitches. Accordingly, *Harmonics* 1.1 is called “Concerning the criteria in harmonics (ἐν ἀρμονική),” and the term *harmonikê* again acts like a substantive indicating the science of harmonics. Moreover, in *Harmonics* 1.4, Ptolemy discusses the proper object of the science of harmonics:

Divided sounds are those the locations of whose movements are clearly apparent, when their parts remain equal-toned over a perceptible interval [of time], as in the juxtaposition of different colors that are unmixed and have not run together. But the former are foreign to harmonics (ἀρμονική), never laying down anything that is one and the same, so that—contrary to what is proper to the sciences (παρά τὸ τῶν ἐπιστημῶν ἴδιον)—they cannot be encompassed by a definition or a ratio; while the latter are at home in harmonics…

Thus, Ptolemy uses *harmonikê* as a substantive signifying the science (ἐπιστήμη) of harmonics.

Correspondingly, Ptolemy uses the substantive *harmonikos* to signify the student of the science of harmonics. He titles *Harmonics* 1.2 “What the aim of the student of harmonics is” (Τίς πρόθεσις ἀρμονικῶς)” and goes on to state, “The aim of the student of harmonics

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Quintilianus, in the third century C.E., defines the making of rhythm in *De musica* 1.19.13: Ῥυθμοποίει μὲ ἔστι δύναμις ποιητικῆ....

47 Ptolemy *Harmonics* 3.3, D94.13-16, after Andrew Barker.
48 Ibid. 1.1, D3.0.
49 Ibid. 1.4, D10.11-18.
50 Ibid. 1.2, D5.10.
Ptolemy uses the same adjective, *harmonikos*, to characterize the instrument the student of harmonics employs, or the *kanôn*. In *Harmonics* 1.2, he introduces the instrument as such: “The instrument of this kind of method is called the harmonic *kanôn* (κανών ἀρμονικός), a term adopted out of common usage and from its straightening (κανονίζειν) those things in sense perception that are inadequate to reveal the truth.”

Similarly, in *Harmonics* 2.12, Ptolemy states, “Since our remaining task, in the enterprise of displaying with complete clarity the agreement of reason with perception, is that of dividing up the harmonic *kanôn* (ἀρμονικὸν κανόνον)…”

In *Harmonics* 3.3, Ptolemy discusses the practice of the student of harmonics and utilizes the substantive *harmonikos* when describing the type of reason he employs: “For reason (λόγος), considered in general and without qualification, is productive of order and proportion, while harmonic reason (ἀρμονικός), in particular, is productive of them in the class of what is heard, just as is imagistic reason (φανταστικός) in the class of what is seen, and critical reason (κριτικός) in that of what is thought.”

Ptolemy, therefore, uses the adjective *harmonikos* to indicate the student of harmonics, his instrument, the *kanôn*, and his criterion, *logos*.

In two instances, Ptolemy uses *harmonikos* to designate the content of the science of harmonics, or the harmonic ratios themselves. The adjective again modifies the noun λόγος but in its plural form, λόγοι, denoting the ratios that characterize the physical bodies studied. In *Harmonics* 3.4, when discussing the various physical bodies that have the power of harmonia, Ptolemy describes the ratios between musical pitches as *harmonikoi logoi*: “It reveals and displays, so far as it is possible for a human being to grasp it, the pattern of organization that is

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51 Ibid., D5.13-14.
52 Ibid., D5.11-13.
53 Ibid. 2.12, D66.6-8.
54 Ibid. 3.3, D92.27-30.
based on the harmonic ratios (τῶν ἀρμονικῶν λόγων) of the notes…”55 Likewise, in *Harmonics* 3.8, Ptolemy labels the ratios formed by the movements of celestial bodies *harmonikoi*: “Our next task is to display the fundamental postulates about the heavenly bodies as being completely determined in accordance with the harmonic ratios (τῶν ἀρμονικῶν λόγων).”56 Soon after, Ptolemy uses the same adjective to modify the *systêmata* of harmonics. Explaining how both celestial bodies and musical pitches experience only one type of change, movement from place to place, he makes the following argument:

> It is indicated also by the fact that all the circuits of the aetherial things are circular and orderly, and that the cyclic recurrences of the harmonic *systêmata* (τῶν ἀρμονικῶν συστημάτων) have the same features; for the order and pitch of the notes apparently advances, as it were, along a straight line, but their function (δύναμις) and their relation to one another, which constitutes their special character, is determined and enclosed within one and the same circuit…57

Ptolemy uses the adjective *harmonikoi* to describe both the ratios that the science of harmonics examines as well as the *systêmata* that are characterized by these ratios. Therefore, Ptolemy uses the term *harmonikos*, in its various declinations, to describe the many components of the practice and content of the science of harmonics.

After *dynamis* and *harmonikê*, what remain to examine are Ptolemy’s definitions of *harmonia*. Ptolemy uses *harmonia* in five instances to denote the science of harmonics and the field of discourse utilized by the science. For example, in *Harmonics* 1.12, 3.6, and 3.11, he describes ‘genera’ as a term used ‘in *harmonia*’. In 1.12, he defines a genus (γένος) as a relation between the notes of concords: “This sort of movement is called modulation in respect of genus, and a genus in *harmonia* (ἐν ἀρμονίᾳ) is a relation, of some [determinate] quality, that

55 Ibid. 3.4, D95.24-26.
56 Ibid. 3.8, D100.24-26.
57 Ibid., D100.32-101.4.
the notes composing the concord of the fourth have to one another.” 58 In 3.6, Ptolemy refers to what are called ‘genera’ ‘according to harmonia’: “Hence one might appropriately compare with each of these three genera the three items called by the same name, ‘genera’, according to harmonia (κατὰ τὴν ἀρμονίαν)...” 59 In 3.11, Ptolemy gives the chapter the title “How the vertical movement of the stars is comparable to the genera in harmonia (ἐν ἀρμονίᾳ),” 60 and he goes on to make the following association between the vertical movement of heavenly bodies, which I explain below, and the genera: “We shall find that the second of these differences, the vertical, is similar to the difference between what in harmonia (ἐν ἀρμονίᾳ) are called the genera.” 61 Ptolemy does not say that genera are grasped or caused by harmonia. Nor does he describe them as forms of harmonia. In each of the three cases, he represents genera as an item of discourse used within the field of harmonia. Moreover in Harmonics 2.9, Ptolemy discusses principles in harmonia:

In the same way, since the tonoi contained in the octave correspond to the nature of the concords and take their origin from them, so that the systêmata, taken as wholes, may have differences that are concordant, if people seek either to make them more in number than the seven species and ratios of the octave, or to make the differences between all of them equal, we must not agree with them; for they have no persuasive reason to offer, either for the equality of the augmentations between one whole tonos and another—such a thing being condemned as altogether inappropriate in harmonia (ἐν ἀρμονίᾳ)—or for the claim that all the differences are tones... 62

In this passage, Ptolemy uses the term harmonia to signify the science of harmonics, including its various postulates. Hence, he uses harmonia to represent the theoretical study and the discourse of harmonics.

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59 Ibid. 3.6, D98.11-13.
60 Ptolemy Harmonics 3.11, D105.23, trans. Andrew Barker.
61 Ibid., D105.23-24.
62 Ptolemy Harmonics 2.9, D61.1-9, after Andrew Barker.
As Barker and Swerdlow argue, Ptolemy also uses *harmonia* to signify the capacity human beings have to grasp harmonic relations. He does so, however, only in the context of *Harmonics* 3.3. As stated above, when summarizing this chapter in the first sentence of *Harmonics* 3.4, he uses the phrase ‘the power of *harmonia*’ (τὴν ὁμονοίαν δύναμις) as a periphrasis of *dynamis harmonikê*. In *Harmonics* 3.3, Ptolemy consistently uses *harmonia* to signify the power of human beings to study and demonstrate distinctions in pitch. He characterizes *harmonia* as an active cause that imposes form on matter: “…we should not accept that *harmonia* (τὴν ὁμονοίαν) is that which underlies (for it is something active, not something passive), nor that it is the end, since on the contrary it is what produces some end, such as good melody, good rhythm, good order and beauty, but that it is the cause, which imposes the appropriate form on the underlying matter.”63 Moreover, Ptolemy characterizes *harmonia* as a cause corresponding to reason:

Of the cause that is in accordance with reason (λόγον), one aspect is intelligence, corresponding to the diviner form, one is skill, corresponding to reason itself, and one is habit, corresponding to nature. Hence we can find *harmonia* (τὴν ὁμονοίαν) fulfilling its proper purpose in connection with all of them. For reason, considered in general and without qualification, is productive of order and proportion, while harmonic (ὁμονικός) reason, in particular, is productive of them in the class of what is heard…64

Ptolemy here treats ὁμονία as equivalent to ὁμονικός, harmonic reason. It is a productive cause that human beings employ when studying and demonstrating the principles of the science of harmonics: “It makes correct the ordering that exists among things heard, which we give the special name ‘melodiousness’, through the theoretical discovery of proportions by means of intelligence, through their practical exhibition by means of skill, and through experience in

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64 Ptolemy *Harmonics* 3.3, D92.24-29, after Andrew Barker
following them by means of habit." Therefore, in *Harmonics* 3.3, *harmonia* is equivalent to the *dynamis harmonikê* as a power of human beings.

Ptolemy also characterizes *harmonia* as a formal cause, as Swerdlow implies in his article "Ptolemy’s *Harmonics* and the ‘Tones of the Universe’ in the *Canobic Inscription*." In *Harmonics* 3.5, he describes the complete *systῆma* of music as having *harmonia*:

\[
The \text{whole condition of a philosopher is like the whole } \text{harmonia (<stdlib>_hrμoνία_StdString<) of the complete systῆma, comparisons between them, part by part, being made by reference to the concords and the virtues, while the most complete comparison is made by reference to what is, as it were, a concord of melodic concords and a virtue of the soul’s virtues, constituted out of all the concords and all the virtues.}\]

Similarly, in *Harmonics* 3.7, Ptolemy refers to modulations in *harmonia* when discussing changes in *tonoi*:

\[
\text{“…so in the same way, in modulations in } \text{harmonia (<stdlib>_hrμoνία_StdString<), the same magnitude is turned in the higher } \text{tonoi towards a greater capacity to excite, and in the lower ones towards a greater capacity to calm….”}\]

These modulations in *harmonia* are not changes in the power of human beings to grasp these changes but rather changes in the relations between the pitches. Human beings examine these relations by means of two criteria, hearing and reason. In the first sentence of *Harmonics* 1.1, after defining harmonic knowledge, Ptolemy states, "…and the criteria of *harmonia* (<stdlib>_hrμoνία_StdString<) are hearing and reason, not however in the same way." These criteria enable the student of harmonics to grasp the relations between high and low pitches. *Harmonia*, in these instances, then, signifies the ratios, or the formal relations, existing between musical pitches.

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65 Ibid., D92.30-93.4.
66 Swerdlow, 151.
69 Ptolemy *Harmonics* 1.1, D3.3-4, trans. Andrew Barker.
Moreover, in *Harmonics* 3.10 Ptolemy refers to two *harmoniai*: “Let that be a sufficient account of the facts concerning the circular movement itself, considered in respect of both *harmoniai* (κατ’ ἀμφότερας τὰς ἀρμονίας), and of the arrangements that share the general titles ‘concordant’ and ‘discordant’.”

Ingemar Düring is correct in suggesting that with ἀμφότερας Ptolemy is referring to τὴν τε μουσικὴν καὶ τὴν οἰκονικήν, music and astronomy. In other words, Ptolemy is discussing concordant and discordant ratios which characterize the complete systēma in both music and the zodiacal circle. While both systems use the same ratios, Ptolemy claims that two *harmoniai* exist. He does so most likely because the ratios are attributes of at least two types of physical bodies: sounds and heavenly bodies. Therefore, Ptolemy’s use of *harmoniai* in *Harmonics* 3.10 indicates that *harmonia* is not only a formal cause of specific ratios but also the embodiment of this formal cause, such as in sounds and in the heavens. Ptolemy also uses the term *harmoniai* in *Harmonics* 3.5. In this chapter, as in *Harmonics* 3.10, *harmoniai* signifies the existence of specific ratios in various sets of physical bodies. In the following passage, Ptolemy examines the ratios that characterize the human soul while in the condition of justice:

The best condition of the soul as a whole, justice, is as it were a concord between the parts themselves in their relations to one another, in correspondence with the ratio governing the principal parts, the parts concerned with intelligence and rationality being like the homophones, those concerned with good perception and skill, or with courage and moderation, being like the concords, while those concerned with the things that can produce and the things that participate in the *harmoniai* (τὰ ποιητικὰ καὶ τὰ μετέχουσα τῶν ἀρμονιῶν) are like the species of the melodics.

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70 Ptolemy *Harmonics* 3.10, D104.18-20, after Andrew Barker.
71 Ingemar Düring, *Die Harmonielehre des Klaudios Ptolemaios* (Göteborg: Elanders Boktryckeri Aktiebolag, 1930), 104.
72 Ptolemy *Harmonics* 3.5, D97.27-33, trans. Andrew Barker.
Barker interprets the use of *harmoniai* here to mean the capacity of human beings to produce harmonic ratios in physical bodies, including sounds and the human soul: “The reference to the *harmoniai* is not here purely musical: the capacity is that of making in things external to us, and building in our own character, structures conforming to the ‘harmonious’ patterns discerned by reason.”73 The text, however, does not imply that it is human beings that produce *harmoniai* but rather that it is the parts of human souls that produce and participate in *harmoniai*. In this way, Ptolemy’s uses of the term *harmoniai* in *Harmonics* 3.5 and 3.10 are consistent. In each case, the term refers to the existence of harmonic ratios in physical bodies, including musical pitches, heavenly bodies, and human souls.

While Ptolemy’s portrayal of *harmonia* as a formal cause may seem to imply that he adheres to Aristotle’s four-cause framework, Ptolemy does not state in any of his extant texts that he accepts Aristotle’s four causes. Instead, he propounds three causal principles: matter, form, and movement. In *Almagest* 1.1, for instance, he proclaims, “For everything that exists is composed of matter (variably defined), form (the *eidous*), and movement (the *kinhēsew*); none of these [three] can be observed in its substratum by itself, without the others; they can only be imagined.”74 In the *Harmonics*, Ptolemy again differentiates matter, form, and movement. In *Harmonics* 1.1, he states, “For since matter is determined and bounded only by form (a matter defined and bounded only by form, the *eidē*), and modifications only by the causes of movements (of modifications), and since of these the former [i.e., matter and modifications] belong to sense perception, the latter to reason….”75 Similarly, in *Harmonics* 3.3, Ptolemy defines *harmonia*—here denoting the

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75 Ptolemy *Harmonics* 1.1, D3.8-10, trans. Andrew Barker.
capacity of human beings to grasp and demonstrate harmonic ratios—with reference to three principles:

Since all things, then, have as their first principles (ἀρχὴς) matter (ὑλή) and movement (κίνησις) and form (ἐνδεικνύει), matter corresponding to what underlies a thing and what it comes from, movement to the cause and agency, and form to the end and purpose, we should not accept that harmony is that which underlies (for it is something active, not something passive), nor that it is the end, since on the contrary it is what produces some end, such as good melody, good rhythm, good order and beauty, but that it is the cause, which imposes the appropriate form on the underlying matter.76

According to Harmonics 3.3, matter is what underlies an object, like Aristotle’s material cause; movement is a cause that produces an end, like Aristotle’s efficient cause; form is the end or purpose caused by movement. This definition of form implies a combination of Aristotle’s formal and final causes. This amalgamation of the formal and final causes is not novel, as it has a precedent in Aristotle’s corpus. In Physics 2.7.198a24-26, for instance, Aristotle acknowledges that the formal and final causes often coincide. For Ptolemy, however, the formal and final causes are identical as a rule. In Harmonics 3.4, Ptolemy again distinguishes three causal principles and explains that movements act as causes which alter matter and form.

Concerning the ontology of a ratio, he explains, “It is not found, however, in movements (κίνησις) that alter the matter (ὑλή) itself, since because of its inconstancy neither the quality of the matter nor its quantity is capable of being defined; but it is found in those movements that are involved most closely with forms (ἐνδεικνύει).”77 Therefore, according to Ptolemy, three causal principles (ἀρχής) explain phenomena and the changes they experience: matter, form, and movement.

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76 Ptolemy Harmonics 3.3, D92.9-16, after Andrew Barker.
77 Ptolemy Harmonics 3.4, D95.17-20, trans. Andrew Barker.
In *Harmonics* 3.3, Ptolemy elaborates on this causal framework. After introducing the three ἄρχαι—matter, form, and movement—he argues that, at the highest level, three causes exist: nature, the cause of an entity’s existence; reason, the cause of an entity’s being good; and god, an entity which is good and eternal. Ptolemy applies this schema in his classification of harmonia as a cause corresponding to reason:

Now causes fall into three kinds, at the highest level (καὶ μὴν τῶν σῖτιων τῶν ἀνωτάτων τριῶν λαμβανομένων), one corresponding to nature (παρὰ τὴν φύσιν) and concerned only with being (τὸ ἐἶναι), one corresponding to reason (παρὰ τὸν λόγον) and concerned only with being well (τὸ ἕκαστον ἐκεῖνον), and one corresponding to god (παρὰ τὸν θεὸν), concerned with being well eternally (τὸ ἔνικαὶ αἰεὶ ἐκεῖνον). The cause involved in harmonia (κατὰ τὴν ἀρμονίαν) is not to be identified as corresponding to nature, since it does not implant being in the underlying matter, nor to god, since it is not the primary cause of eternal being, but, clearly, to reason, which falls between the other causes mentioned and joins with them in producing the well (συναπεργάζεται τὸ ἔνικα); the gods have it with them always, since they are always the same, whereas not all natural things do so, nor do they do so in all ways, for the opposite reason.  

While Ptolemy describes matter, form, and movement as ἄρχαι, he defines nature, reason, and god as σῖτια. They are the causes (σῖτια) of changes in the principles (ἄρχαι). In *Harmonics* 1.1, quoted in the previous paragraph, Ptolemy refers to the causes of movements (τοῖς σῖτίοις τῶν κινησεων) and, in 3.4, he portrays movements as altering matter and form. These changes in matter, form, and movement have three fundamental causes. In *Harmonics* 3.3, Ptolemy draws on the ontology of the three theoretical sciences to define what these three causes are. Nature is the physical cause of an object’s existence, god is the theological cause of an object’s always existing in a good way, and reason is an intermediate cause, like mathematics, which joins with the others to produce the good existence of physical and theological objects. Ptolemy asserts in *Almagest* 1.1 that mathematical objects are “an attribute of all existing things without

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78 Ptolemy *Harmonics* 3.3, D92.16-24, after Andrew Barker.
exception, both mortal and immortal.” While I argued in the previous chapter that Ptolemy most likely means here that mathematical objects characterize sub- and superlunary bodies, as opposed to both physical and theological objects, his three-cause framework in *Harmonics* 3.3 suggests that mathematics, and reason in general, is the cause that joins with nature and god to make all objects—physical, mathematical, and theological—exist in a good way. Harmonic reason, then, as a capacity of human beings, joins with nature and god to impose the formal characteristics of harmonic ratios onto physical bodies, which already have the capacity, or *dynamis*, to have these formal characteristics. In this way, human beings, by means of harmonic reason, actualize the capacity of physical bodies and make them exist in a good way.

### 3.2 Mathematical Objects as Beautiful

Ptolemy repeatedly calls mathematical objects beautiful in the *Harmonics*. When discussing the aim of the student of harmonics in *Harmonics* 1.2, he asserts that nature produces objects that are rational, orderly, and beautiful:

> For in everything it is the proper task of the theoretical scientist (τοῦ θεωρητικοῦ καὶ ἐπιστήμονος) to show that the works of nature are crafted (δημιουργούμενα) with reason and with an orderly cause, and that nothing is produced by nature at random or just anyhow, especially in its most beautiful (καλλισταίς) constructions, the kinds that belong to the more rational (λογικωτέρων) of the senses, sight and hearing.80

Nature’s most beautiful constructions are objects perceptible by sight and hearing, which perceive the most rational objects perceptible in the cosmos. Mathematics is the rational science that exhibits, practices, and has a theoretical grasp of these beautiful objects:

> When we consider this—that reason in general also discovers the well (τὸ ἑὖ), establishes in practice what it has understood, and brings the underlying material

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into conformity with this by habituation—it is to be expected that the science (ἐπιστήμη) that embraces all the species of science that rely on reason (τῶν παρὰ τοῦ λόγου ἐιδῶν), which has the special name ‘mathematics’ (μαθηματική), is not limited solely by a theoretical grasp of beautiful things (τῶν καλῶν), as some people would suppose, but includes at the same time their exhibition and practice, which arise out of the very act of understanding.81

According to Ptolemy, mathematics is a theoretical science (ἐπιστήμη) through which one studies, exhibits, and practices beautiful objects.

Ptolemy’s portrayal of mathematical objects as beautiful stems from a tradition shared by Plato and Aristotle. For instance, in the Timaeus Plato depicts mathematical objects as beautiful. Timaeus explains that whether an object is modeled after being or becoming determines whether or not it is beautiful: “So whenever the craftsman looks at what is always changeless and, using a thing of that kind as his model, reproduces its form and character, then, of necessity, all that he so completes is beautiful. But were he to look at a thing that has come to be and use as his model something that has been begotten, his work will lack beauty.”82 Because the Demiurge is good, he models the cosmos after the Forms and, thereby, makes it beautiful. Timaeus calls the cosmos “a perceptible god, image of the intelligible Living Thing, its grandness, goodness, beauty, and perfection are unexcelled.”83 The Demiurge makes the cosmos beautiful by giving it order and proportion. He forms the four elements by amalgamating isosceles and scalene triangles, and, in this way, he makes the elements as perfect as possible.84 Even more, the Demiurge forms the four elements in proportionate quantities to one another. After explaining why the cosmos consists of four elements, Timaeus declares, “This is the reason why these four particular constituents were used to beget the body of the world, making it a symphony of

81 Ptolemy Harmonics 3.3, D93.4-10, after Andrew Barker.
83 Ibid. 92c.
84 Ibid. 53b.
proportion. They bestowed friendship upon it, so that, having come together into a unity with itself, it could not be undone by anyone but the one who had bound it together."85 By imposing order and proportion on the cosmos, the Demiurge makes the cosmos beautiful.

Moreover, Timaeus describes harmony and proportion in human souls, which mimic the beauty and order of the cosmos. The Demiurge bestows on the cosmos one type of motion, rotation, which Timaeus associates with intelligence and understanding: “In fact, he awarded it the movement suited to its body—that one of the seven motions which is especially associated with understanding and intelligence. And so he set it turning continuously in the same place, spinning around upon itself.”86 Correspondingly, the world soul is rational and harmonious, as Timaeus depicts it in the following passage:

The soul was woven together with the body from the center on out in every direction to the outermost limit of the heavens, and covered it all around on the outside. And, revolving within itself, it initiated a divine beginning of unceasing, intelligent life for all time. Now while the body of the heavens had come to be as a visible thing, the soul was invisible. But even so, because it shares in reason and harmony, the soul came to be as the most excellent of all the things begotten by him who is himself most excellent of all that is intelligible and eternal.87

Human beings mimic this cosmic reason, harmony, and proportion by modeling their souls after the world soul. Timaeus explains the affinity between the world and human soul accordingly:

Now there is but one way to care for anything, and that is to provide for it the nourishment and the motions that are proper to it. And the motions that have an affinity to the divine part within us are the thoughts and revolutions of the universe. These, surely, are the ones that each of us should follow. We should redirect the revolutions in our heads that were thrown off course at our birth, by coming to learn the harmonies and revolutions of the universe, and so bring into conformity with its objects our faculty of understanding, as it was in its original condition.88

85 Ibid. 32b.
86 Ibid. 34a.
87 Ibid. 36e-37a.
88 Ibid. 90c-d.
Human beings maintain the harmony in their souls by aligning them to the movements of the heavens. By maintaining proper proportion in their souls, they keep their souls and bodies in good condition, and, being good, they are beautiful. Timaeus states, “Now all that is good is beautiful, and what is beautiful is not ill-proportioned. Hence we must take it that if a living thing is to be in good condition, it will be well-proportioned.” Thus, in the *Timaeus*, Plato describes the cosmos as beautiful, because of its order and proportion, and human souls as beautiful, inasmuch as they are harmonious, in good proportion, and in imitation of the heavens.

Similarly, in the *Philebus*, Socrates characterizes certain mathematical objects as beautiful in form. He treats measure and proportion as identifiable with beauty, and in the following passage, as he addresses Protarchus, he depicts geometrical objects, as well as certain colors and sounds, as beautiful:

> My meaning is certainly not clear at the first glance, and I must try to make it so. For when I say beauty of form, I am trying to express, not what most people would understand by the words, such as the beauty of animals or of paintings, but I mean, says the argument, the straight line and the circle and the plane and solid figures formed from these by turning-lathes and rulers and patterns of angles; perhaps you understand. For I assert that the beauty of these is not relative, like that of other things; but they are always absolutely beautiful by nature and have peculiar pleasures in no way subject to comparison with the pleasures of scratching; and there are colors which possess beauty and pleasures of this character. Do you understand?

> I am trying to do so, Socrates, and I hope you also will try to make your meaning still clearer.

> I mean that those sounds which are smooth and clear and send forth a single pure note are beautiful, not relatively, but absolutely, and that there are pleasures which pertain to these by nature and result from them.91

According to Socrates, mathematical objects are absolutely beautiful, whether they are straight lines, circles, two-dimensional objects more broadly, or three-dimensional objects. Furthermore,

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89 Ibid. 87c.
90 Plato *Philebus* 64d.
the senses sight and hearing perceive beautiful objects, such as the color white⁹² and single, pure notes, respectively.

Following Plato, Ptolemy describes sight and hearing as capable of perceiving beauty. As Socrates distinguishes between pleasure and beauty in the *Philebus*, so Ptolemy distinguishes between the senses that perceive pleasure and the senses that perceive beauty. Discussing the *dynamis* of reason, he establishes sight and hearing as criteria of beauty:

This sort of power (δύναμις) employs as its instruments and servants the highest and most marvelous of the senses, sight and hearing, which, of all the senses, are most closely tied to the ruling principle (ἡγεμονικόν), and which are the only senses that assess their objects not only by the standard of pleasure but also, much more importantly, by that of beauty….But no one would classify the beautiful (καλόν) or the ugly as belonging to things touched or tasted or smelled, but only to things seen and things heard, such as shape and melody, or the movements (κίνησεων) of the heavenly bodies, or human actions; and hence these, alone among the senses, give assistance with one another’s impressions in many ways through the agency of the rational part of the soul, just as if they were really sisters.⁹³

Following Plato, Ptolemy describes mathematical objects as beautiful and the senses sight and hearing as perceptive of beauty. According to Ptolemy, sight and hearing are the only senses capable of perceiving beautiful objects and, because perception is a criterion of truth, all identifiably beautiful objects must be perceptible, either by sight or hearing. Beautiful objects, then, such as shape, melody, the movements of heavenly movements, and human actions, are perceptible by either hearing or sight.

Aristotle calls mathematical objects beautiful in *Metaphysics* M3. Distinguishing the good from the beautiful, he asserts that mathematics studies both:

Since the good is different from the beautiful (because the good is always found in some action, while the beautiful is found also in unchanging things), those who say that mathematical branches of knowledge do not speak about the beautiful or

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⁹² Plato *Philebus* 53a-b.
⁹³ Ptolemy *Harmonics* 3.3, D93.11-94.1, after Andrew Barker.
the good are wrong. They do speak about and demonstrate much about them; just because they do not name them in demonstrating their effects and relations, it does not follow that they are not speaking about them. The main forms of the beautiful are order, symmetry, and definiteness, which are what the mathematical branches of knowledge demonstrate to the highest degree. Since these (I mean order and definiteness, for instance) evidently are causes of a lot of things, clearly they are in a sense speaking about this sort of cause too—namely the beautiful as cause. But we will speak about this more intelligibly elsewhere.94

Unfortunately, Aristotle does not discuss this topic more intelligibly in any of his surviving texts.

It is clear in Metaphysics M3 that mathematical objects are beautiful and that order, symmetry, and definiteness are types of beauty, but it is not clear in what sense Aristotle means beauty to be a cause. In his article “The fine and the good in the Eudemian Ethics,” Donald J. Allan comments on this passage and labels τὸ καλὸν a final cause in mathematical explanations:

   In M, 1078 a 31—b 6, the problem is recalled and answered. The good and the fine are distinct; the former is ἀκεχείντα, whereas the latter extends to invariable beings. Those who disparage the mathematical sciences on the ground that they make no mention of the fine or the good are in error, for the concepts are employed, even if those words are not. The principal aspects of ‘the fine’ are order, proportion, and definite form; mathematics is far from being unconcerned with these, and they may even function as causes in some mathematical explanations. Therefore final causation, in the shape of τὸ καλὸν, has some place in mathematical proof, and the fact alleged by the objector is not true.95

Allan identifies τὸ καλὸν as a final cause in mathematical explanations, or proofs, but he does not explain how τὸ καλὸν could be considered a final cause of mathematical objects, as Aristotle implies in M3. Julia Annas makes this same oversight in her commentary on Metaphysics M and N. In her explanation of the passage above, she states the following:

   Teleological explanations are inappropriate in mathematics, but nevertheless mathematicians can and do prefer one proof to another on grounds of simplicity and elegance, which seem to be purely aesthetic grounds. Aristotle is not expansive enough here for us to be sure whether he is merely acknowledging the

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fact that mathematicians do recognize elegance as a desirable factor in proofs, or whether he thinks that elegance is a legitimate mathematical virtue.\textsuperscript{96}

Like Allan, Annas describes τὸ καλόν as a final cause in mathematical proofs and does not address what type of cause Aristotle considers τὸ καλόν to be for mathematical objects. The most obvious answer is that beauty is a formal cause of mathematical objects, just as order, symmetry, and definiteness—which are types of beauty—are formal aspects of mathematical objects and relations. Nevertheless, this question of whether beauty is a final or formal cause would not have been a problem for Ptolemy. After all, in \textit{Harmonics} 3.3, Ptolemy defines form as an end and purpose (τῷ δὲ ἐδείκνυσιν τὸ τέλος καὶ τὸ σῷ ἐνεκέν).\textsuperscript{97} If, for Ptolemy, the form and end of an object represent the same principle (ὁρχή), as he indicates, then beauty is at the same time the form and the end of mathematical objects.

### 3.3 Harmonic Ratios in the Human Soul

Similar to Plato, who in the \textit{Timaeus} portrays human beings as aligning their souls to the movements of the heavens, Ptolemy identifies the same harmonic ratios existing in music as also existing in human souls and the heavens. He devotes chapters 3.5-7 of the \textit{Harmonics} to explaining the structure of the human soul and the harmonic ratios that characterize it. He presents three models: one Aristotelian, one Platonic, and one that is a combination of the previous two. In chapter four, on physical objects, I will further examine Ptolemy’s understanding of the human soul and what functions the parts of the soul have. What are relevant for this chapter are merely the correspondences between harmonic ratios and the parts of the human soul. According to the Aristotelian model Ptolemy presents in \textit{Harmonics} 3.5, the


\textsuperscript{97} Ptolemy \textit{Harmonics} 3.3, D92.11. As stated above, Ptolemy appropriates this identification of formal and final causation from the Aristotelian tradition following \textit{Physics} 2.
human soul consists of three primary parts: the intellectual (νοερόν), the perceptive (σώσθητικόν), and the part that maintains a state (ἐκτικόν). Corresponding to these three parts are the homophone and concords of the fourth and the fifth. The octave corresponds to the intellectual part, “since in each of these there is the greatest degree of simplicity, equality and stability,”98 the fifth corresponds to the perceptive part, and the fourth corresponds to the part that maintains a state. Ptolemy justifies these correspondences by appealing to the hierarchy of the parts of the soul. Just as a living being, such as a plant, has a part that maintains a state but neither a perceptive nor an intellectual part, so the concord of the fourth does not contain within it either the fifth or the octave. In other words, the length of the string that plays the fourth is shorter than the lengths that play the fifth and the octave. At the other end of the biological spectrum, a living being, such as a human being, that has an intellectual part of the soul must also have a perceptive part and a part that maintains a state. Similarly, the octave, with a longer string length, contains both the fifth and the fourth. Lastly, the fifth corresponds to the perceptive part of the soul. A living being, such as an animal, which has a perceptive part must also have a part that maintains a state but not necessarily an intellectual part. In the same way, the fifth contains the fourth but it does not contain the octave. Accordingly, the perceptive part of the soul and the concord of the fifth are intermediate between the two extremes, the part that maintains a state and the intellectual part of the soul, and the fourth and the octave, respectively.

Having established these more general correspondences, Ptolemy associates the species of the concords and homophone with the species of the soul. As the fourth has three species, so too the part that maintains a state has three species: growth, maturity, and decline. Just as the fifth has four species, the perceptive part has four species which Ptolemy associates with four of

the senses: sight, hearing, smell, and taste. The octave, on the other hand, has seven species, like
the intellectual part of the soul, which has the following seven: imagination (φαντασία),
intellect (νοῦς), reflection (ἐννοια), thought (διάνοια), opinion (δόξα), reason (λόγος), and
knowledge (ἐπιστήμη).

Ptolemy uses similar arguments when presenting the Platonic model of the soul. Again,
the soul is tripartite and, as such, its species correspond to the species of the homophone and
conords. He states the following:

Our soul is also divided in another way, into the rational (λογιστικόν), the
spirited (θυμικόν), and the appetitive (ἐπιθυμητικόν). For reasons that explain
their equality, similar to those just mentioned, we may reasonably link the rational
part to the octave, the spirited, which is closely related to the rational, to the fifth,
and the appetitive, which is lowest in order of importance, to the fourth.99

After relating virtue to melodiousness and vice to unmelodiousness, Ptolemy associates the
species of the homophone and concords with the virtues of the corresponding parts of the soul.
Like the concord of the fourth, which has three species, the appetitive part of the soul has three
species of virtue: moderation, self-control, and shame. Corresponding to the four species of the
fifth are the four species of virtue related to the spirited part of the soul: gentleness, fearlessness,
courage, and steadfastness. Lastly, corresponding to the seven species of the octave are the
seven species of virtue related to the rational part of the soul: acuteness, cleverness, shrewdness,
judgment, wisdom, prudence, and experience. As in attunement, where the tuning of the
homophones takes precedence over the tuning of the concords, in the human soul the intellectual
or rational part—in the Aristotelian and Platonic models, respectively—governs the other two,
subordinate parts of the soul.

99 Ptolemy Harmonics 3.5, D96.27-32, after Andrew Barker.
Ptolemy concludes *Harmonics* 3.5 with the presentation of a model which Andrew Barker observes is Ptolemy’s attempt to combine the Aristotelian and Platonic models of the human soul. Ptolemy associates the homophone with rationality and intelligence, the fifth with good perception and skill as well as with the virtues courage and moderation, and the fourth with the capacity to produce and become. In addition, he relates the concordance of the three parts of the soul with the *harmonia* of the complete *systêma*. In other words, Ptolemy finds a way to make correspondences between the entire system of harmonics and the many parts of the human soul, Platonic, Aristotelian, or a combination of the two.

Ptolemy, however, has not yet provided any empirical evidence to justify these correspondences. Andrew Barker discerns the following:

> The chapters on the soul and the virtues, rewarding though they are if considered as an episode in Greek moral psychology, display nothing of the rigorous reasoning of a proper counterpart to harmonics. Little argument is offered to support the proposed analyses and correspondences; and one cannot help feeling that Ptolemy, in his role as a scientist, is only half-heartedly engaged in the project.

In *Harmonics* 3.5, Ptolemy does not offer any observational evidence in support of the correspondences he delineates between harmonic relations and the parts of the human soul. Thus far, he has presented only dialectical arguments describing the analogous relationships of the homophone and concords, as well as their species, with the parts, species, and virtues of the human soul. In other words, without any empirical evidence at his disposal, Ptolemy provides only dialectical arguments as proof of the correspondences.

Ptolemy continues this project in *Harmonics* 3.6 by elaborating on the correspondences between harmonic relations and the activities of the human soul. He relates the tripartite

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100 Barker, 1989, 377.
101 Barker, 2000, 268.
divisions of theoretical and practical knowledge to the genera in *harmonia*. As discussed in
Chapter 2, Ptolemy divides theoretical philosophy into the physical, mathematical, and
theoretical sciences and practical philosophy into the ethical, domestic, and political. He claims
that the subfields of either theoretical or practical philosophy differ from one another not in kind
but in their magnitude and scope: “These do not differ from one another in function (δινάμει),
since the virtues of the three genera are shared and dependent on one another; but they do differ
in magnitude and value and in the compass of their structure.”\(^{102}\) Since the three genera—the
enharmonic, chromatic, and diatonic—differ from one another in their magnitude and, as
Andrew Barker explains, in “the size of the interval between the lowest note of the tetrachord
and the higher of its two moveable notes,”\(^{103}\) Ptolemy maps the three genera onto each subfield
of theoretical and practical philosophy. The enharmonic genus corresponds to physics and
ethics, because of its smaller magnitude; the diatonic corresponds to theology and politics,
because of its order and majesty; the chromatic corresponds to mathematics and domestics,
because each of these fields is intermediate between the two extremes. Ptolemy affirms that
these correspondences are relevant to the discussion of the harmonic structure of the soul by
calling these subfields of theoretical and practical philosophy the “genera to which the primary
virtues belong.”\(^{104}\) Just as the genera govern the species in harmonics, so theoretical and
practical philosophy govern the species of virtue.

In *Harmonics* 3.7, Ptolemy associates modulations of *tonos* with changes in the human
soul resulting from external influences. He opens the chapter with the following:

> In the same way, we can relate modulations (μεταβολαίς) of *tonos* in *systēmata* to
> changes (μεταβολαίς) in souls brought about by crises in the circumstances of

\(^{102}\) Ptolemy *Harmonics* 3.6, D98.9-11, after Andrew Barker.

\(^{103}\) Barker, 1989, 378.

\(^{104}\) Ptolemy *Harmonics* 3.6, D98.5, trans. Andrew Barker.
life. For just as in the former, when the genera are kept the same, there can be an alteration in the melody, depending on whether or not its sequence of familiar steps adopts different positions for the expression of its activity, so also in changes in human life the same species of psychological disposition are sometimes turned to different courses of behavior, being drawn along with the customs of the political systems they happen to encounter into conditions more suitable to these systems…

Ptolemy includes among the changes that the soul may experience the turn towards stability and reasonableness in peaceful conditions, the turn towards boldness and disdainfulness in conditions of war, the turn towards moderation and thriftiness in conditions of poverty, and the turn towards liberality and lack of restraint in conditions of plentitude. The higher tonoi have the capacity to excite, as do the conditions of war and plentitude, and the lower tonoi have the capacity to calm, as do the conditions of stability and poverty.

For the first time in these chapters on the soul, Ptolemy presents empirical evidence in support of the correspondences he makes between the changes the human soul experiences and changes in music. In *Harmonics* 3.7, he relates how the modulations of musical tones affect the human soul:

> Indeed, our souls are quite plainly affected in sympathy with the actual activities of a melody, recognizing the kinship, as it were, of the ratios belonging to its particular kind of constitution, and being molded by the movements specific to the idiosyncracies of the melodies, so that they are led sometimes into pleasures and relaxations, sometimes into griefs and contractions; they are sometimes stupefied and lulled to sleep, sometimes invigorated and aroused; and they are sometimes turned towards peacefulness and restraint, sometimes towards frenzy and ecstasy, as the melody itself modulates in different ways at different times, and draws our souls towards the conditions constituted from the likenesses of the ratios.

Ptolemy describes here observable changes the human soul experiences in sympathy with modulations in music. Changes in melody have the ability to relax or give pleasure to a human

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106 Ibid., D99.25-100.7.
soul, stupefy it and lull it to sleep, invigorate and arouse it, and so on. By introducing this empirical data, Ptolemy supplements his dialectical arguments for correspondences between music and the human soul. While he bases the analogies between the components of the complete systêma and the parts, virtues, and changes of the human soul on dialectical arguments, in the end he introduces empirical data. The effects modulations of tonos have on the human soul are observable and act as evidence for the existence of the same relations in the human soul. Consequently, because of the way music affects the human soul, the soul must be characterized by the same ratios and changes that characterize and affect musical pitches.

3.4 Harmonic Ratios in the Heavens

After examining the harmonic ratios that characterize the soul, Ptolemy goes on to investigate how these same ratios exist in the heavens. He dedicates the remainder of the Harmonics to explaining how these ratios are evident in astrological and astronomical phenomena. At the beginning of Harmonics 3.8, Ptolemy announces, “Our next task is to display the fundamental hypotheseis about the heavenly bodies as being completely determined in accordance with the harmonic ratios.”

Ptolemy observes that the changes experienced in music and in the heavens are of only one kind, movement from place to place. The objects that move—whether the air that vibrates or the heavenly bodies—do not experience any other type of change, such as those changes that alter an object’s being, at least as regards their scientific study. Ptolemy explains as follows:

In the first place, then, the truth of our proposition is plainly indicated by the very fact that both the notes [of music] and the courses of the heavenly bodies are determined by intervallic movement alone, upon which there attends none of the changes that alter a thing’s being. It is indicated also by the fact that all the

107 Ibid. 3.8, D100.24-26.
circuits of the aetherial things are circular and orderly, and that the cyclic recurrences of the harmonic systêmata have the same features; for the order and pitch of the notes apparently advances, as it were, along a straight line but their function (δυναμίς) and their relation to one another, which constitutes their special character, is determined and enclosed within one and the same circuit, since in their nature there is no starting point among them, and their starting point in respect of position (θέσει) is shifted in different ways at different times to the various successive places in the series.\footnote{Ibid., D100.28-101.6.}

Not only are changes in music and the heavens limited to movement from place to place, but, for both sets of objects, harmonic and heavenly, the movements are also circular. As the heavenly bodies revolve on spheres of aether, so, too, pitches progress along a closed circuit. Andrew Barker explains how Ptolemy maps a system of two octaves onto a circle:

This refers to the treatment of the two-octave series of dynameis in Book II ch. 5, and in the succeeding chapters on the tonoi. As successive tonoi are mapped onto the system of theseis, note-functions that were located in the upper part of the system move round to reappear at the bottom: the ‘lowest’ note-function, proslambanomenos, becomes identical with the ‘highest’, nê tô hyperbolaiôn…Hence the series of dynameis has no ‘natural starting point’, and the ‘starting point in respect of theseis’ stands at a different place in the dynamic cycle of each tonos.\footnote{Barker, 1989, 380.}

Ptolemy’s claim that changes in music and in the heavens are of the same kind—movements in place along a circular path—allows him to map harmonic ratios onto heavenly phenomena. Ptolemy begins by analyzing the relationships among astrologically significant phenomena, and he discovers that harmonic ratios characterize the relationships between zodiacal signs. Swerdlow explains, “We are apparently to imagine the system superimposed upon the twelve zodiacal signs although which tones correspond to which signs is not specified aside from the equinoxes at the beginning, middle, and end.”\footnote{Swerdlow, 153.} While Ptolemy does not specify which tone corresponds to which zodiacal sign—except for the equinoxes being situated at the

\begin{footnotes}
\item[108] Ibid., D100.28-101.6.
\item[109] Barker, 1989, 380.
\item[110] Swerdlow, 153.
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beginning, middle, and end of the complete systêma—certain harmonic relationships hold no matter how one imagines the exact correspondences. For instance, on the circle of the two-octave series in music—where two complete octaves are formed—homophones lie at opposite ends of the diameter of the zodiacal circle. Correspondingly, the stars in the zodiac that are diametrically opposite one other are in opposition, a relationship Ptolemy calls “the most invigorating,” or “active” (ἐνεργητικῶτατοι).\textsuperscript{111}

In addition to the octave, the concords of the fourth and the fifth are evident in the zodiacal circle. In *Harmonics* 3.9, Ptolemy divides the zodiacal circle into four unequal parts and demonstrates how these harmonic ratios exist in the relationships between the zodiacal signs. He divides the zodiacal circle accordingly:

Let us draw a circle, AB, and divide it, starting from some one point, A, into two equal parts by means of line AB, into three equal parts by means of line AC, into four equal parts by line AD, and into six equal parts by line CB. Then arc AB will make the configuration of diametrical opposition, AD that of a square, AC that of a triangle, and CB that of a hexagon. And the ratios of the arcs, starting from the same point, that is, from A, will include those of the homophones and the concords, and that of the tone besides, as we can see if we suppose the circle to consist of twelve segments, since this is the first number to have a half, a third, and a fourth part.\textsuperscript{112}

Ptolemy justifies splitting the zodiac into twelve parts by explaining that if a circle is to encompass the ratios of the concords, it must have the number of parts that contain a half, a third, and a fourth. Moreover, by splitting the zodiacal circle into these four unequal parts, Ptolemy explains why the astrological relationships of opposition, trine, and quartile are significant aspects in astrology. Zodiacal signs that are in opposition, trine, and quartile exhibit the ratios of the homophone and concords. Signs in opposition divide the circle in the 2:1 ratio of the octave, signs in trine make the 3:2 ratio of the fifth, and signs in quartile make the 4:3 ratio of the fourth.

\textsuperscript{111} Ptolemy *Harmonics* 3.8, D101.25, trans. Andrew Barker.
\textsuperscript{112} Ptolemy *Harmonics* 3.9, D102.4-13, after Andrew Barker.
One may also divide the zodiacal circle into other harmonious ratios, such as 3:1 for the octave plus a fifth, 4:1 for the double octave, 8:3 for the octave plus a fourth, and 9:8 for a single tone.

As Swerdlow observes, Ptolemy divides the zodiac in this same way in *Tetrabiblos* 1.13. In this chapter, Ptolemy alludes to the importance of harmonics for explaining the aspects in astrology:

> We may learn from the following why only these intervals have been taken into consideration. The explanation of opposition is immediately obvious, because it causes the signs to meet on one straight line. But if we take the two fractions and the two superparticulars most important in music, and if the fractions one-half and one-third be applied to opposition, composed of two right angles, the half makes the quartile and the third the sextile and trine.\(^{113}\)

In both the *Tetrabiblos* and in the *Harmonics*, Ptolemy describes how the harmonic ratios that form the relationships between musical pitches are present in the heavens, and he affirms that certain aspects between zodiacal signs are significant, because harmonic ratios characterize their relationships.

Furthermore, in *Harmonics* 3.9, Ptolemy explains why zodiacal signs in other relationships are not significant in astrology. Adjacent signs, characterized by the ratio 12:11, as well as the signs exhibiting the ratios 12:5 and 12:7 are either discordant or unmelodic. Swerdlow explains Ptolemy’s reasoning as follows: “…an interval of a tone was fitted to one-twelfth of the circle…This interval is not a concord, but melodic, as is 12/11, a semitone in Ptolemy’s even diatonic and tense chromatic, and ratios of 12/5 or 12/7, made by a line cutting five-twelfths of the circle, would be unmelodic, which is why none of these aspects is

effective.” Similarly, Ptolemy explains in *Tetrabiblos* 1.16 why these relations, between signs that are adjacent or five signs apart, are disjunct:

“Disjunct” and “alien” are the names applied to those divisions of the zodiac which have none whatever of the aforesaid familiarities with one another. These are the ones which belong neither to the class of commanding or obeying, beholding or of equal power, and furthermore they are found to be entirely without share in the four aforesaid aspects, opposition, trine, quartile, and sextile, and are either one or five signs apart; for those which are one sign apart are as it were averted from one another and, though they are two, bound the angle of one, and those that are five signs apart divide the whole circle into unequal parts, while the other aspects make an equal division of the perimeter.

In both the *Tetrabiblos* and the *Harmonics*, Ptolemy designates the same ratios as disjunct. The ratios 12:11, 12:5, and 12:7—which, like 12:5, signifies signs that are five apart—are not concordant in harmonics and, as such, are disjunct. Therefore, the *Tetrabiblos* and the *Harmonics* are coherent in their accounts of the aspects and disjunct relations between zodiacal signs. By applying harmonics to astrology, Ptolemy explains the various relationships that hold between zodiacal signs, and he demonstrates his claim in *Almagest* 1.1 that mathematics has the ability to make a significant contribution to physics.

In *Harmonics* 3.10-12, Ptolemy presents correspondences between harmonic relations and the diurnal motion, motion in depth, and motion in declination of heavenly bodies. While in *Harmonics* 3.8-9 Ptolemy explains that the same ratios that exist between musical pitches also characterize the relationships between zodiacal signs, the correspondences he establishes in 3.10-12 are not mathematical. As such, they resemble the correspondences he establishes between harmonic relations and the parts, species, and changes of the human soul. In other words, Ptolemy suggests that the heavenly movements of *Harmonics* 3.10-12 are characterized by the same relations that exist between musical pitches but only in a qualitative way. The numeric

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114 Swerdlow, 155.
115 Ptolemy *Tetrabiblos* 1.16, Cam36-37, trans. F.E. Robbins.
values of the harmonic ratios do not characterize the relationships between these movements.

Rather, the heavenly movements have the same qualitative formal structure; the movements have the same function within the system of the heavens as the corresponding musical relations have within the harmonic *systêmata*. In *Harmonics* 3.10-12, Ptolemy sets out to explain these various movements in the heavens:

> We must next investigate the facts about the principal kinds of difference between movements in the heavens. There are three kinds, the longitudinal (κατὰ μῆκος), in the direction of forwards or backwards, in accordance with which the differences between their risings and their settings are brought about, and the converse; the vertical (κατὰ βάθος), in the direction of lower and higher, in accordance with which they make their movements further from the earth or closer around it; and finally the lateral (κατὰ πλάτος), in the direction of the sides, in accordance with which their passage comes to be more to the north of us or more to the south.\textsuperscript{116}

Firstly, in discussing movement in length (κατὰ μῆκος), Ptolemy refers simply to the daily rising and setting of heavenly bodies, or their diurnal rotation. He does not discuss here the movement west to east of the planets along the ecliptic or the precession of the equinoxes, although he could mean to include these movements as subsumed within the diurnal rotation. According to Ptolemy, corresponding to the rising and setting of heavenly bodies is the rising and falling of musical pitches. When a heavenly body is near the horizon, when either rising or setting, its position is analogous to the lowest pitch; when at the zenith, its position is analogous to a highest pitch. As the heavenly body rises, the pitch rises; as the heavenly body sets, the pitch falls. When the heavenly body is below the horizon, its position is analogous to silence. Ptolemy summarizes this system as follows:

> Again, the risings and settings are lowest down, the positions in mid-heaven the highest up. The latter are reasonably compared to the highest notes, the former to the lowest; and hence the movements of the stars towards the positions in mid-heaven correspond to the progress of the notes from lower pitches to higher, while

\textsuperscript{116} Ptolemy *Harmonics* 3.10, D104.20-27, after Andrew Barker.
the movements away from the positions in mid-heaven correspond, conversely, to their progress from higher pitches to lower.\textsuperscript{117}

Hence, heavenly bodies’ motion in length, or their diurnal rotation, corresponds to the fall and rise of pitches to and from silence.

Secondly, in \textit{Harmonics} 3.11, Ptolemy associates the genera—the enharmonic, chromatic, and diatonic—with the changes in distance and velocity a heavenly body experiences as a result of its motion in depth (κατὰ βάθος). Swerdlow discerns that Ptolemy does not specifically relate this motion in depth to either an eccentric or an epicyclic model: “Ptolemy does not specify any model to which the relation of distance and speed applies, but we shall illustrate it using an epicyclic model…an eccentric model is also possible—in which the relation is determined by the direction of motion on the epicycle.”\textsuperscript{118} Either model, the eccentric or epicyclic, demonstrates the change in velocity a heavenly body undergoes, either as apparent from the earth, in the case of the eccentric model, or as a result of the combination of two circular motions, as in the case of the epicyclic model. Ptolemy compares the motion of planets at intermediate velocities, when at intermediate distances, to the chromatic genus, in which the two movable notes make intermediate divisions in the tetrachords. He compares motion at the least velocities with the enharmonic genus, in which the two movable notes are close together, and motion at the greatest velocities with the diatonic genus. While for an eccentric model, the greatest velocity occurs at perigee and the least velocity at apogee, Ptolemy states that the greatest and least speeds may occur at either perigee or apogee. Barker explains that the direction of an epicycle on a deferent determines where the greatest and least velocities occur:

\begin{quote}
When the epicycle is carrying a planet ‘backwards’, against the direction in which it moves round the large circle’s circumference, the effective speed of its overall
\end{quote}

\textsuperscript{117} Ibid., D105.16-22.
\textsuperscript{118} Swerdlow, 159.
forward movement is slower than at other times; when it is carrying it in the same direction as the main circle, it is swifter. Since an epicycle may rotate either ‘backwards’ at the top and ‘forwards’ at the bottom or the converse, the planet’s slower overall movement may occur either when it is further from the earth or when it is nearer; hence Ptolemy’s insistence on leaving both possibilities open.\textsuperscript{119}

In the \textit{Almagest}, Ptolemy hypothesizes that the sun and moon’s epicycles move in the opposite direction to their deferents. As a result, they move most quickly when at perigee and most slowly when at apogee. The planets’ epicycles, on the other hand, move in the same direction as their deferents, and so their greatest velocities are at apogee and their least velocities at perigee. Ptolemy refers to this distinction when asserting in \textit{Harmonics} 3.11 that the least and greatest velocities may occur at either perigee or apogee.

Thirdly, in \textit{Harmonics} 3.12, Ptolemy relates the modulation of \textit{tonos} with motion in breadth (κατὰ πλάτος), or in declination from the celestial equator. Ptolemy draws seven parallel circles between the two tropics, and these seven circles correspond to the seven \textit{tonoi}. As a planet moves in declination between the tropics during the course of a year, it modulates between the seven \textit{tonoi}. Ptolemy explains the placement of the seven \textit{tonoi} in the celestial sphere accordingly:

Among them we should compare the Dorian \textit{tonos}, which is right in the middle of the others, with the middle positions of their lateral movements, those set along the celestial equator, as it were, in the case of each of the spheres; the Mixolydian and the Hypodorian, as being the extremes, with the most northerly and southerly positions, conceived in the guise of tropics; and the remaining four \textit{tonoi}, which are between the ones mentioned, with those falling on the parallels between the tropics and the celestial equator, these being themselves four in number, because of the division of the slantwise circle [i.e., the ecliptic] into twelve, corresponding to the twelve parts of the zodiac.\textsuperscript{120}

Ptolemy maps the seven \textit{tonoi} onto the celestial sphere by drawing circles, parallel to the celestial equator, through the signs of the zodiac. The Dorian \textit{tonos} corresponds to the celestial

\textsuperscript{119} Barker, 1989, 386.  
\textsuperscript{120} Ptolemy \textit{Harmonics} 3.12, D106.23-107.6, trans. Andrew Barker.
equator, the Mixolydian and Hypodorian tonoi correspond to the tropics, and the remaining four tonoi correspond to the parallels drawn through the remaining zodiacal signs. As a planet moves in declination, its movements mimic the modulations between the seven tonoi.

Ptolemy bases these correspondences between changes in pitch, the three genera, and the modulation of the seven tonoi and planets’ diurnal motion, motion in depth, and motion in declination solely on dialectical arguments. He does not offer any empirical evidence in support of these seemingly loose analogies. Conversely, Ptolemy’s mapping of harmonic ratios onto the zodiacal circle in *Harmonics* 3.9 seems to be a natural consequence of the geometry of the circle. The mathematician easily divides the circle into twelve equal parts and calculates the ratios characterizing the relations between the arcs of the circle. Moreover, the harmonic ratios present in the zodiacal circle serve to explain astrological aspects and the changes planets’ powers undergo as they move through the zodiac. Despite the lack of quantitative analysis and empirical evidence in *Harmonics* 3.10-12, Swerdlow observes that, if one examines the correspondences between harmonic phenomena and the three general movements a planet undergoes, a striking consequence results:

Of course, these could all be independent and nothing more than analogies. But if they are put together, something interesting happens. Since the synodic periods for motion in depth are not the same as the zodiacal periods for motion in breadth, all the tonoi will appear in all the different genera as the planet’s speed changes, a complete cycle taking approximately: Saturn 59 years, Jupiter 71 years, Mars 79 Years, Venus 8 years, Mercury 46 years, here using periods, originally Babylonian, given by Ptolemy in *Almagest* 9.3 in which the planet completes, with residuals of only a few days or degrees, nearly integral numbers of synodic and zodiacal revolutions. When applied to all the planets, when their periods are combined, the complexity of this system is almost beyond comprehension, for it will not repeat as a whole until they have all together completed integral numbers of synodic and zodiacal periods, which takes many, many thousands of years. If one can imagine a nearly eternal variety in the music of the spheres, Ptolemy surely provides it in these three seemingly innocent chapters. But, as noted, they
could be independent, nothing more than analogies, and this grand music of the spheres not intended.\footnote{Swerdlow, 161-162.}

It is unknown whether Ptolemy believed these correspondences to be more than loose analogies. Nevertheless, if he considered these heavenly movements to have the same qualitative function as harmonic relations or, even more, if he believed that the planets do indeed create music as they move through the heavens, then this symphony of the heavens would create every single note in the complete systêma. Not only would the system of music and the parts of the human soul represent the full harmonic system in their structures and modulations, but the movements in the heavens would produce every single harmonic relation as well.

\section{3.5 The Relationship between Harmonics and Astronomy}

Ptolemy explains that the relations in music, the human soul, and the heavens have the formal characteristics of harmonic ratios because these objects have more complete (τελειώτερος) and rational (λογικῶτερος) natures than do other physical bodies. He claims in Harmonics 3.4 that the power of harmonia (τῆς ἀρμονίας δύναμις) is present to some degree in all natural bodies but to the greatest extent in complete and rational ones:

We must also insist that this sort of power (τῆν τοιοῦτην δύναμιν) must necessarily be present to some extent in all things that have in themselves a source of movement, just as must the other powers, but especially and to the greatest extent in those that share in a more complete (τελειοτέρας) and rational (λογικῶτερας) nature, because of the suitability of the way in which they were generated. In these alone can it be revealed as preserving fully and clearly, to the highest degree possible, the likeness of the ratios that create appropriateness and attunement in the various different species. For in general, each of the things put in order by nature is characterized by some ratio both in its movements and in its underlying materials.\footnote{Ptolemy Harmonics 3.4, D95.4-12, after Andrew Barker.}
Every natural body is characterized to some degree by a ratio, in its movements and in the configuration of its matter. The more complete and rational an object is in its movements and form, the more it is characterized by harmonic ratios. According to Ptolemy, the most complete and rational objects are, in addition to musical pitches, the human soul and heavenly bodies:

It is not found, however, in movements that alter the matter itself, since because of its inconstancy neither the quality of the matter nor its quantity is capable of being defined; but it is found in those movements that are involved most closely with forms. These, as we said, are those of things that are most perfect and rational in their natures, as among divine things are the movements of the heavenly bodies, and among mortal things those of human souls, most particularly, since it is only to each of these that there belong not only the primary and complete sort of movement (that in respect of place), but also the characteristic of being rational.123

Because the most complete and rational objects are those that experience only one type of change, namely motion from place to place, and the most complete and rational objects are characterized to the greatest extent by harmonic ratios, because musical pitches, the human soul, and heavenly movements experience only motion from place to place and are, therefore, the most complete and rational objects, they are characterized by harmonic ratios.

As mentioned above, Ptolemy adopts Plato’s privileging of sight and hearing as the only senses capable of perceiving beauty, such as the beauty of mathematical objects. Ptolemy adds that sight and hearing are most closely affiliated with the ruling part of the soul, or hêgemonikon. When discussing the dynamis harmonikê, Ptolemy proclaims in Harmonics 3.3, “This sort of power (ἡ τοιαύτη δύναμις) employs as its instruments and servants the highest and most marvelous of the senses, sight and hearing, which, of all the senses, are most closely tied to the ruling principle (ἡγεμονικόν), and which are the only senses that assess their objects not only by

the standard of pleasure but also, much more importantly, by that of beauty.”124 Ptolemy repeats this association between the ἥγεμονικὸν and the senses sight and hearing in On the Kritērion and Hégemonikon. He describes these two senses as being located physically higher in the body and, as a result, close to the soul’s faculty of thought: “Among the latter some are more easily activated and more valuable, viz. sight and hearing, and because they are located above the others approach more closely to the soul’s faculty of thought (πρὸς τὸ διανοητικὸν τῆς ψυχῆς ...).”125 In other words, because the senses sight and hearing are located in a human being’s head, they are physically close to the soul’s faculty of thought. Ptolemy adds that the ruling part of the soul, the ἥγεμονικὸν, is in some respects identical with the faculty of thought: “If we give the name ἥγεμονικὸν to what is the best absolutely and the most valuable, it will be located in the brain. We have given sufficient proof that the faculty of thought has a higher degree of worth and divinity, both in power and in substance and both in the universal and in us, and also that its place is the highest position, heaven in the universe, the head in man.”126 The ἥγεμονικὸν, as identifiable with the faculty of thought, is the chief cause of living well (τὸ ἐυζήν),127 and the senses sight and hearing assist in this purpose. Ptolemy explicates this τέλος of sight and hearing in the following:

If a second prize has to be awarded to one of the other means towards the end (τέλος) of living well, the prize would go elsewhere than to the faculty of thought: what is around the heart would not even be runner-up. It would go rather to the senses, and if not to all of them, then only to those which contribute most to assist thought in its consideration and judging of real things, i.e. hearing and sight. These are themselves positioned near the head and the brain, above the other

124 Ptolemy Harmonics 3.3, D93.11-14, after Andrew Barker.
126 Ibid., La22.
127 Ibid.
senses, and near neighbors, because of their special relationship, to the first and chief cause of living well.\textsuperscript{128}

Just as reason is the cause of objects existing in a good way (τὸ ἔν ἔνσεστι), as Ptolemy explains in *Harmonics* 3.3, sight and hearing join with the faculty of thought in causing a human being to live in a good way (τὸ ἔν ζῆν).

As a result of the affiliation of sight and hearing with the faculty of thought, these two senses are able to perceive what the faculty of thought considers to be beautiful and rational objects. The sense of sight perceives beautiful and rational objects that are visible, and the sense of hearing perceives beautiful and rational objects that are audible. Ptolemy comments on sight and hearing, as well as their ability to cooperate with one another, in *Harmonics* 3.3:

It is therefore not just by each one’s grasping what is proper to it, but also by their working together in some way to learn and understand the things that are completed according to the appropriate ratio, that these senses themselves, and the most rational of the sciences (ἐπιστημῶν σί λογικῶτατά) that depend on them, penetrate progressively into what is beautiful and what is useful.\textsuperscript{129}

Ptolemy associates one branch of mathematics with each sense that is perceptive of rational objects: “Related to sight, and to the movements in place of the things that are only seen—that is, the heavenly bodies—is astronomy; related to hearing and to the movements in place, once again, of the things that are only heard—that is, sounds—is harmonics.”\textsuperscript{130} Astronomy is the science of rational objects that are perceptible only by sight, and harmonics is the science of rational objects that are perceptible only by hearing. Furthermore, each of these sciences employs an indisputable mathematical tool. Astronomy utilizes geometry; harmonics utilizes arithmetic. Ptolemy explains, “They employ arithmetic and geometry, as indisputable instruments, to discover the quantity and quality of the primary movements; and they are as it

\textsuperscript{128} Ibid., La23.
\textsuperscript{129} Ptolemy *Harmonics* 3.3, D94.9-13, trans. Andrew Barker.
\textsuperscript{130} Ptolemy *Harmonics* 3.3, D94.13-16, after Andrew Barker.
were cousins, born of the sisters, sight and hearing, and brought up by arithmetic and geometry as children most closely related in their stock.\textsuperscript{131} According to Ptolemy, astronomy and harmonics are comparable as if they were cousins. The former uses geometry when studying objects that are only visible, and the latter uses arithmetic when analyzing objects that are only audible.

Ptolemy’s emphasis on the cousinhood of astronomy and harmonics is not a given in the ancient Greek natural philosophical tradition. After all, in \textit{Metaphysics} M2-3, Aristotle contrasts harmonics not with astronomy but with optics. In M2, he argues against the possibility that mathematical objects have a separate, transcendent existence, as Plato suggests in \textit{Republic} 7. Contending that mathematical objects are inseparable, rather than separate, from physical bodies, he discusses the relationships among the mathematical sciences and juxtaposes the objects of harmonics not with the objects of astronomy but with those of optics:

\begin{quote}
Moreover, how can we solve the difficulties reviewed in the \textit{Discussion of Problems}? There will be objects of astronomy over and above perceptible objects, just like objects of geometry—but how can there be a \textit{separate} heaven and its parts, or anything else with movement? Similarly with the objects of optics and harmonics; there will be utterance and seeing over and above perceptible individual utterances and seeings.\textsuperscript{132}
\end{quote}

More strikingly is Aristotle’s account in \textit{Metaphysics} M3, where he discusses how optics and harmonics study the mathematical form of their specific objects: “The same account applies to harmonics and optics; neither studies its objects as seeing or as utterance, but as lines and numbers (these being proper attributes of the former); and mechanics likewise.”\textsuperscript{133} Therefore, Aristotle juxtaposes the mathematical science that studies audible objects, or harmonics, with the mathematical science that studies visible objects in general, or optics.

\textsuperscript{131} Ibid., D94.16-20.
\textsuperscript{132} Aristotle \textit{Metaphysics} 1077a, trans. Julia Annas.
\textsuperscript{133} Ibid. 1078a.
Aristotle echoes this juxtaposition of optics and harmonics in the *Posterior Analytics*. Rather than specifying that optics relies on sight and harmonics on sound, he bases his comparison of them in this text on their subordination to other branches of mathematics. Optics utilizes geometry, and harmonics utilizes arithmetic. He states, “Nor can you prove by any other science what pertains to a different science, except when they are so related to one another that the one falls under the other—as e.g. optics is related to geometry and harmonics to arithmetic.” Aristotle repeats this association—of optics and harmonics with geometry and arithmetic, respectively—two chapters later: “But a demonstration does not attach to another kind—except that, as I have said, geometrical demonstrations attach to mechanical or optical demonstrations, and arithmetical demonstrations to harmonical.” In 77b and 87a, Aristotle describes optics and harmonics independently of one another, but he still maintains that optics and harmonics rely on geometry and arithmetic, respectively.

Even more, Aristotle describes astronomy as comparable not to optics and harmonics but, rather, to arithmetic and geometry. Discussing the claims that arithmetic and geometry make about their objects of study, he explains the following:

Proper too are the items which are assumed to exist and concerning which the science studies what holds of them in themselves—e.g. units in arithmetic, and points and lines in geometry. They assume that there are such items, and that they are such-and-such. As for the attributes of these items in themselves, they assume what each means—e.g. arithmetic assumes what odd or even or quadrangle or cube means and geometry what irrational or inflexion or verging means—and they prove that they are, through the common items and from what has been demonstrated. Astronomy proceeds in the same way.

Aristotle claims that astronomy works by the same method as arithmetic and geometry. They each assume that certain objects exist—whether they are units, one- and two-dimensional

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135 Ibid. 76a.
136 Ibid. 76b.
objects, or celestial bodies—and that these objects have certain properties. At the same time, Aristotle contrasts astronomy with optics and harmonics. He again describes optics as falling under geometry and harmonics under arithmetic, but he portrays astronomy as on the same order as arithmetic and geometry: “These are the cases which are related to each other in such a way that the one falls under the other, e.g. optics to geometry, mechanics to solid geometry, harmonics to arithmetic, star-gazing (τὰ φαινόμενα) to astronomy.”\(^{137}\) In this passage, Aristotle portrays astronomy as an ἐπιστήμη, like arithmetic and geometry, which has a subordinate field. Optics and harmonics are subordinate to geometry and arithmetic, respectively, because they account for the observable facts that are explainable by means of the superior sciences geometry and arithmetic. In the same way as geometry and arithmetic explain optical and harmonic phenomena, astronomy explains celestial bodies (τὰ φαινόμενα). Aristotle’s subordination of the sciences in this passage differs from the previous account. Optics and harmonics are subordinate not only as branches of mathematics that utilize geometry and arithmetic but, as similar to star-gazing, they are mathematical fields that study and explain physical bodies. Aristotle makes a similar distinction in *Physics* 2.2.194a7-12, where he calls optics, harmonics, and astronomy—not star-gazing, as in the *Posterior Analytics*—more physical than mathematical, because they deal with mathematical objects *qua* physical. In this way, Aristotle draws from Plato’s distinction between the mathematics of intelligible and visible objects in *Republic* 7. For now what is significant is that, when Ptolemy juxtaposes harmonics with astronomy and depicts astronomy as applying geometry, he applies an Aristotelian type of subordination; however, his particular schema is not Aristotle’s.

\(^{137}\) Ibid. 78b.
Ptolemy chooses to contrast astronomy and harmonics—as the sciences that utilize arithmetic and geometry as well as the criteria of sight and hearing—because these two sciences study the most rational objects in the cosmos that are visible and audible, respectively. In other words, Ptolemy juxtaposes the mathematical science that studies rational visible objects, or astronomy, with the mathematical science that studies rational audible objects, or harmonics. Ptolemy derives this emphasis on the rationality of these objects and the sciences that study them from the Platonic tradition. As Barker observes in his *Scientific Method in Ptolemy’s Harmonics*, Ptolemy develops the metaphor of the kinship of the sciences—the sisterhood of arithmetic and geometry and the cousinhood of astronomy and harmonics—from Plato’s *Republic*.138 In *Republic* 7, when discussing the education of the philosopher-king, Socrates describes astronomy and harmonics as counterparts. After elaborating on the proper way to study astronomy, he carries on the following dialogue with Glaucon:

> Besides the one we’ve discussed, there is also its counterpart.  
> What’s that?  
> It’s likely that, as the eyes fasten on astronomical motions, so the ears fasten on harmonic ones, and that the sciences of astronomy and harmonics are closely akin. This is what the Pythaoreans say, Glaucon, and we agree, don’t we? We do.139

When outlining the education of the philosopher-king, Plato includes the fields of inquiry that direct the soul from becoming to being, from the perceptible phenomena to the Forms. Accordingly, he includes astronomy and harmonics as branches of mathematics that direct the soul towards knowledge. Correspondingly, Ptolemy calls astronomy and harmonics cousin sciences, because they are the sciences that, according to Ptolemy, study rational and beautiful

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138 Barker, 2000, 266. Barker also mentions the opening of Archytas fr. 1 as a possible influence on Ptolemy’s use of the metaphor of the kinship of the sciences.
objects, the movements of the heavens and melodious sounds. Therefore, in juxtaposing astronomy and harmonics as branches of mathematics that utilize geometry and arithmetic, respectively, Ptolemy blends an Aristotelian subordination of the sciences with the Platonic esteem for astronomy and harmonics as integral components of a philosopher’s education. For Ptolemy, by studying harmonics and astronomy, one gains knowledge of rational and beautiful objects.

Still, the question remains as to whether Ptolemy believed astronomy and harmonics produce knowledge absolutely. After all, he claims in *Almagest* 1.1 that mathematics, in general, produces sure and incontrovertible knowledge. Examination of Ptolemy’s practice of mathematics in the *Harmonics* and *Almagest*, however, reveals a more nuanced position. While the text of the *Harmonics* indicates that he believed that the science of harmonics does produce knowledge, the *Almagest* suggests that he believed astronomy produces knowledge only to a limited degree. To begin with, in the *Harmonics*, Ptolemy demonstrates that by following his scientific method—the skillful interplay of perception and reason—the student of harmonics produces an accurate model of harmonic relations. His aim is to determine and demonstrate which arithmetic ratios characterize the relations between melodic pitches. In *Harmonics* 1.3-4, Ptolemy argues that the differences between pitches are quantitative, and in *Harmonics* 1.7 he maintains that it is best to follow the lead of the Pythagoreans and posit whole-number ratios as descriptive of the relations between pitches. He states, “Given these preliminary distinctions we must move on into the discussion that follows from them, adopting the same initial principle as the Pythagoreans—the principle, that is, according to which we assign equal numbers to equal-toned notes, and unequal numbers to unequal-toned notes, since that sort of thing is self-
Unlike the Pythagoreans, who let their abstract number-theory drive their harmonic theory, Ptolemy joins arithmetic with empiricism. According to Ptolemy, the student of harmonics endeavors to determine which whole-number ratios produce what are observed to be melodious pitches. He explicitly states this aim of the student of harmonics in *Harmonics* 1.2. Already quoted above, he proclaims, “The aim of the student of harmonics must be to preserve in all respects the rational *hypothesēs* of the *kanôn*, as never in any way conflicting with the perceptions that correspond to most people’s estimation…” Barker explains Ptolemy’s meaning here as follows:

Correspondingly, the project of the harmonic scientist is not the relatively trivial one of confirming that the principles on which his monochord has been built are correct, though that must indeed be done along the way. It is to show that when appropriate comparisons are made, the ear will accept as musically well formed just those relations which rational principles determine, and which can be offered to the judgement of our hearing through this instrument’s operations. The aim of the student of harmonics is to determine which ratios characterize the relations between pitches, construct an instrument which is capable of accurately displaying these ratios, and demonstrate, by imposing these ratios onto the instrument, that the pitches produced with the instrument are observably melodious.

Ptolemy’s principal instrument of demonstration in the *Harmonics* is the monochord, which he calls the harmonic *kanôn*. It consists of a single string, a movable bridge, and a graduated ruler, which he uses for measuring lengths along the string. He also uses instruments with many strings, either eight or fifteen of equal length, and he tunes the strings in unison using the movable bridges. Without the use of an instrument, the sense of hearing observes phenomena only approximately. By constructing the *kanôn* according to rational postulates and

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140 Ptolemy *Harmonics* 1.7, D15.18-21, trans. Andrew Barker.
141 Ptolemy *Harmonics* 1.2, D5.13-15, after Andrew Barker.
subsequently using the kanôn, the student of harmonics is able to refine his sense of hearing and observe the true, accurate pitches: homophones, concords, and otherwise. When expounding the aim of the student of harmonics, Ptolemy introduces the kanôn: “The instrument of this kind of method is called the harmonic kanôn, a term adopted out of common usage, and from its straightening (κανονιζειν) those things in sense perception that are inadequate to reveal the truth.”143 Ptolemy depicts the rational hypotheseis of the kanôn as “having been taken from the obvious and rough and ready phenomena, but finding the points of detail as accurately as is possible through reason.”144 While sense perception alone cannot reveal the hypotheseis, or rational postulates, underlying the phenomena, the use of the kanôn, constructed according to reason, demonstrates that the ratios imposed on the string(s) are the true hypotheseis which characterize the relations between musical pitches.

Ptolemy uses the kanôn to demonstrate the ratios of the concords in Harmonics 1.8. Comparing the use of the kanôn to other instruments, such as the auloi and syringes, Ptolemy states, “But the string stretched over what is called the kanôn will show us the ratios of the concords more accurately and readily (ακριβέστερον τε και προχειρότερον).”145 After describing the manner by which one judges the string’s “evenness of constitution,”146 Ptolemy asserts that by imposing the appropriate ratios onto the string, the student of harmonics creates pitches that are observably the concords: “When something of this kind has been found, and the measuring-rod has been divided in the ratios of the concords that have been set out, by shifting the bridge to each point of division we shall find that the differences of the appropriate notes

143 Ptolemy Harmonics 1.2, D5.11-13, trans. Andrew Barker.
144 Ibid., D5.17-19.
145 Ibid. 1.8, D17.20-22.
146 Ibid., D18.19.
agree most accurately (ἀκριβεστατον) with the hearing.”147 The ratios that the student of harmonics imposes on the kanôn produce what are observable as and judged to be melodious pitches, such as the homophone and concords. Moreover, because the pitches are judged to be the true homophones, concords, etc., the ratios imposed on the kanôn are judged to be the true hypotheseis underlying harmonic phenomena.

Central to Ptolemy’s evaluation of the senses’ ability to perceive phenomena, with and without the aid of reason—e.g., the ability of the sense of hearing to perceive the concords, with and without the aid of the kanôn—is his assessment of their potential to be accurate (ἀκριβής). He lends two meanings to the term. In one sense, Ptolemy associates ἀκριβής with precision. Without the aid of instruments, the senses perceive objects only approximately, while reason grasps them precisely. Accordingly, Ptolemy states in Harmonics 1.1, “Rather, hearing is concerned with the matter and the modification, reason with the form and the cause, since it is in general characteristic of the senses to discover what is approximate (συνεγγυς) and to adopt from elsewhere what is accurate (ἀκριβούς), and of reason to adopt from elsewhere what is approximate (συνεγγυς), and to discover what is accurate (ἀκριβούς).”148 In another sense, Ptolemy suggests that an account of phenomena that is ἀκριβής is true. After all, Ptolemy explains that reason determines not only what is accurate but also what is accepted:

For since matter is determined and bounded only by form, and modifications only by the causes of movements, and since of these the former [i.e., matter and modifications] belong to sense perception, the latter to reason, it follows naturally that the apprehensions of the senses are determined and bounded by those of reason, first submitting to them the distinctions that they have grasped in rough outline (ὁλοσχερόστερον)—at least in the case of the things that can be detected through sensation—and being guided by them towards distinctions that are accurate (ἀκριβείς) and accepted (ομολογούμενος).149

147 Ibid., D18.22-19.1.
148 Ibid. 1.1, D3.4-8.
149 Ibid., D3.8-14.
This description of distinctions that are accepted recalls Ptolemy’s definition of knowledge (ἐπιστήμη) in On the Kriterion as corresponding to a “highly lucid and agreed (ὁμολογουμένη) judgment.” Moreover, Ptolemy distinguishes between mathematical constructions that are more and less accurate. By using accuracy as a measure of whether a circle that is drawn is actually a circle and whether a pitch is properly tuned, Ptolemy differentiates between mathematical forms that are true and less than true:

Thus just as a circle constructed by eye alone often appears to be accurate (ἀκριβῶς), until the circle formed by means of reason brings the eye to a recognition of the one that is really accurate (τοῦ τῶν ὑπ’ ἀκριβοῦς), so if some specified difference between sounds is constructed by hearing alone, it will commonly seem at first to be neither less nor more than what is proper; but when there is tuned against it the one that is constructed according to its proper ratio (ἐφαρμοσθείσης δὲ τῆς κατὰ τὸν ὑκείων λόγου ἐκλαμβανόμενης), it will often be proved not to be so, when the hearing, through the comparison, recognizes the more accurate (ἀκριβεστέραν) as legitimate (γνησίαν), as it were, beside the bastardy (νόθον) of the other…

In other words, the more accurate circles and pitches are legitimate. By legitimate, Ptolemy means true, as he suggests in the passage which follows the above:

This sort of deficiency in perceptions does not miss the truth (ἀληθείας) by much when it is simply a question of recognizing whether there is or is not a difference between them, nor does it in detecting the amounts by which differing things exceed one another, so long as the amounts in question consist in larger parts of the things to which they belong. But in the case of comparisons concerned with lesser parts the deficiency accumulates and becomes greater, and in these comparisons it is plainly evident, the more so as the things compared have finer parts. The reason is that the deviation from the truth (τὸ παρὰ τὴν ἀληθείαν καθόποξ βραχύτατον), being very small when taken just once, cannot yet make the accumulation of this small amount perceptible when only a few comparisons have been made, but when more have been made it is obvious and altogether easy to detect.

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150 Ptolemy On the Kriterion, La7, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
151 Ptolemy Harmonics 1.1, D3.20-4.7, after Andrew Barker.
152 Ibid., D4.10-19.
After adopting the less precise observations of sense perception, reason has the ability to produce accurate—precise and truthful—postulates. By imposing these postulates on the kanôn, the student of harmonics observes that these postulates accurately produce harmonic phenomena, such as the homophone and concords expounded in Harmonics 1.8. As a result, the student of harmonics considers these postulates to be true.

Ptolemy’s contrast of true, or legitimate (γνησίως), knowledge with bastard (νόθων) knowledge suggests an Atomist influence on his epistemology. After all, Democritus makes a similar contrast in his fragments. In Adversus mathematicos 7, Sextus Empiricus discusses Democritus’ epistemology as follows:

But in his Canons he says that there are two kinds of knowledge (γνώσεις), the one through the senses, the other through the mind. Of these, he calls the one through the mind ‘genuine’ (γνησία), testifying in favor of its trustworthiness for judging the truth (ἀλήθεια), while the one through the senses he names ‘dark’ (σκοτία), denying it inerrant recognition of the truth. His precise words are: “Of knowing there are two forms, the one genuine (γνησία), the other dark (σκοτία). And of the dark kind this is the complete list: sight, hearing, smell, taste, and touch. The one which is genuine, but separated from this one….” Then, by way of judging the genuine one superior to the dark one, he adds these words: “…is when the dark one (σκοτία) is no longer able either to see in the direction of greater smallness, nor to hear nor to smell nor to taste nor to sense by touch other things in the direction of greater fineness.” Therefore according to him too, reason is a criterion, which he calls ‘genuine knowing’ (γνήσια γνώμη).

According to Democritus, and similarly for Ptolemy, the legitimate (γνησία) form of knowledge conveys the truth (ἀλήθεια), while the other form of knowledge, whether dark (σκοτία) or bastard (νόθου), does not. In addition, Democritus claims that the senses are limited in their ability to observe small objects, just as Ptolemy argues that with only the senses one

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154 Ptolemy’s distinction of legitimate (γνησία) from bastard knowledge recalls his remark on legitimate (γνήσιως) philosophers in Almagest 1.1, H4.
cannot draw an accurate circle. According to Ptolemy, with the aid of reason, one comes to recognize the circle that is really accurate ($τοῦ \ τῶν \ ὁντι \ ἀκριβοῦς$). This concept is markedly Platonic, and it is in this last point that Ptolemy’s epistemology diverges from Democritus’. For Democritus, the senses are categorically limited in their ability to observe the truth behind the appearances, but, according to Ptolemy’s Platonic empiricism, the senses gain the ability to distinguish the accurate from the inaccurate when aided by reason.

The interpretation I have been propounding for Ptolemy’s use of the terms ἀκριβός, γνησία, and ἀληθεία substantiates a realist interpretation of Ptolemy’s use of the term ὑποθεσία. Barker argues in favor of Ptolemy’s realism, and against any instrumentalism on his part, in *Scientific Method in Ptolemy’s Harmonics*. He interprets Ptolemy’s use of the term *hypothesis* as follows:

I have suggested elsewhere that at certain moments in the *Harmonics* the word *hypothesis* is best construed as referring to principles inherent in the world itself, aspects of the reality ‘underlying’ the behaviour of perceptible things, rather than merely to propositions about them enunciated by the scientist. This cannot be regarded as certain, though it arguably gives the most plausible reading of 100.25, and perhaps of a handful of other passages too. But there is a related and much more significant point on which I must certainly take a stand. It is that in cases where a *hypothesis* has been established as scientifically reliable, it is so because it is true, because it formulates as a proposition a principle that holds in the external world. It is not just a convenient fiction by which the scientist is enabled to organise his data.155

Barker substantiates this realist interpretation—that Ptolemy believed his *hypotheses* represent true, physical and mathematical, reality—by appealing to Ptolemy’s adherence to his own scientific method, relying as it does on the interaction of perception and reason. Barker presents his argument as follows:

In the *Harmonics*, fortunately, there is much less room for dispute, since the mathematical *hypotheses* deployed in its theoretical derivations are explicitly

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underpinned, in their turn, by the results of investigations in physical acoustics that occupy 1.3. Relations between pitches can properly be represented as ratios between quantities because that is what, in physical reality, they are; and if they were not, no amount of mathematical or methodological conjuring would, in Ptolemy’s view, justify the *hypothesis* that treat them in this way. Certain high-level *hypotheses* about the mathematical character of the ratios that are assigned a privileged place in harmonics are justified similarly, as we shall see in Chapter 5, by their status as accurate representations, in their formal aspect, of the structure of processes actually going on in the physical realm, which in their perceived guise are assigned privileged musical status by the ear. The construction and use of Ptolemy’s experimental instruments depends equally on the physical truth, not merely the mathematical convenience of the *hypotheses* that guide their design.156

Barker argues that because Ptolemy bases his harmonics on a foundation of empiricism, he intends the *hypothesis* he puts forward for harmonic relations to represent the true, mathematical relations existing between the physical bodies examined. Through the interplay of reason and perception, the student of harmonics determines which ratios exist between musical pitches. Having heard and analyzed the harmonic ratios by means of reason, he has the further ability to reproduce the pitches on the harmonic *kanôn* and demonstrate the truth of the postulates. Basing the *hypothesis* of harmonics on his criterion of truth, which utilizes both reason and perception, Ptolemy establishes, sure and incontrovertibly, the truth of the ratios that exist in the relations between musical pitches.

The case is different with Ptolemy’s exposition of astronomy in the *Almagest*. However one interprets Ptolemy’s use of the term *hypothesis* in this text, Ptolemy makes it clear that, while he is confident in the veracity of certain aspects of his astronomical models, other aspects are less accurate. Starting with the true aspects, in *Almagest* 1.3, Ptolemy puts forward several arguments—empirical and dialectical—for the sphericity of the heavens: (1) The size and mutual

156 Ibid., 25.
distances of the stars does not appear to change;\textsuperscript{157} (2) The spherical shape of the heavens is the only \textit{hypothesis} that explains sundial observations; (3) The motion of the heavens is the freest of all motions, and the freest moving solid shape is a sphere; (4) The heavens are greater in size than all other bodies and, therefore, should have the shape that has the greatest volume, or the sphere; (5) Because the heavens consist of aether—which, in turn, consists of parts that are the most like each other—the heavens should have a shape wherein its parts are the most like each other, or a sphere; (6) Because the aether consists of spherical parts, the heavens, being composed of aether, are spherical (H12-14). Ptolemy uses the most assertive language in his second argument, which, like the first, draws on empirical data, in this case derived from sundial observations: “No other \textit{hypothesis} but this can explain how sundial constructions produce correct results….”\textsuperscript{158} Because the empirical data is explainable only by the \textit{hypothesis} of the sphericity of the heavens, this \textit{hypothesis} must be true. Moreover, in \textit{Almagest} 1.8, Ptolemy asserts that the \textit{hypotheses} he has discussed thus far, including the sphericity of the heavens, will be proven in subsequent chapters by their agreement with observation:

It was necessary to treat the above \textit{hypotheses} first as an introduction to the discussion of particular topics and what follows after. The above summary outline of them will suffice, since they will be completely confirmed (\textit{βεβαιωθηθεύεται}) and borne witness (\textit{ἐπιμαρτυρηθεύεται}) by the agreement with the phenomena of the theories which we shall demonstrate in the following sections.\textsuperscript{159}

Ptolemy makes it clear that certain basic astronomical \textit{hypotheses} are proven true by their agreement with empirical data just as, for example, the \textit{hypothesis} of the sphericity of the

\textsuperscript{157} Ptolemy notes one exception: stars appear larger when close to the horizon. Here, in the \textit{Almagest}, he gives a physical and optical explanation for this phenomenon, but in \textit{Optics} 3.60 he provides a psychological explanation.

\textsuperscript{158} Ptolemy \textit{Almagest} 1.3, H13, after G.J. Toomer.

\textsuperscript{159} Ibid. 1.8, H26.
heavens is the only hypothesis that, according to Ptolemy, agrees with sundial observations. As a result, the heavens must be spherical.

In the quote above, Ptolemy uses the participle ἐπιμαρτυρηθησόμενας, from ἐπιμαρτύρησις, which is a technical term in Epicurean epistemology meaning ‘witnessing’, or the direct confirmation of a claim by a phenomenon. A.A. Long maintains that this term was used commonly across school boundaries in Roman-Empire philosophy. The opposite of ἐπιμαρτύρησις is ἀντιμαρτύρησις, translated at ‘counter-witnessing’, or the refutation of a claim by a phenomenon. Sextus Empiricus defines these terms in Adversus mathematicos 7. He explains, “Of opinions, then, according to Epicurus, some are true (ἀληθεῖς), others false (ψευδεῖς); the true being those which testify for (ἐπιμαρτυρούμεναι), and not against (οὐκ ἀντιμαρτυρούμεναι), the evidence of sense, and the false those which testify against (ἀντιμαρτυρούμεναι), and not for (οὐκ ἐπιμαρτυρούμεναι), that evidence.” In the above passage from Almagest 1.8, Ptolemy imbues the term ἐπιμαρτυρηθησόμενας with the Epicurean meaning. The hypothesēs of chapters 1.3-7, so he claims, are confirmable by means of the observation of the phenomena, which are explained in the subsequent chapters. Ptolemy uses the term ἐπιμαρτυρηθησόμενας on two other occasions, both in Tetrabiblos 4.9. The term seems to take on a peculiar, astrological meaning in this text, but he also uses the term ἀντιμαρτύρησις, and in both the Almagest and the Harmonics, this term assumes the technical,

Epicurean meaning. In *Almagest* 1.7, for instance, when contesting the idea that the earth moves from place to place, Ptolemy states the following:

> But certain people, [propounding] what they consider a more persuasive view, agree with the above, since they have no argument to bring against it, but think that there could be no evidence to oppose (ἀντιμαρτυρήσειν) their view if, for instance, they supposed the heavens to remain motionless, and the earth to revolve from west to east about the same axis [as the heavens], making approximately one revolution each day…\(^{163}\)

Ptolemy uses the verb ἀντιμαρτυρήσειν to indicate the observation of a phenomenon that would bear witness against the theory that the earth rotates. In *Almagest* 1.3, Ptolemy again uses this verb and argues that the heavens must be spherical because the phenomena bear witness against all other hypotheses: “The result was that in the beginning they got to the aforementioned notion solely from such considerations; but from then on, in their subsequent investigation, they found that everything else accorded with it, since absolutely all phenomena are in contradiction (ἀντιμαρτυροῦντων) to the alternative notions which have been propounded.”\(^{164}\) Similarly, in *Harmonics* 1.1, Ptolemy reasons that a method—such as using the *kanôn*—is needed to produce results which the sense of hearing would not contradict: “For the ears, similarly, which with the eyes are most especially the servants of the theoretical and rational part of the soul, there is needed some method derived from reason, to deal with the things that they are not naturally capable of judging accurately, a method against which they will not bear witness (οὐκ ἀντιμαρτυρήσουσιν), but which they will agree is correct.”\(^{165}\) In each of these cases, Ptolemy conveys the Epicurean meaning of the terms ἐπιμαρτυρήσεις and ἀντιμαρτυρήσεις. Observation of phenomena either bears witness to the truth or falsity of a


\(^{164}\) Ibid. 1.3, H11.

\(^{165}\) Ptolemy *Harmonics* 1.1, D5.6-10, trans. Andrew Barker.
hypothesis. Accordingly, the truth of the hypothesis that the heavens have a spherical shape is borne witness, or evidenced by observations, such as with a sundial.

In addition to the hypothesis of the sphericity of the heavens, Ptolemy posits the eccentric and epicyclic natures of the aethereal spheres as necessarily true consequences of the heavens’ spherical shape. The heavens must consist of eccentric and epicyclic spheres of aether because the natural uniform circular motion of the aether must be reconciled with the planets’ seemingly irregular movements. Ptolemy presents his dialectical argument for the existence of eccentric and epicyclic spheres in *Almagest* 3.3:

Our next task is to demonstrate the apparent anomaly of the sun. But first we must make the general point that the rearward displacements of the planets with respect to the heavens are, in every case, just like the motion of the universe in advance, by nature uniform and circular. That is to say, if we imagine the bodies or their circles being carried around by straight lines, in absolutely every case the straight line in question describes equal angles at the centre of its revolution in equal times. The apparent irregularity [anomaly] in their motions is the result of the position and order of those circles in the sphere of each by means of which they carry out their movements, and in reality there is in essence nothing alien to their eternal nature in the ‘disorder’ which the phenomena are supposed to exhibit. The reason for the appearance of irregularity can be explained by two hypotheses, which are the most basic and simple. When their motion is viewed with respect to a circle imagined to be in the plane of the ecliptic, the centre of which coincides with the centre of the universe (thus its centre can be considered to coincide with our point of view), then we can suppose, either that the uniform motion of each [body] takes place on a circle which is not concentric with the universe, or that they have such a concentric circle, but their uniform motion takes place, not actually on that circle, but on another circle, which is carried by the first circle, and [hence] is known as the ‘epicycle’. It will be shown that either of these hypotheses will enable [the planets] to appear, to our eyes, to traverse unequal arcs of the ecliptic (which is concentric to the universe) in equal times.166

After arguing for the sphericity of the heavens, with both empirical and dialectical arguments, Ptolemy argues dialectically for the existence of eccentric and epicyclic spheres. The need to reconcile the observation of the planets’ seemingly irregular movements with the uniform

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166 Ptolemy *Almagest* 3.3, H216, after G.J. Toomer.
circular motion of the aether necessitates the existence of eccentric and epicyclic spheres. As a result, the \textit{hypotheseis} of eccentric and epicyclic spheres are, according to Ptolemy, true.\textsuperscript{167}

Ptolemy does not display the same confidence, however, in the other aspects of his astronomical models. In \textit{Almagest} 3.1, he controverts the possibility that astronomers can know the exact periods of heavenly movements. In particular, he discusses the limits to observation which prevent one from accurately determining the period of the tropical year. Ptolemy explains that there exists a possible error of $\frac{1}{4}$ of a day in his observations:

Thus in these observations too there is no discrepancy worth noticing, even though it is possible for an error of up to a quarter of a day to occur not only in observations of solstices, but even in equinox observations. For suppose that the instrument, due to its positioning or graduation, is out of true ($\pi\rho\alpha\lambda\lambda\epsilon\zeta\pi\tau\iota\varsigma$ $\alpha\kappa\rho(\beta\epsilon\iota\alpha\varsigma)$) by as little as $\frac{1}{3600}$th of the circle through the poles of the equator; then, to correct an error of that size in declination, the sun, [when it is] near the intersection [of the ecliptic] with the equator, has to move $\frac{1}{4}^\circ$ in longitude on the ecliptic. Thus the discrepancy ($\delta\iota\alpha\phi\omega\omicron\nu\iota\alpha\nu$) comes to about $\frac{1}{4}$ of a day.\textsuperscript{168}

While a possible error of $\frac{1}{4}$ of a day is small enough for Ptolemy to discount when affirming the constancy of the length of the tropical year, the existence of any possible error, whatever its amount, is sufficient to prevent Ptolemy from claiming that he has or ever will accurately determine the length of the tropical year.

Ptolemy allows that if one increases the length of time between observations, then the accuracy of the calculated tropical year, or any other period, increases; however, because the length of time between observations is necessarily limited, the true tropical year cannot be known. Ptolemy explains as follows:

\textsuperscript{167} While Ptolemy demonstrates that the heavens consist of both types of spheres, eccentric and epicyclic, in the sun’s model the two are exclusive, as the sun has only one anomaly. Although both save the phenomena, Ptolemy chooses the former because it is simpler. See \textit{Almagest} 3.4, H232.

\textsuperscript{168} Ptolemy \textit{Almagest} 3.1, H197, trans. G.J. Toomer.
However, the longer the time between the observations compared, the greater the accuracy (εγγιστα ακριβως) of the determination of the period of revolution. This rule holds good not only in this case, but for all periodic revolutions. For the error due to the inaccuracy inherent in even carefully performed observations is, to the senses of the observer, small and approximately the same at any [two] observations, whether these are taken at a large or a small interval. However, this same error, when distributed over a smaller number of years, makes the inaccuracy in the yearly motion [comparatively] greater (and [hence increases] the error accumulated over a longer period of time), but when distributed over a larger number of years makes the inaccuracy [comparatively] less. Hence we must consider it sufficient if we endeavor to take into account only that increase in the accuracy of our hypoteses concerning periodic motions (τη των περιοδικων υποθεσεων εγγυτητι) which can be derived from the length of time between us and those observations we have which are both ancient and accurate (ακριβων). We must not, if we can avoid it, neglect the proper examination [of such records]; but as for assertions (διαβεβαιωσεις) ‘for eternity’, or even for a length of time which is many times that over which the observations have been taken, we must consider such as alien to a love of science (φιλοσοφειας) and truth (φιλαληθειας).  

Observation is necessarily limited in precision and scope. While a possible error of at least ¼ of a day is built into the instruments Ptolemy and his predecessors used to make observations, the length of time between their observations is contingent upon and, therefore, limited by the collective lifetime of the observational astronomers and their extant records. As a result, Ptolemy concludes that astronomers cannot know and, therefore, should not claim that their values for the tropical year are valid for all of eternity. The best they can do is offer an approximation of the length of the tropical year, such as Ptolemy’s 365;14;48d, which he calls “the closest possible approximation (εγγιστα υμνως δι ενι μαλιστα) which we can derive from the available data.”

Ptolemy echoes this attention to possible error in observation in his praises of Hipparchus. Throughout *Almagest* 3.1, Ptolemy calls Hipparchus a lover of truth.

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169 Ptolemy *Almagest* 3.1, H202-203, after G.J. Toomer.
He draws attention to Hipparchus’ misapplication of observations—such as in deducing that the tropical year is not constant—while, at the same time, he commends him for attempting to keep his models in accordance with observations. For instance, Ptolemy explains how Hipparchus offered his observations as possible evidence for a second solar anomaly:

However, it is my opinion that Hipparchus himself realized that this kind of argumentation provides no persuasive evidence for the attribution of a second anomaly to the sun, but his love of truth (φιλαλήθεια) led him not to suppress anything which might in any way lead some people to suspect [such an anomaly].

Similarly, Ptolemy quotes Hipparchus’ *On the displacement of the solsticial and equinoctial points*. In this fragment, Hipparchus takes into account possible observational error when determining the tropical year:

For, in his treatise ‘On the displacement of the solsticial and equinoctial points’, he first sets out those summer and winter solstices which he considers to have been observed accurately (ἀκριβεία), in succession, and himself admits that these do not display enough discrepancies to allow one to use them to assert the existence of any irregularity in the length of the year. He comments on them as follows: ‘Now from the above observations it is clear that the differences in the year-length are very small indeed. However, in the case of the solstices, I have to admit that both I and Archimedes may have committed errors of up to a quarter of a day in our observations and calculations [of the time]. But the irregularity in the length of the year can be accurately (ἀκριβεία) perceived from the [equinoxes] observed on the bronze ring situated in the place at Alexandria called the “Square Stoa”. This is supposed to indicate the equinox on the day when the direction from which its concave surface is illuminated changes from one side to the other’.

In this quotation, Hipparchus, like Ptolemy after him, recognizes that there are degrees of accuracy in observation and one must take possible errors into account when forming *hypotheses*. Ptolemy praises Hipparchus for his attention to observation and its potential error.

Correspondingly, he criticizes astronomers who, unlike Hipparchus, do not consider the

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171 Cf. Ptolemy *On the Kritêrion*, La5, for Ptolemy’s use of the term φιλαλήθειατος.
172 Ptolemy *Almagest* 3.1, H200, after G.J. Toomer.
limitations of observation when presenting the periods they have calculated for heavenly phenomena.

Why, then, does Ptolemy accept all of his harmonic *hypotheseis* as true but only some of his astronomical *hypotheseis*? After all, both branches of mathematics employ Ptolemy’s criterion of truth—the collaboration of perception and reason. Discussing Ptolemy’s method in the *Harmonics*, Swerdlow maintains that Ptolemy uses the same method in this text as he does in the *Almagest*:

> I shall only mention, as I did earlier, that Ptolemy’s method is rigorously mathematical and rigorously empirical, that it is exactly the method he follows in the *Almagest*, and that it is exactly the method that has been followed in the best work in the applied mathematical sciences ever since. Even if the astronomical and astrological parts of the *Harmonics*, which we have considered here, perhaps in greater detail than they are worth, are not on Ptolemy’s highest level (as indeed they are not), his statements of method and his exposition of harmonics itself certainly are, and that is enough to make the *Harmonics*, perhaps Ptolemy’s earliest work, of lasting importance to the history of the mathematical sciences.\(^{174}\)

In both the *Harmonics* and in the *Almagest*, Ptolemy creates his mathematical models by means of the interplay of perception and reason. If harmonics and astronomy share the same method, then the disparity in their truth claims must rest on one or more of the following: (1) A difference in the objects that these sciences study, (2) A difference in the access to or quality of the perceptual evidence utilized by the sciences, or (3) A dissimilarity in the sciences’ aims. I will argue that the crucial difference is the last. This difference rests on the adherence of harmonics and astronomy to Ptolemy’s criterion of truth—the skillful interplay of reason and perception—and it is exemplified in their relationship to arithmetic and geometry.

In both *Almagest* 1.1 and *Harmonics* 3.3, Ptolemy calls arithmetic and geometry indisputable. In the former, he states that mathematics, in general, uses arithmetic and geometry:

\(^{174}\) Swerdlow, 176.
“…only mathematics can provide sure and incontrovertible knowledge to its devotees, provided one approaches it rigorously. For its kind of proof proceeds by indisputable methods (ἀναμφίσβητων ὀδῶν), namely arithmetic and geometry.” In the latter, Ptolemy specifies that harmonics and astronomy, specifically, use arithmetic and geometry. After explaining that astronomy uses the criteria of sight and reason, and harmonics uses the criteria of hearing and reason, he asserts, as quoted above, “They employ arithmetic and geometry, as indisputable (ἀναμφίσβητοι) instruments, to discover the quantity and quality of the primary movements; and they are as it were cousins, born of the sisters, sight and hearing, and brought up by arithmetic and geometry as children most closely related in their stock.”

Arithmetic and geometry produce sure and incontrovertible knowledge. Harmonics and astronomy, however, produce knowledge only inasmuch as they utilize the indisputable mathematical tools of arithmetic and geometry. As explained above, the student of harmonics aims to determine and demonstrate which arithmetic ratios characterize the relations between musical pitches. In this way, he adopts the whole-number ratios of arithmetic, but instead of simply discussing the ratios as abstract units, as does the arithmetician, he applies them as explanations of the formal relationships between musical pitches. He demonstrates the accuracy of his hypotheseis by constructing and utilizing the harmonic kanôn. He can play the kanôn anytime and anywhere within the cosmological sphere of air, and the kanôn can have any dimension whatsoever. While it is imperative that the strings of Ptolemy’s kanônes be of equal length, their overall length, as well as the length of the single string of the kanôn, is irrelevant. No matter what a string’s length, dividing it according to a 2:1 ratio will produce was is observably an octave, dividing it according to a 3:2 ratio will

175 Ptolemy Almagest 1.1, H6, after G.J. Toomer.
176 Ptolemy Harmonics 3.3, D94.16-20, after Andrew Barker.
produce what is observably the concord of the fifth, and dividing it according to a 4:3 ratio will produce what is observably the concord of the fourth. The same holds for the rest of the melodic tunings. Because they depend on ratios, they hold in every instrument that resonates in air and can be divided accurately according to the arithmetic ratios which characterize the relations between harmonic pitches. After determining—through the interplay of perception and reason—which arithmetic ratios underlie the relations between melodious pitches, the student of harmonics has only one remaining task. He must demonstrate that the arithmetic ratios, when imposed on a suitable instrument, such as the harmonic kanôn, indeed produce what is observed to be melodious pitches. This process may involve several stages—such as determining the ratios of the homophones and concords, the tetrachords, and the systémata—but each stage is alike in kind. The task at every stage is to determine and demonstrate the arithmetic ratios that characterize the relations between the pitches. In this way, the student of harmonics transfers the indisputable authority of arithmetic to the science of harmonics. He discovers which indisputable, arithmetic ratios underlie the relations between pitches and then demonstrates that these ratios accurately produce what are observed to be melodious pitches.

While harmonics adopts its ratios from arithmetic, astronomy Appropriates the objects of geometry. As stated above, in the Almagest, Ptolemy argues that the heavens must be spherical in shape. After all, according to Ptolemy, a sphere is the only shape that explains sundial observations. Moreover, the heavens must consist of eccentric and epicyclic spheres, because these hypotheseis reconcile the sphericity of the heavens and the natural circular motion of the aether with the seemingly irregular movements of the planets. By describing the heavens as consisting of spheres—eccentric and epicyclic—Ptolemy employs geometry in his explanation of heavenly phenomena. He claims that certain geometrical objects, namely spheres, exist and that
they exist, specifically, in the heavens. The heavens are spherical in shape and consist of several eccentric and epicyclic spheres. So far, the astronomer’s aim has mimicked the aim of the student of harmonics. The latter adopts the numerical ratios of arithmetic and determines which apply to harmonic phenomena. The astronomer adopts the objects of geometry and determines that eccentric and epicyclic spheres account for astronomical phenomena.

The astronomer, however, has a further task. After portraying the heavens as consisting of geometrical objects, namely spheres, he must determine the spheres’ relative and absolute sizes as well as their periods. More specifically, in the *Almagest* Ptolemy endeavors to calculate the periods of celestial phenomena, how many eccentric and/or epicyclic spheres exist in each planetary system, what the relative sizes of the spheres are, and the absolute sizes of the lunar and solar systems. This process involves two disparate stages. The first involves the construction of the abstract models of the planetary systems; the second consists in the quantification of the models. When introducing his argument for the identity of the eccentric and epicyclic models, Ptolemy distinguishes the two stages involved in constructing astronomical models. He explains, “If these conditions are fulfilled, the identical phenomena will result from either of the hypotheseis. We shall briefly show this [now] by comparing the ratios in abstract, and later by means of the actual numbers we shall assign to them for the sun’s anomaly.”¹⁷⁷

Throughout the *Almagest*, Ptolemy treats the development of his astronomical models as a two-stage process. Having procured the most precise observations possible of astronomical phenomena, Ptolemy constructs an abstract model of each planet’s system of heavenly spheres. This model embodies the number of anomalies the planet is observed to experience in its movements through the heavens. As such, it consists of one or more spheres, eccentric and/or

¹⁷⁷ Ptolemy *Almagest* 3.1, H220, after G.J. Toomer.
epicyclic. Having established this general model, Ptolemy then applies numerical values to the spheres in order to determine their relative sizes as well as the absolute sizes of the lunar and solar systems.

In the first stage, the construction of an abstract model, Ptolemy follows the geometrical tradition epitomized by Euclid’s *Elements*. The definitions and propositions of the *Elements* describe abstract geometrical figures that are meant to describe the most fundamental relations between mathematical objects. Accordingly, the objects presented are not particulars but general examples of mathematical objects. When discussing the lack of visual demonstrations in the *Elements*, Árpád Szabó, in his *The Beginnings of Greek Mathematics*, states, “It seems that Euclid abandoned visual demonstrations because he wanted his proof to be valid for all possible cases. He turned to logical arguments in his search for greater generality.” Furnishing logical, rather than visual demonstrations, Euclid presents propositions that apply to general examples of mathematical objects rather than particulars. Ptolemy takes a similar approach when constructing astronomical models. At first, he presents an abstract model, characterized by the number and configuration of the eccentric and/or epicyclic spheres which represent a planet’s anomalies. Only once he has established this abstract model does he then apply quantitative data of the planet’s periods to the model. Ptolemy adheres to this two-stage process—constructing an abstract model before applying quantitative data to it—in every planetary model he constructs in the *Almagest*.

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179 Ptolemy’s method of constructing the moon’s model is more complicated. While in *Almagest* 4 he follows this two-stage process, in Book 5 he revisits the moon’s model in order to take into account the moon’s second anomaly, which is at its maximum at both quadratures.
The second stage, the quantification of the model, is different in kind from the first. While geometry provides the objects of the abstract model—the eccentric and/or epicyclic spheres which embody each planet’s anomalies—the astronomer cannot derive the quantitative aspects of his models from geometry and determine, through reason, what the periods and sizes of the spheres are. While the student of harmonics derives every aspect of his models from arithmetic, by merely applying the ratios to the phenomena, the astronomer must go beyond geometry. He affirms that the heavens consist of several eccentric and epicyclic spheres—dialectical and empirical evidence, or reason and perception, have confirmed these *hypotheseis*—but, in order to determine the dimensions and periods of the spheres, he must rely solely on observation. Only by extrapolating from a series of observations, which are as accurate as possible and as far apart in time as possible, can the astronomer attempt to determine the quantitative parameters of his models. Ptolemy recognizes, however, that observation is plagued by potential error and that the scope of observations is limited by the lifetime of human beings and the existence of their records. As a result, he argues in *Almagest* 3.1 that the astronomer cannot know the exact periods of heavenly phenomena. While he is certain that geometrical objects exist in the heavens, he is uncertain of their exact dimensions and periods, which only observation can reveal to a limited degree.

Furthermore, the numbers that Ptolemy utilizes in the *Almagest* to describe the periods and relative sizes of the heavenly spheres are not the simple ratios of harmonics. For instance, in *Almagest* 4.3, Ptolemy begins his calculation of the individual mean motions of the moon with the following:

If, then, we multiply the mean daily motion of the sun which we derived, ca. 0;59,8,17,13,12,31°d, by the number of days in one [mean synodic] month, 29;31,50,8,20°d, and add to the result the 360° of one revolution, we will get the mean motion of the moon in longitude during one synodic month as ca.
389;6,23,1,24,2,30,57⁰. Dividing this by the above number of days in a month, we get the mean daily motion of the moon in longitude as ca. 13;10,34,58,33,30,30⁰.\textsuperscript{180}

With long chains of sexigesimal fractions, Ptolemy’s values for periodic phenomena, such as the moon’s mean motions, are not simple. Moreover, it is not clear whether they represent rational or irrational numbers. After all, Ptolemy asserts that these values are approximations. He carries them out to six or so places merely because he believes that this level of precision is sufficient for his calculations. For instance, when calculating the sun’s mean daily motion, Ptolemy declares, “Since we have shown that one revolution contains 365;14,48⁰, dividing the latter into the 360˚ of the circle, we find the mean daily motion of the sun as approximately 0;59,8,17,13,12,31˚ (it will be sufficient to carry out divisions to this number \[i.e. 6\] of sexagesimal places).”\textsuperscript{181} Whether the values for astronomical phenomena are commensurable or incommensurable does not seem to concern Ptolemy. What is more concerning is their cumbersomeness, on a practical level, as well as their inelegance. They are not the simple, beautiful ratios of harmonics. As another example, in Almagest 5.15 Ptolemy calculates the distances of the moon and sun:

\begin{verbatim}
Therefore we have calculated that where the earth’s radius is 1
the mean distance of the moon at the syzygies is 59
the distance of the sun is 1210
and the distance from the centre of the earth to the apex of the shadow cone is 268.\textsuperscript{182}
\end{verbatim}

The results of extensive calculations from values that are only approximations, the ratios between these mean distances are not the simple, beautiful ratios of harmonics.

\textsuperscript{180} Ptolemy Almagest 4.3, H278, trans. G.J. Toomer.
\textsuperscript{181} Ibid. 3.1, H209.
\textsuperscript{182} Ibid. 5.15, H425.
Thus, while harmonics adopts the principles of arithmetic but not of geometry, astronomy, too, borrows its principles from only one indisputable mathematical tool. The astronomer posits spheres in the heavens, but the spheres do not have relative sizes and periods that are expressible by means of simple ratios. The simple ratios of harmonics accurately describe the relationships between astrological phenomena, such as the relations between the zodiacal signs, but they describe neither the periods of celestial phenomena nor the relative sizes of the heavenly spheres. While the observations Ptolemy uses to determine the periods and sizes of the heavenly spheres are as accurate as possible, they do not yield values that approach the simple, elegant ratios that are evident in harmonic phenomena. Therefore, because observation is limited and, in this case, reason—the other component of Ptolemy’s criterion of truth—is inapplicable, it is not clear what the accurate values of the periods and sizes of the heavenly spheres are. Ptolemy does not maintain that the sense of hearing is more accurate than the sense of sight; however, when determining the ratios of the musical pitches, the student of harmonics will recognize, even without the kanôn, that his rough and ready observations will, at least approximately, reveal the simple, whole-number ratios that are demonstrably correct by means of the kanôn. The astronomer’s observations, however, do not approximate the rational and beautiful ratios of arithmetic, and reason cannot dictate which values are correct. Only observation, as limited and only one half of the criterion of truth, can attempt to determine the periods and sizes of the heavenly spheres.

While the task of the student of harmonics is to determine which ratios describe the relations between pitches, he must also demonstrate that the ratios are correct. He imposes the

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183 In Tetrabiblos 1.1, Ptolemy proclaims that astronomy is prior to astrology in order and power, but the applicability of harmonics to the relations between the zodiacal signs makes astrology more exact than astronomy in this one sense.
ratios on the harmonic *kanôn* and thereby demonstrates that these ratios produce what are observed to be musical pitches. While the astronomer must determine that the heavens consist of spheres as well as observe and calculate the spheres’ periods and sizes, the astronomer does not demonstrate by means of an instrument that the heavens consist of spheres or what their approximate periods and sizes are. The student of harmonics uses the *kanôn* as his instrument, but, according to *Harmonics* 1.2, the comparable instrument for astronomy is the heavens themselves:

The aim of the student of harmonics must be to preserve in all respects the rational *hypotheses* of the *kanôn*, as never in any way conflicting with the perceptions that correspond to most people’s estimation, just as the astronomer’s aim is to preserve the *hypotheses* concerning the movements of the heavenly bodies in concord with their carefully observed courses…

The student of harmonics determines which ratios describe the relations between pitches and demonstrates that they are accurate by means of the *kanôn*. Correspondingly, while the astronomer determines that the heavens consist of eccentric and epicyclic spheres and endeavors to determine their periods and sizes, he cannot demonstrate that the heavens consist of spheres by means of the heavens themselves. Even if he were to construct a model of the heavens, such as the didactic tool he describes in Book I of the *Planetary Hypotheses*, the model could not demonstrate that his astronomical models are correct.

Nevertheless, the instruments of harmonics and astronomy, the *kanôn* and the heavens, are different only in degree. The student of harmonics imposes ratios on the *kanôn* and produces what he observes to be, for example, homophones and concords, as in *Harmonics* 1.8. The astronomer, on the other hand, while he does not impose the spheres on the heavens or the spheres’ periods and sizes, he does observe certain phenomena which, like the homophones and

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184 Ptolemy *Harmonics* 1.2, D5.13-17, after Andrew Barker.
concord, are indisputable upon observation. A lunar eclipse, for instance, appears the same from anywhere on earth. When introducing his discussion of lunar phenomena in Almagest 4.1, Ptolemy states the following:

Rather, to establish our general notions [on this topic], we should rely especially on those demonstrations which depend on observations which not only cover a long period, but are actually made at lunar eclipses. For these are the only observations which allow one to determine the lunar position precisely (ἀκριβῶς): all others, whether they are taken from passages [of the moon] near fixed stars, or from [sightings with] instruments, or from solar eclipses, can contain a considerable error due to lunar parallax.¹⁸⁵

Ptolemy affirms that the astronomer can have no doubt that a lunar eclipse is occurring, since the occurrence itself as well as the type of eclipse reflects the relations of the moon, earth, and sun independently of the observer. If the astronomer should miss observing the eclipse—or any other astronomical phenomenon for that matter—while he cannot make the phenomenon repeat itself, with patience and time he, or another human being, can observe it again, because all astronomical phenomena are periodic. In this same way, the student of harmonics cannot perceive that the ratio he imposed on the kanôn sometime in the past created a homophone or concord, but he can impose the ratio on the instrument again and produce what is observably the intended pitch. As a result, the ability of the student of harmonics to impose mathematical objects on his instrument distinguishes his study from the astronomer’s only in degree. By utilizing the kanôn, the student of harmonics can observe harmonic phenomena repeatedly and within a short (or long) period of time. The student of astronomy, on the other hand, must wait a long period of time in order to observe the same phenomenon twice. Indeed, the wait may be so long that it extends beyond a human lifetime, and, as a consequence, he may choose to consult the records of astronomers from previous centuries, as Ptolemy does throughout the Almagest.

Therefore, just as the student of harmonics utilizes the *kanôn* to perceive musical pitches, albeit repeatedly and at his disposal, the astronomer observes his instrument, the heavens, to observe and record significant phenomena for his calculations as well as the calculations of future astronomers.

The distance of the astronomer from the phenomena he observes proves not to be a factor in Ptolemy’s truth claims. Despite the distance and inaccessibility of the heavens, the astronomer is certain that the heavens consist of eccentric and epicyclic spheres. He is sure of this truth even though he cannot manipulate the heavens, as his instrument, and demonstrate the truth of these *hypotheseis*. His sureness stems from the empirical proof of sundial observations as well as the logical necessity of reconciling the heavens’ uniform circular motion with the perceived irregularity of the planets’ motions. If the astronomer were able to rise up to the aether and observe the heavens from close-at-hand—not that Ptolemy introduces this thought experiment—he would observe that the heavens indeed consist of eccentric and epicyclic spheres. While on earth he needs sundials and rational arguments to demonstrate the truth of these *hypotheseis*, from the perspective of the heavens, he would be able to affirm their truth simply by observing the rotation of the spheres.\(^{186}\) Nevertheless, even from close-at-hand, he would not be able to determine the periods of the spheres’ rotation or the spheres’ sizes. These calculations depend on precise observations, independent from reason, and the inherent potential error of observation limits their accuracy. While the astronomer’s observation of celestial phenomena from close-at-hand would no doubt increase the precision of his observations, according to Ptolemy observation is fundamentally limited and only reason is capable of providing true precision. Because the astronomer must depend solely on observation for the

\(^{186}\) Presumably, Ptolemy would also be able to empirically determine whether the sun’s aethereal system is eccentric or epicyclic.
periods and sizes of the heavenly spheres, values for the periods and sizes are necessarily approximate.

Consequently, it is not the distance of astronomical phenomena from the earth that determines which aspects of his astronomical *hypotheseis* Ptolemy considers to be incontrovertibly true. It is the distinction in the aspects of astronomical models—more specifically, whether the derivation of the various aspects depends on Ptolemy’s criterion of truth—that serves as the crucial factor. Ptolemy considers all of his harmonic *hypotheseis* to be true, because the student of harmonics simply applies arithmetic ratios to the relations between musical pitches. This application utilizes both the indisputable mathematical tool of arithmetic and the skillful interplay of reason and perception. Concerning his astronomical *hypotheseis*, Ptolemy treats as true only those aspects which are derivable directly from geometry, which, like arithmetic, is an indisputable tool. The heavens indisputably consist of eccentric and epicyclic spheres, which are geometrical objects; these *hypotheseis* are confirmed by dialectical and empirical arguments, or reason and perception. The periods of celestial phenomena, however, and the relative and absolute sizes of the spheres are knowable by means of observation alone and, therefore, are known only to an approximate degree. The astronomer can attempt to calculate these values, but his observations, limited as they are in precision and scope, ultimately restrict their knowability. Therefore, it is the aim of astronomy that differentiates it from harmonics. Because the astronomer, unlike the student of harmonics, aims to incorporate in his models quantitative values that are derivable not from reason and an indisputable mathematical tool but only from observation, the truth claims of astronomy and harmonics differ.

By regarding arithmetic and geometry as indisputable, and harmonics and astronomy as indisputable only to the degree that they adopt the postulates of arithmetic and geometry,
Ptolemy echoes an epistemological sentiment Aristotle relates in *Metaphysics* M3. Aristotle argues that the simpler an object is, the more accurate human beings’ comprehension of it is:

The more that what is known is prior in definition, and the simpler (ἄπλουστέρων), the greater the accuracy (i.e. simplicity) obtained (τοσούτω μᾶλλον ἔχει τὸ ἀκριβές [τοῦτο δὲ τὸ ἄπλοῦν ἐστίν]). So there is more accuracy where there is no magnitude than where there is, and most of all where there is no movement; though if there is movement accuracy is greatest if it is primary movement, this being the simplest, and uniform movement the simplest form of that.\(^{187}\)

Aristotle offers here an epistemological hierarchy. One has the most accurate comprehension of the simplest objects and the least accurate comprehension of complex objects. Aristotle adds in the *Posterior Analytics* that one science is more accurate than another depending on how many items it posits:

One science is more accurate (Ἀκριβεστέρα) than another and prior to it if it is concerned both with the facts and with the reason why and not with the facts separately from the science of the reason why; or if it is not said of any underlying subject and the other is said of an underlying subject (as e.g. arithmetic is more exact than harmonics); or if it proceeds from fewer items and the other from some additional posit (as e.g. arithmetic is more exact than geometry).\(^{188}\)

In this passage, Aristotle examines the relative accuracy of sciences in a relation of subordination. Disregarding the relation between arithmetic and geometry—which for Ptolemy seem to be equally indisputable—what Aristotle asserts is that subordinated sciences are less accurate than the sciences to which they are subordinated. For instance, arithmetic is more accurate than harmonics, and geometry is more accurate than astronomy, because harmonics and astronomy apply arithmetic and geometry, respectively, to specific sets of physical bodies.

As I explained in Chapter 2, Ptolemy rejects Aristotle’s overall epistemology, as he claims that mathematics alone yields knowledge. Yet, Ptolemy applies a similar hierarchy in his

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\(^{188}\) Aristotle *Posterior Analytics* 87a, trans. Jonathan Barnes.
epistemology of the various tools and branches of mathematics. Arithmetic and geometry, because they are not applicable to specific sets of objects in the cosmos, are simple. Therefore, they are indisputable and can be used as tools by the branches of mathematics. Harmonics and astronomy, as branches of mathematics, apply arithmetic or geometry to specific sets of phenomena. Because harmonics simply applies the ratios of arithmetic to the relations between pitches, it produces true hypotheseis. Astronomy applies geometry to the heavens and, accordingly, the geometric hypotheseis, of the eccentric and epicyclic spheres, are true. The astronomer, however, also endeavors to discover the parameters and periods of the heavenly spheres, and once he attempts these calculations, the indisputability of geometry no longer applies. In this way, the applicability of arithmetic and geometry to harmonic and astronomical models, respectively, exemplifies the difference in the aims of the two sciences. It is the aspects of astronomical models that are not derivable from geometry that are not knowable sure and incontrovertibly. Again, the determination of the sizes and periods of the heavenly spheres depends solely on observation, independently of reason. Because observation is necessarily limited, in precision and scope, the astronomer cannot accurately determine these quantitative values. As a result, in the Almagest, Ptolemy does not claim to know—and, indeed, disparages those astronomers who do make such claims—the accurate periods and sizes of the heavenly spheres.

3.6 Observation as a Criterion and Mathematics’ Contribution to Physics

Underlying these epistemological claims is Ptolemy’s adherence to his criterion of truth. Observation reveals the existence of an object, and reason, through its interplay with observation, determines the accurate, precise and true, characteristics of an object, such as its form,
movements, and relations with other objects. As already stated, Ptolemy clearly believes in the existence of harmonic ratios. He derives them directly from arithmetic and demonstrates their existence by means of the harmonic kanôn. Furthermore, he produces observational evidence for these ratios existing not only in the relations between musical pitches but also in the human soul and in the heavens. In Harmonics 3.7, Ptolemy describes the observable effects modulations in melody have on the human soul, and, in Harmonics 3.9, he accounts for the significance of astrological aspects—which he further elaborates in Tetrabiblos 1.13—by explaining how harmonic ratios exist within the zodiacal circle. Moreover, the correspondences to celestial bodies’ diurnal motion, motion in depth, and motion in declination give the appearance of simple analogies, but, as Swerdlow comments,\(^{189}\) if one assumes that the heavens are characterized by the harmonic relations Ptolemy specifies, and if one combines these various harmonic relations, the end result is the complete systêma. The heavenly movements create every single melodious pitch in the harmonic system. Ptolemy, of course, does not mention this result, and, as a consequence, scholars today have assumed that the relations Ptolemy draws between music, the human soul, and the heavens, are, at least for the most part, fanciful. Swerdlow, for instance, derides Ptolemy’s analogies between music and heavenly movements:

> Yes, the planets do rise and set, vary in distance and speed, and move north and south of the equator as they move through the zodiac, but not one of Ptolemy’s comparisons of these motions to rising and falling pitch, change of genus, and change of tonos is quantitative, not one is based on anything empirical or specific, all are merely fanciful.\(^{190}\)

While Swerdlow claims that the correspondences between harmonic relations and heavenly bodies’ diurnal motion, motion in depth, and motion in declination are not empirical, he also

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\(^{189}\) Swerdlow, 161-162.

\(^{190}\) Ibid., 174.
suggests that Ptolemy successfully identifies the same harmonic ratios in astrological phenomena as exist between musical pitches:

In applying harmonics to astrology, Ptolemy is somewhat more successful. The aspects divide the zodiac into arcs in simple numerical ratios, and the same ratios are found in musical concords. In this way, the efficacy of the recognized aspects is explained on the basis of harmonics as well as why signs separated by arcs not in the ratios of concords do not have effective aspects.\footnote{Ibid.}

Swerdlow observes that Ptolemy locates the harmonic ratios of the homophone and concords in the zodiacal circle and, by applying harmonics to astrology, he explains why certain relationships between zodiacal signs are significant astrologically. While Swerdlow does not treat Ptolemy’s analogies between harmonic ratios and the parts of the human soul in depth, Barker concludes that these analogies are not well reasoned:

The chapters on the soul and the virtues, rewarding though they are if considered as an episode in Greek moral psychology, display nothing of the rigorous reasoning of a proper counterpart to harmonics. Little argument is offered to support the proposed analyses and correspondences; and one cannot help feeling that Ptolemy, in his role as a scientist, is only half-heartedly engaged in the project.\footnote{Barker, 2000, 268.}

Yet, the same rationale appears to underlie Ptolemy’s discovery of harmonic ratios in the heavens and in the human soul. Ptolemy applies harmonics to two branches of physics: astrology and psychology. With the support of empirical evidence as well as dialectical arguments—or reason and perception, the two components of Ptolemy’s criterion of truth—he discovers that the same harmonic ratios forming relationships between musical pitches also exist in the heavens and in human souls.

Without the aid of harmonics, psychology and astrology, as branches of physics, would be mere conjecture. Nevertheless, Ptolemy manages to produce what he considers to be valid
results in these fields through the application of mathematics. According to *Almagest* 1.1, mathematics yields knowledge because the mathematician is able to make accurate observations of stable phenomena. Using the *kanôn*, the student of harmonics imposes arithmetic ratios onto a string and produces what are observed to be melodious pitches. Subsequently, he can observe how changes in melody affect the human soul, and, by dividing the zodiacal circle according to these same harmonic ratios, he is able to explain why relationships between zodiacal signs are either aspects or disjunct relations. With a scientific method based on empiricism, Ptolemy assures that he is producing knowledge of real objects, both physical and mathematical. In this way, he demonstrates his claim in *Almagest* 1.1 that mathematics can make a significant contribution to physics. By applying harmonics to psychology and astrology, he explains the various relationships that hold between the parts of the soul and between the zodiacal signs. As for the physical properties of these bodies, I will examine the epistemology and ontology of Ptolemy’s physics in the following chapter.
Chapter 4

Ptolemy’s Epistemology and Ontology of Physics

In the introduction to the *Almagest*, Ptolemy declares that physics is conjectural but mathematics can contribute significantly to the study of physics. This claim is borne out by Ptolemy’s practice of physics. Amidst his natural philosophical investigations, he labels physics conjecture and accounts for physical phenomena in mathematical terms before describing their physical nature. Only in *On the Kritêrion*, Ptolemy’s sole text devoid of mathematics, does he stray from this method. I have already mentioned Ptolemy’s application of geometry to element theory in Chapter 2. In this chapter, I further examine this application but focus on the physics of composite bodies. Ptolemy devotes the majority of his extant natural philosophical investigations to three branches of physics: astrology, psychology, and cosmology. In the previous chapter, I delineated Ptolemy’s application of harmonics to astrology and psychology. Here I emphasize how he depicts the nature, rather than the structure, of these physical objects. First, I present the astrological system portrayed in the *Tetrabiblos*. Second, I analyze Ptolemy’s most detailed models of the human soul, which he provides in *On the Kritêrion* and *Harmonics* 3.5. Third, I examine the cosmological models of celestial souls and bodies in Book 2 of the *Planetary Hypotheses*. What emerges is a coherent system of physics, which is dependent on the application of mathematics.
4.1 Astrology

In the first chapter of the *Tetrabiblos*, Ptolemy defines astrology in juxtaposition with astronomy. He does not, however, use different terms in order to distinguish the two, as we do today.¹ According to the *Tetrabiblos*, astronomy and astrology are both fields of inquiry with a predictive goal, and each of these fields procures its goal by means of ἀστρονομία. Ptolemy uses this term, ἀστρονομία, six times in the *Tetrabiblos* but, rather surprisingly, never in the *Almagest*. In five of the instances in the *Tetrabiblos*, Ptolemy repeats its use in the first line of *Tetrabiblos* 1.1; the phrase δι’ ἀστρονομίας characterizes a type of prognostication.² In the sixth instance, in the title of chapter 1.2, δι’ ἀστρονομίας signifies a means for obtaining understanding (γνῶσις). The term ἀστρονομία occurs in only one other instance in Ptolemy’s corpus. In *Harmonics* 3.3, Ptolemy compares harmonics to astronomy, ἀρμονική to ἀστρονομία.³ In this passage, ἀστρονομία is one of the most rational of the sciences (ἐπιστημών αἱ λογικῶταται). More specifically, it is the branch of mathematics which utilizes geometry to study the quantity and quality of movements from place to place of bodies that are only visible, or the heavenly bodies. In the *Tetrabiblos*, ἀστρονομία carries the same meaning where, as a branch of mathematics, it serves as a means for achieving prognostic goals, such as the goals of astronomy and astrology. For astronomy, ἀστρονομία allows for the prediction of the relations, or configurations (σχηματισμοῖ), between celestial bodies (as well as their relations with the earth) resulting from their movements. Astrology uses ἀστρονομία to predict the qualitative changes resulting in the sublunary realm from these configurations.

¹ Cf. Ptolemy *On the Kritērion*, La11, where Ptolemy declares that, rather than analyzing the terms ‘soul’ and ‘body’, he prefers to discuss the actual differences between these natural objects. He may be taking the same approach here where, instead of differentiating astronomy and astrology terminologically, he simply characterizes them differently.
² Ptolemy *Tetrabiblos* 1.1, Cam1; 1.3, Cam9, Cam15-16; 2.1, Cam53.
³ Ptolemy *Harmonics* 3.3, D94.9-16.
In *Tetrabiblos* 1.1, Ptolemy adds that what we call astronomy is prior to astrology in both order (τὰ ἔξοχα) and power (δύναμις). He bases this claim on a comparison of the method and epistemic success of each field. Concerning astronomy, Ptolemy’s description of it in the *Tetrabiblos* is consistent with the definition of mathematics in the *Almagest*. In *Almagest* 1.1, mathematics examines movements (κίνησις), in the *Tetrabiblos*, astronomy predicts configurations resulting from these movements. On the other hand, Ptolemy characterizes astrology, albeit not explicitly, as a branch of physics. According to the *Tetrabiblos*, the relations between the heavenly bodies cause physical changes in the sublunar realm, and it is these physical changes that astrology aims to predict. Astronomy is prior to astrology, then, because, as branches of mathematics and physics, respectively, these two fields of inquiry have different claims to truth. Following his assertion in *Almagest* 1.1—that mathematics yields sure and incontrovertible knowledge (βεβαίως καὶ ἀμετάπτιστον...ἐπίδησιν) but physics is conjectural—in *Tetrabiblos* 1.1 Ptolemy characterizes the study of astronomy as sure and unvarying but the claims of astrology as merely possible. He discusses this epistemic distinction as follows:

We shall now give an account of the second and less self-sufficient method (μὴ ὁμοσύνως αὐτοτελεῖς) in a way that is concordant with philosophy (κατὰ τὸν ἀρμόζοντα φιλοσοφία τρόπου), so that one whose aim is the truth might never compare its apprehension (κατάληψιν) with the sureness of the first, unvarying science (τῆς τοῦ πρώτου καὶ ἀεί ὁμοσύνως ἔχουσος βεβαιότητι), for he ascribes to it the weakness and unpredictability of material qualities (τὸ ἐν πολλοῖς ἀσθενεῖς καὶ δυσεἰκαστον τῆς ὑλικῆς ποιότητος) found in individual things, nor yet refrain from such investigation as is within the bounds of

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4 Ptolemy *Almagest* 1.1, H5.

5 κατάληψις for Ptolemy does not have the Stoic meaning. It merely signifies a type of apprehension of varying epistemic success. Astronomy’s κατάληψις is sure, while astrology’s is only possible.
Ptolemy distinguishes astronomy from astrology on three implicit accounts. First, he sets out to describe astrology in a philosophical way, as opposed to the demonstrative way (ἀποδεικτικῶς) in which, as he explains, he has already examined astronomy in the *Almagest*. Second, because astronomy is a branch of mathematics while astrology is a branch of physics, the former produces judgments that are sure while the latter produces claims that are only possible. Third, as a branch of physics, astrology examines qualitative changes in the sublunary realm, which are caused by the superlunary movements and configurations studied by astronomy. Therefore, the practice of astrology is dependent on astronomical data.

As Franz Boll remarks, in distinguishing astronomy from astrology, Ptolemy appropriates Aristotle’s differentiation between the super- and sublunary realms. According to both Aristotle and Ptolemy, the heavens experience only one type of change, movement from place to place, and the sublunary sphere experiences many changes. Ptolemy reiterates this distinction in *Tetrabiblos* 1.3: “Rather is it true that the movement of the heavenly bodies, to be

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7 By stating that an account of astrology is philosophical, Ptolemy does not mean that it is unempirical. Astrology, like all branches of physics, is conjectural; therefore, unlike a mathematical demonstration, its account is not sure and incontrovertible but philosophical instead. Galen makes a similar distinction in *De propriorum animi cuiuslibet affectuum dignotione et curatione*, B102-103, cf. B93. He contrasts the demonstrative method (λόγον ἀποδεικτικοῦ) that mathematicians use with philosophers’ arguments, which are at most possible and likely (ἐνδεχόμενος τε καὶ εἰκότας).

8 Boll, 156.
sure, is eternally performed in accordance with divine and unchangeable fate (καθ’ ἑιμαρμένην θείαν καὶ ἀμετάπτωτον), while the change of earthly things is subject to a natural and mutable fate (καθ’ ἑιμαρμένην φυσικὴν καὶ μεταπτώτην), and in drawing its first causes from above it is governed by chance and natural sequence.”

Because astrology examines qualitative changes in the sublunar realm, where bodies experience many changes, its claims are merely possible.

Ptolemy dedicates Tetrabiblos 1.2 to proving that the claims of astrology are possible (δυνατὸς), and, in the midst of his argument, he refers to astrology as conjecture (ἐυστόχως). For example, when presenting a hypothetical situation in which a man knows the exact periods of planetary phenomena as well as the types of change that the planets cause in the sublunar realm, Ptolemy asserts the following, given these conditions:

…if he is capable of determining in view of all these data, both naturally (φυσικῶς) and by successful conjecture (ἐυστόχως), the distinctive mark of quality resulting from the combination of all the factors, what is to prevent him from being able to tell on each given occasion the characteristics of the air from the relations of the phenomena at the time, for instance, that it will be warmer or wetter? Ptolemy adds that any field of inquiry concerned with the quality of matter is conjectural (ἔικαστικήν): “For in general, besides the fact that every field of inquiry that deals with the quality of matter (τὴν περὶ τὸ ποιόν τῆς ῥήλης θεωρίαν πᾶσαν) is conjectural (ἔικαστικήν) and not to be absolutely affirmed (διαφεβεσιωτικήν), particularly one which is composed of many unlike elements…” Ptolemy applies this same term, ἔικαστικὰ, to physics in Almagest 1.1. Hence, in the Tetrabiblos, as in Almagest 1.1, physics deals principally with sublunar

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9 Ptolemy Tetrabiblos 1.3, Cam11, after F.E. Robbins.
10 Ibid. 1.2, Cam5.
11 Ibid., Cam7.
12 Ptolemy Almagest 1.1, H6.
objects, and astrology’s claims, like the claims of every other branch of physics, are conjectural, or merely possible.

Following his description of astrology as conjectural, Ptolemy lists the several shortcomings of astrology, which prevent it from producing incontrovertible claims. In addition to its subject matter, the changing qualities of the sublunary realm, the primary cause of these changes, or the movements of the heavenly bodies, proves to be an obstacle to astrology’s epistemic success. Ptolemy asserts that the exact periods of celestial movements are indeterminable. Recalling his argument in *Almagest* 3.1—where he argues that the exact periods of planets’ movements, such as the tropical year, are unknowable—Ptolemy affirms in *Tetrabiblos* 1.2 that the exact return of heavenly bodies to the same positions occurs either not at all or, at the very least, not within the lifetime of human beings:

…it is furthermore true that the ancient configurations of the planets, upon the basis of which we attach to similar aspects of our own day the effects observed by the ancients in theirs, can be more or less similar to the modern aspects, and that, too, at long intervals, but not identical, since the exact return of all the heavenly bodies and the earth to the same positions, unless one holds vain opinions of his ability to comprehend and know the incomprehensible (περὶ τὴν τῶν ἀκαταλήπτων κατάληψιν καὶ γνώσιν), either takes place not at all or at least not in the period of time that falls within the experience of man; so that for this reason predictions sometimes fail, because of the disparity of the examples on which they are based.\(^{13}\)

As in *Almagest* 3.1, where he also attacks advocates of the ‘Great Year’, Ptolemy argues that the exact periods of the planets cannot be known. Consequently, astrology, which relies on astronomical data, can make only approximate predictions.

In addition to this astronomical limitation, the preponderance of causes which affect sublunary changes prevents astrology from producing certain claims. Ptolemy argues that while astrology takes into account only the movements of heavenly bodies when making predictions,

\(^{13}\) Ptolemy *Tetrabiblos* 1.2, Cam7, trans. F.E. Robbins.
atmospheric phenomena as well as genetic, national, and cultural influences have an impact on the development of a seed into a living being.¹⁴ Ptolemy attests to the influence of causes besides celestial ones, or ambient (ἀπὸ τοῦ περιέχοντος) causes, in the following:

Unless each one of these things is examined together with the causes that are derived from the ambient, although this latter be conceded to exercise the greatest influence (for the ambient is one of the causes for these things being what they are, while they in turn have no influence upon it), they can cause much difficulty for those who believe that in such cases everything can be understood, even things not wholly within its jurisdiction, from the motion of the heavenly bodies alone.¹⁵

Even though many causes contribute to the development of living beings, a hierarchy exists among the causes. Because the movements of heavenly bodies have the greatest influence on sublunar events, even though astrology does not account for all causes, because it takes into account the most influential ones, its claims are possible.

Bounded by the inherent and practical limitations of astrology, the astrologer still aims to make his predictions as likely as possible by keeping his theories in conformity with nature. Just as the subject matter of astrology consists of physical qualities, the astrologer aims to follow a method that is φυσικός. For instance, when Ptolemy examines the occurrence of annual phenomena in relation to the two solstices and two equinoxes, he remarks, “It seems more proper and natural (φυσικῶτερον) to me, however, to employ the four starting-points for investigations which deal with the year…”¹⁶ In this passage, Ptolemy rejects the habit of other astrologers and cultures to prioritize one solstice or equinox over the others in order to determine a single starting-point for the year. He maintains that each solstice and equinox has a reasonable (ἐικότως) claim. At the spring equinox, the daylight hours begin to exceed the night and, furthermore, this equinox occurs during the moist season, which signifies birth; the summer

¹⁴ Ptolemy Tetrabiblos 1.2, Cam7-8.
¹⁵ Ibid., Cam8-9, trans. F.E. Robbins.
¹⁶ Ibid. 2.10, Cam92.
solstice has the longest days and, for the Egyptians, it signifies the flooding of the Nile as well as the rising of the star Sirius; by the fall equinox, farmers have harvested their crops and begun sowing seeds for future crops; with the winter solstice, the days once again begin to lengthen.

Ptolemy, however, chooses to abide by a principle which Aristotle articulates in the *De Caelo*. Just as Aristotle maintains that a circle has no beginning or end,\(^\text{17}\) Ptolemy affirms that each solstitial and equinoctial point is a natural starting-point, but no one is prior:

> To be sure, one could not conceive what starting-point to assume in a circle, as a general proposition; but in the circle through the middle of the zodiac one would properly take as the only beginnings the points determined by the equator and the tropics, that is, the two equinoxes and the two solstices. Even then, however, one would still be at a loss which of the four to prefer. Indeed, in a circle, absolutely considered, no one of them takes the lead, as would be the case if there were one starting-point…\(^\text{18}\)

It is more natural to treat each of the solstitial and equinoctial points as a starting-point, because this theory abides by the natural attributes of the ecliptic. It crosses the celestial equator at two points, and it is farthest from it at another two points, but none of these points is prior, because, as Aristotle argues, a circle has no beginning.

Ptolemy maintains this preference for natural theories and methods elsewhere in the *Tetrabiblos*. When discussing the difficulty involved in establishing the degree of the horoscopic point, he asserts that the astrologer must use natural reasoning: “It would therefore be necessary that an account first be given how one might, by natural and consistent reasoning (τὸν φυσικὸν καὶ ὀκόλουθον λόγον), discover the degree of the zodiac which should be rising…”\(^\text{19}\)

Similarly, when explaining his method for determining length of life, he declares, “The method

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\(^{17}\) Aristotle *De caelo* 279b.

\(^{18}\) Ptolemy *Tetrabiblos* 2.10, Cam91, trans. F.E. Robbins.

\(^{19}\) Ibid. 3.2, Cam108-109.
most pleasing to us and, besides, in harmony with nature (φύσεως) is the following.\textsuperscript{20}

Correspondingly, Ptolemy explicitly rejects methods that are unnatural. For example, he spurns
the so-called Chaldean division of zodiacal signs into places and degrees according to planetary
boundaries because it is not logical (ἄλογον), not natural (οὐ φυσικόν), and conceited
(κενόδοξον).\textsuperscript{21} In each of these instances, Ptolemy affirms his preference for theories and
methods which he considers to be natural, rather than unnatural.

Ptolemy refines his position in \textit{Tetrabiblos} 3.1. Recalling his exposition in \textit{Tetrabiblos}
1.2 on the many causes that affect sublunary changes, he draws attention to the impossibility of
accounting for every celestial movement when making astrological predictions:

Since it is our present purpose to treat of this division likewise systematically on
the basis of the discussion, introduced at the beginning of this compendium, of the
possibility (δυνατοῦ) of prediction of this kind, we shall decline to present the
ancient method of prediction, which brings into combination all or most of the
stars, because it is manifold and well-nigh infinite, if one wishes to recount it with
accuracy (ἀκριβῶς). Besides, [the ancient method] depends much more upon
the particular attempts of those who make their inquiries directly from nature
(τῶν φυσικῶν ἐπισκεπτομένων) than of those who theorize on the basis of the
traditional powers (ἐν ταῖς παραδοσεῖς ἄναθεωρείσθαι δυναμένων); and
furthermore we shall omit it on account of the difficulty in using it and following
it. Those very procedures through which each kind of thing is apprehended by the
practical method, and the active influences (ποιητικῶς δυναμεῖς) of the stars,
both special and general, we shall, as far as possible, consistently and briefly, in
accordance with natural conjecture (τοῦ φυσικοῦ στοχασμόν), set forth.\textsuperscript{22}

While Ptolemy endeavors to utilize the most natural theories and methods, the limitations of
astrology prevent him from doing so absolutely. The celestial bodies’ relations are so many, that
it is impractical to account for every one. For practical reasons, then, the astrologer must rely on
a more limited account of the data, such as the traditional allocation of the planets’ powers. In
other words, the proper method, rather than the ancient one, reduces the phenomena to the

\textsuperscript{20} Ibid. 3.10, Cam127.
\textsuperscript{21} Ptolemy \textit{Tetrabiblos} 1.22, Cam50.
\textsuperscript{22} Ibid. 3.1, Cam106-107, after F.E. Robbins.
celestial bodies’ powers. Correspondingly, as Franz Boll observes, Ptolemy treats Aries as the beginning of the zodiacal circle even though, as quoted above, he argues in favor of treating each solstice and equinox as a starting-point in *Tetrabiblos* 2.10. In the following chapter, *Tetrabiblos* 2.11, Ptolemy lists the weather signs of Aries before the signs of the other zodiacal signs, and in *Almagest* 2.7 he designates Aries as the first zodiacal sign: “We call the first division, beginning at the spring equinox and going towards the rear with respect to the motion of the universe, ‘Aries’, the second ‘Taurus’, and so on for the rest, in the traditional order of the twelve signs.”

Therefore, while Ptolemy argues in favor of utilizing the most natural theories and methods, the practice of astrology forces him to admit the limited nature of astrology’s claims, utilize methods that are not absolutely natural, and aim only at producing predictions that are possible.

After arguing for the possibility and utility of astrology in *Tetrabiblos* 1.2 and 1.3, respectively, in *Tetrabiblos* 1.4 Ptolemy presents the first data on which to base his predictions. These data consist of the planets’ powers (δυνάμεις), which Ptolemy also refers to as productive causes (ποιητικά) and activities (ἐνέργεια). These powers, however, are not the essential characteristics of the planets, as aethereal bodies. Rather, they are the effects caused by the planets which are experienced in the sublunar realm. Ptolemy distinguishes between the underlying nature of a planet and its power in *Tetrabiblos* 1.2: “…even though he may discern, not their underlying (ὑποκείμενον), but only their potentially effective qualities (τὰς γε δυνάμει ποιητικάς), such as the sun’s heating and the moon’s moistening, and so on with the rest….“

Just as the sun and moon affect animate and inanimate beings in the sublunar realm, so do the stars and the other planets. The power of each planet is characterized by two qualities

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23 Boll, 166.
25 Ptolemy *Tetrabiblos* 1.2, Cam5, after F.E. Robbins.
from a set of four—hot, cold, wet, and dry—which are Aristotle’s primary contraries in *On Generation and Corruption*.²⁶ Ptolemy appropriates the traditional allocation of the planets’ powers, and the power of each planet consists in two of the four contraries. While the sun heats and dries, the moon heats and humidifies, because of its proximity to the earth and the exhalations it emits. Jupiter and Venus, like the moon, heat and humidify, but Jupiter predominately heats while Venus mainly humidifies. Mars, on the other hand, heats and dries, while Saturn dries and cools. In this way, Mars’ and Saturn’s powers are in opposition to the powers of Jupiter and Venus. Unlike the other planets, Mercury is changeable in its powers. Because of its proximity to both the sun and the moon—to the former in longitude and to the latter in the order of the aethereal spheres—it both dries and humidifies, heats and cools.

A planet’s power increases and diminishes as it moves through the zodiac and forms relations with other planets and zodiacal signs. While the sun’s power affects sublunary events to the greatest degree, each planet’s power plays a part. Ptolemy explains as follows:

> Then, too, their aspects to one another (οἱ πρὸς ἀλλὰς σχηματισμοί), by the meeting and mingling of their dispensations (διαδοσεων), bring about many complicated changes. For though the sun’s power (δυνάμεως) prevails in the general ordering of quality, the other heavenly bodies aid or oppose it in particular details, the moon more obviously and continuously, as for example when it is new, at quarter, or full, and the stars at greater intervals and more obscurely, as in their appearances, occultations, and approaches.²⁷

Not only do the planets have δυνάμεις, but the stars do as well. These powers, of the planets and stars, increase and diminish as the planets travel through the zodiac. Ptolemy summarizes how these powers affect one another in the following passage:

> Such are the effects produced by the several planets, each by itself and in command of its own nature. Associated, however, now with one and now with another, in the different aspects, by the exchange of signs, and by their phases

²⁶ Aristotle *On Generation and Corruption* 2.2-3.
²⁷ Ptolemy *Tetrabiblos* 1.2, Cam3-4, trans. F.E. Robbins.
with reference to the sun, and experiencing a corresponding tempering of their powers, each produces a character, in its effect, which is the result of the mixture of the natures that have participated, and is complicated.  

The relations that the planets form with one another as they move through the heavens are the aspects—opposition, trine, quartile, and sextile—and disjunct relations, which Ptolemy presents in *Tetrabiblos* 1.13 and 1.16, respectively. As I discussed in Chapter 3, in both the *Harmonics* and the *Tetrabiblos*, Ptolemy uses the mathematical science of harmonics to explain why these particular relations are significant. In *Tetrabiblos* 1.13, he adds that trine and sextile are harmonious (συμφωνος), because signs in these relations are of the same kind. Quartile and opposition, on the other hand, are inharmonious (ασυμφωνος), because signs in these relations are of opposite kinds. Whether the planets are in harmonious or inharmonious relations determines whether their powers increase or diminish.

The planets transmit their powers through the heavens and down into the sublunary realm by means of rays (ακτινως). Ptolemy nowhere states what these rays consist of or how the planets transmit them. Yet, these rays have the ability to bring the planets’ powers into contact with one another and with sublunary bodies. In *Tetrabiblos* 1.24, Ptolemy juxtaposes the bodily conjunctions of planets—when the planets occupy the same meridian—with the convergence of the planets’ rays at the center of the earth. Discussing the manner in which the planets’ powers affect one another, Ptolemy states, “Such a relation is taken to exist whether it happens by bodily (σωματικως) conjunction or through one of the traditional aspects…In the case of applications and separations by aspect, however, such a practice is superfluous, because all rays (ακτινως) always fall and similarly converge from every direction upon the same point, that is, the centre of

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28 Ibid. 2.8, Cam88.
the earth.”29 In other words, the planets’ rays travel in straight lines through the sublunary realm towards the center of the earth.

Ptolemy also depicts the rays as traveling through the heavens to the various zodiacal signs. For instance, in *Tetrabiblos* 3.10, he juxtaposes the bodily conjunction of the planets with the projection of rays to other parts of the zodiac, when the planets are in the process of prorogation, an astrological technique of continuous horoscopy:

In the prorogation which follows the order of following signs, the places of the maleficent planets, Saturn and Mars, destroy, whether they are approaching bodily (σωματικῶς), or project their rays (ἀκτίνα) from any place whatever in quartile or in opposition, and sometimes too in sextile, upon the signs called “hearing” or “seeing” on grounds of equality of power (ισοδυναμίας); and the sign that is quartile to the prorogative sign in the order of following signs likewise destroys.30

Similarly, in *Tetrabiblos* 3.9 Ptolemy mentions how the planets project their rays through the zodiac:

And in such circumstances, if the luminaries should chance to be removing from conjunction with one of the beneficent planets, or are in some other aspect to them, but nevertheless cast their rays (ἀκτίνως) in the parts that precede them, the child that is born will live a number of months or days, or even hours, equal to the number of degrees between the prorogator and the nearest rays (ἀκτίνων) of the maleficent planets, in proportion to the greatness of the affliction and the power of the planets ruling the cause (πρὸς τὸ μέγεθος τῆς κακόσεως καὶ τῆς δύναμιν τῶν το ἀρίστου ποιοῦντων). But if the rays (ἀκτίνες) of the maleficent planets fall before the luminaries, and those of the beneficent behind them, the child that has been exposed will be taken up and will live.31

Hence, Ptolemy portrays the planets as projecting rays through the aether, to various zodiacal signs, and down through the sublunary realm, toward the center of the earth.

In addition to using the term ἀκτίνες for the planets’ rays, Ptolemy uses other terms to denote the rays of the sun and moon. He calls the sun’s rays σύγατη, and he uses this term

29 Ibid. 1.24, Cam52.
30 Ibid. 3.10, Cam132.
31 Ibid. 3.9, Cam126.
exclusively for the sun. For instance, in Tetrabiblos 2.6 Ptolemy states, “for planets when they are rising or stationary produce intensifications in the events, but when setting, and under the rays of the sun (συγάς), or advancing at evening, they bring about an abatement.”\textsuperscript{32} On the other hand, Ptolemy uses the term ἀπόρροια—a technical term in astrology meaning ‘separation’—to denote the emanation from stars in Tetrabiblos 3.10\textsuperscript{33} and the effluence of the moon, specifically, in Tetrabiblos 1.2: “The moon, too, as the heavenly body nearest the earth, bestows her effluence (ἀπόρροια) most abundantly upon mundane things, for most of them, animate or inanimate (ἀψύχων καὶ ἐμψύχων), are sympathetic (συμπαθούντων) to her and change in company with her…”\textsuperscript{34} Hence, while Ptolemy uses the term ὀκτιβιες to signify rays from any planet, he uses σύγατο to denote the rays projected from the sun and ἀπόρροιαι to denote rays from the stars and the moon in particular.

Ptolemy does not describe the composition of these rays, whether they are material or immaterial nor, if material, whether they consist of aether or another element. Yet, because the rays have the ability to affect bodies and souls—as stated in the quote above and explained in further detail below—and because bodies and souls are material, as discussed below, it is most likely that Ptolemy imagined these rays to be composed of matter. Ptolemy could have believed that the rays are some sort of immaterial causes or powers perpetuated by bodies, even though they themselves are not bodies, but in On the Kritêrion Ptolemy makes plain his affinity for the Hellenistic view that every object which can act or be acted upon is a body.\textsuperscript{35} If Ptolemy did conceive of these rays as being composed of some body, he most likely imagined them to be aethereal. After all, he appropriates Aristotle’s fifth element as the material of the heavens, and,

\begin{itemize}
\item[\textsuperscript{32}] Ibid. 2.6, Cam78.
\item[\textsuperscript{33}] Ibid. 3.10, Cam128.
\item[\textsuperscript{34}] Ibid. 1.2, Cam3.
\item[\textsuperscript{35}] Ptolemy On the Kritêrion, La11.
\end{itemize}
while sublunary objects experience the planets’ powers in terms of four sublunary qualities—hot, cold, wet, and dry—it is unlikely that Ptolemy would have conceived of the planets as emitting any other substance than that of which they consist: aether. If the rays do consist of aether, the question arises as to why they, as aethereal, leave the heavens and travel into the sublunary realm.

Nevertheless, Ptolemy reveals in *On the Kritêrion* that aether exists in the sublunary realm as well. I will discuss this point in further detail below, but at La20.6-8 he states that the human soul is composed of air, fire, and aether. Moreover, he specifies at La20.17 that the faculty of thought is composed of the element that is only active, or aether. Ptolemy appropriates this portrayal of the soul as aethereal from a tradition following Aristotle. In *Generation of Animals*, Aristotle portrays the δύναμις of the soul as a body that is more divine than the elements, and he describes semen as containing within it a substance that is analogous to the element of the stars (τὸ τῶν ἄστρων στοιχεῖον). Cicero provides us with a Hellenistic reference to this tradition. In *Academica* 1.7.26, he relates, “Aristotle deemed that there existed a certain fifth sort of element, in a class by itself and unlike the four that I have mentioned above, which was the source of the stars and of thinking minds.” If Ptolemy believed that the faculty of thought consists of aether—as he states in *On the Kritêrion* and which accords with this Aristotelian tradition—it is plausible that he also believed that aether exists in the sublunary realm in the form of the planets’ rays.

Moreover, Simplicius and Symeon Seth, an eleventh-century Byzantine writer, attribute a theory of sublunary aether to Ptolemy. First, in his commentary on Aristotle’s *De Caelo*,

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36 Aristotle *Generation of Animals* 736b30-737a1.
Simplicius states that Ptolemy discussed the natural motion of the elements in the *Optics*.\textsuperscript{38} This discussion may have been in the first book, now lost, of the *Optics*, for it does not exist in the extant text. If Ptolemy examined elemental motion in the *Optics*, he most likely did so because he believed that the optical ray is composed of some element.\textsuperscript{39} Second, in his *Conspectus rerum naturalium* 4.74, Symeon Seth remarks that Ptolemy’s optical *pneuma*—probably denoting the visual ray—is aethereal. If the optical ray, as aethereal, travels in a straight line, as Ptolemy indicates in the *Optics*, then it is entirely congruent to suppose that the aethereal rays transmitted by the planets also travel in straight lines through the sublunary realm. In other words, when the planets’ rays travel through the heavens, they move circularly, according to the natural motion of the aether in its natural place; however, when they move through the sublunary realm, they travel in straight lines. That Ptolemy should imagine the rays as moving circularly in their natural place and rectilinearly when outside their natural place is consistent with Simplicius’ discussion of Ptolemy’s element theory in his lost book *On the Elements*. According to Simplicius, Ptolemy argued that elements move rectilinearly only when outside their natural places but either rest or move circularly when in them.\textsuperscript{40} If Ptolemy applied this theory of natural motion to the aether as well as to the four sublunary elements, then his element theory would support the interpretation of the planets’ rays as aethereal. When in their natural place, or the heavens, the rays move circularly, but when outside their natural place, when in the sublunary realm, they move rectilinearly.

\textsuperscript{39} Alexander Jones argues for the materiality of Ptolemy’s optical ray in *Ptolemy’s Sciences* (forthcoming).
\textsuperscript{40} Heiberg, 264-265.
When the planets’ rays enter the sublunary realm, they affect all sublunary bodies, starting with the elemental layers of fire and air, which reside at the periphery of the sublunary sphere. Ptolemy portrays the sequence of how each element affects the next in *Tetrabiblos* 1.2:

A very few considerations would make it apparent to all that a certain power (δύναμις) emanating from the eternal aethereal substance (ἀπὸ τῆς αἰθέρωδου καὶ αἰδίου φύσεως) is dispersed through and permeates the whole region about the earth, which throughout is subject to change, since, of the primary sublunary elements, fire and air are encompassed and changed by the motions in the aether, and in turn encompass and change all else, earth and water and the plants and animals therein.ductive

Ptolemy does not indicate here that the planets’ rays, specifically, affect changes in the sublunary realm. He could simply be suggesting that the aether’s circular movement through the heavens affects sublunary changes in the same manner as it does in Aristotle’s *On Generation and Corruption* and *Meteorologica*. In the former, Aristotle portrays the sun’s annual motion along the ecliptic as causing generation and corruption in the sublunary world. In the *Meteorologica*, friction between the aether and the layer of fire below it produces meteorological phenomena, including comets, meteors, and the Milky Way. Nevertheless, because Ptolemy propounds elsewhere in the *Tetrabiblos* a theory of rays, which transmit the powers of the planets, it is plausible that he would have supposed in this passage that the planets’ rays, specifically, affect the layers of fire and air. Either way, the effect the planets’ powers have on the sublunary elements causes various meteorological phenomena. Ptolemy portrays the causal relationship between the stars’ movements and meteorological phenomena in *Tetrabiblos* 2.12:

For the hour by hour intensifications and relaxations of the weather vary in response to such positions of the stars as these, in the same way that the ebb and flow of the tide respond to the phases of the moon, and the changes in the air-currents are brought about especially at such appearances of the luminaries at the

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41 Ptolemy *Tetrabiblos* 1.2, Cam2-3, after F.E. Robbins.
42 Aristotle *On Generation and Corruption* 2.10.
43 Aristotle *Meteorologica* 1.4, 6-8.
angles, in the direction of those winds towards which the latitude of the moon is found to be inclining.44

Therefore, the planets’ powers directly affect meteorological phenomena.

More important for Ptolemy’s purposes in the Tetrabiblos is the effect the planets’ powers have on human beings. As indicated above, the planets’ rays influence the development of human beings’ bodies and souls. Ptolemy summarizes these effects on human beings in the following passage:

In somewhat summary fashion it has been shown how prognostication by astronomical means is possible (δυνατόν), and that it can go no further than what happens in the ambient and the consequences to man from such causes—that is, it concerns the original endowments of faculties and activities of soul and body (περὶ τῶν ἓξ ἄρχης ἐπιτηδείωσει τῶν δυνάμεων καὶ πρᾶξεων σώματος καὶ ψυχῆς), their occasional diseases, their endurance for a long or a short time, and, besides, all external circumstances that have a directive and natural (φυσική) connection with the original gifts of nature, such as property and marriage in the case of the body and honor and dignities in that of the soul, and finally what befalls them from time to time.45

In Tetrabiblos 3.1, Ptolemy explains that the configurations of the stars at one’s conception determines the qualities of a human being’s body and soul for the rest of his or her life:

Since the chronological starting-point of human nativities is naturally (φύσει) the very time of conception, but potentially and accidentally the moment of birth, in cases in which the very time of conception is known either by chance or by observation, it is more fitting that we should follow it in determining the distinctive traits of body and soul (τὰ τοῦ σώματος καὶ τὰ τῆς ψυχῆς ἱδιώματα), examining the effective power (ποιητικόν) of the configuration of the stars at that time. For to the seed is given once and for all at the beginning some sort of quality (ποιόν πῶς) by the endowment of the ambient; and even though it may change as the body subsequently grows, since by natural (φυσικῶς) process it mingles with itself in the process of growth only matter (ὕλην) which is akin to itself, thus it resembles even more closely the type of its initial quality.46

44 Ptolemy Tetrabiblos 2.12, Cam99, trans. F.E. Robbins.
46 Ibid. 3.1, Cam105.
Thus, the configuration of celestial bodies in the heavens determines the potency of the planets’ powers, which in turn, by means of rays, affect human beings’ bodies and souls, at conception and thereafter.

The planets’ rays have this ability to affect bodies and souls because all three—the rays, the bodies, and the souls—are composed of matter. I have already argued above that the rays are aethereal in nature. I will discuss below Ptolemy’s account of the soul’s materiality in *On the Kritèrion*. For now, the only evidence I will present is Ptolemy’s remark in *Tetrabiblos* 3.11 that the body is more material (ὑλικότερον) than the soul:

> Now that the procedure in the matter of the length of life has been explained, we speak about the form and character of the body, beginning the detailed discussion in the proper order, inasmuch as naturally (κατὰ φύσιν), too, the bodily parts are formed prior to the soul; for the body, because it is more material (ὑλικότερον), carries almost from birth the outward appearances of its idiosyncrasies, while the soul shows forth the characters conferred upon it by the first cause (ἀπὸ τῆς πρῶτης ἀρχῆς) only afterwards and little by little, and external accidental qualities come about still later in time.⁴⁷

The planets’ powers influence the development of a human being’s body and soul, because the aethereal rays, which the planets emit, come into physical contact—either directly or indirectly, via the human being’s environment—with the body and soul at conception and constantly thereafter, over the course of one’s lifetime.

Ptolemy examines the effects celestial powers have on the human body in *Tetrabiblos* 3.11-12. More interesting for our purposes is his analysis of the effects on the human soul in the chapters that follow. In *Tetrabiblos* 3.13, for instance, Ptolemy explains how the planets and their movements affect the human soul’s quality (ποιότης) and distinctive traits (ἴδιωματα). As he discusses these effects, he introduces terms for parts of the soul, some of which are identical with the terms he employs in *On the Kritèrion* and the *Harmonics*. For example, in the

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⁴⁷ Ptolemy *Tetrabiblos* 3.11, Cam141-142, trans. F.E. Robbins.
Tetrabiblos, Ptolemy begins his account of astrological effects on the human soul with the following:

Of the qualities of the soul, those which concern the rational and intellectual part (τὸ λογικὸν καὶ νοερὸν μέρος) are apprehended by means of the condition of Mercury considered (θεωρούμενος) on the particular occasion; and the qualities of the sensory and irrational part (τὸ συσθητικὸν καὶ αλογον) are discovered from the one of the luminaries which is the more corporeal (σωματωδεστέρου), that is, the moon, and from the planets which are configured with it in its separations and applications.

In this passage, Ptolemy distinguishes the rational part of the soul from the irrational. In so doing, he applies two terms to the former and two to the latter. The former is the rational (λογικὸν) and intellectual (νοερὸν) part. The use of these two terms is significant, as Ptolemy describes a rational (λογικὸν) faculty in On the Kritèrion and an intellectual (νοερὸν) part of the soul in the Harmonics. Moreover, Ptolemy’s use of these two terms repeats his tendency in On the Kritèrion and the Harmonics to use both Platonic and Aristotelian terminology for the parts of the soul. In Tetrabiblos 3.13, he labels the other part of the soul the sensory (συσθητικὸν) and irrational (αλογον) part. The former describes an Aristotelian faculty of the

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48 Ptolemy’s reference to the moon as more corporeal suggests that he adopted a view similar to Plutarch’s in On the Face in the Moon. Because Ptolemy appropriated Aristotle’s fifth element, he may have believed that the aether, specifically, varies in quality. Indeed, he may have been obliged to believe in this variance because the moon looks different from the other celestial bodies. Aristotle portrays the aether as varying in purity—depending on its distance from the earth—in Meteorologica 340b. In Tetrabiblos 1.4, Ptolemy explains that most of the moon’s power consists in humidifying, because it is close to the earth and the moist exhalations rising from it. He adds, however, that Venus humidifies, like the moon, because it appropriates (νοσφιξομενος) the earth’s moist exhalations. This description of planets appropriating the earth’s exhalations recalls Stoic meteorology more than Aristotelian. For the Stoics, including Posidonius, the moon was a mixture of fire and air. See Posidonius, Fr. 122 Kidd (Cambridge: Cambridge University Press, 1989); Aetius Placita 2.25.5, 26.1, 27.1; Stobaeus Eclogae, 1.219.16 W; Dox. Gr. 356-7. Ptolemy, however, may not have meant that the planet Venus absorbs the exhalations, but rather that the exhalations are merely under the influence of Venus’ power.

49 Ptolemy Tetrabiblos 3.13, Cam154, after F.E. Robbins.

50 Ptolemy On the Kritèrion, La6.

51 Ptolemy Harmonics 3.5, D95.28.
soul, which Ptolemy discusses in the *Harmonics*\(^{52}\) and *On the Kritērion*;\(^{53}\) the latter serves to combine Plato’s two irrational parts. As in both the *Harmonics*\(^{54}\) and *On the Kritērion*, Ptolemy amalgamates the spirited and appetitive parts of the soul into a single part. In *On the Kritērion*, he calls this part the faculty of impulse (ὀρμητικόν). Here, in *Tetrabiblos* 3.13, after discussing the sensory and irrational part of the soul, he remarks on the soul’s impulses: “But since the variety of the impulses (ὀρμάς) of the soul is great, it stands to reason that we would make such an inquiry in no simple or offhand manner, but by means of many complicated observations.”\(^{56}\) Ptolemy mentions the soul’s impulses again in *Tetrabiblos* 4.10: “Finally to Saturn falls as his lot old age, the latest period, which lasts for the rest of life. Now the movements both of body and of soul (τῶν τε σωματικῶν καὶ τῶν ψυχικῶν κινήσεων) are cooled and impeded in their impulses (ὀρμαί), enjoyments, appetites (ἐπιθυμίας), and speed….”\(^{57}\) Hence, Ptolemy’s amalgamation of the irrational parts of the soul is a theme in the *Tetrabiblos*, *On the Kritērion*, and *Harmonics*, and he associates impulses with the resultant part in the *Tetrabiblos* and *On the Kritērion*.\(^{58}\) Of further note is Ptolemy’s reference in *Tetrabiblos* 3.14 and 4.10 to the rational part of the soul as the intelligent (διώνοματικόν) part. In the former, he contrasts the διώνοματικόν with a passive (παθητικόν) part of the soul; in the latter he

\(^{52}\) Ibid., D95.28-29, 96.17.  
^{53}\) Ptolemy *On the Kritērion*, La13.  
^{54}\) Ptolemy *Harmonics* 3.5, D97.31-32.  
^{55}\) Ptolemy *On the Kritērion*, La21.  
^{56}\) Ptolemy *Tetrabiblos* 3.13, Cam154, trans. F.E. Robbins.  
^{57}\) Ptolemy *Tetrabiblos* 4.10, Cam 206-207, after F.E. Robbins.  
^{58}\) Ptolemy appropriates this grouping of the spirited and appetitive parts of the soul, as irrational, in contrast to the rational part of the soul from the tradition following Plato. On the bipartite model of the soul in Plato, Aristotle, and the early Academy, see D.A. Rees, “Bipartition of the Soul in the Early Academy,” *The Journal of Hellenic Studies* 77, no. 1 (1957): 112-118; Christopher Gill, *The Structured Self in Hellenistic and Roman Thought* (Oxford: Oxford University Press, 2006), 211-212. For Ptolemy, the emotive and appetitive parts combine into a single part within a tripartite model rather than a bipartite.
associates it with the logical (λογικόν) part. While Ptolemy does not describe a passive part of the soul in *On the Kritērion*, he does associate the διανοητικόν with the λογικόν.\(^{59}\) Thus, in the *Tetrabiblos*, Ptolemy employs similar terms for the parts of the soul as he utilizes in *On the Kritērion* and the *Harmonics*. In addition, he repeats certain theoretical choices, such as the use of both Platonic and Aristotelian terms for the parts of the soul and the combination of Plato’s two irrational parts into a single part. Ptolemy’s discussion of the parts of the soul in the *Tetrabiblos* is brief; however, in *On the Kritērion* and the *Harmonics*, he presents detailed accounts.

4.2 The Nature of the Human Soul

The human soul falls into a special category for Ptolemy. It is mortal (θνητή)\(^{60}\) and composed of matter, but, unlike physical objects, as defined in *Almagest* 1.1, it is not perceptible. Ptolemy contrasts body (σῶμα) and soul (ψυχή) in *On the Kritērion*:

> The parts in us distinguished by the most general differentiae are (a) body, (b) soul. By ‘body’ we mean the part composed of bones, flesh, and similar perceptible things (τῶν τοιούτων σώματων), and by ‘soul’ the part which is the cause of the movements (κινήσεων) occurring in or through these and which we can only grasp through its powers (οὐ τῶν δυνάμεων μόνων ἀντιλαμβάνομεθα).\(^{61}\)

While body is perceptible, soul is imperceptible. Yet, unlike theological objects, which are ungraspable as a result of their imperceptibility, the human soul is graspable by means of the observation of its effects on the human body. Ptolemy refers to these effects as powers, or δυνάμεις, the term Aristotle uses in the *De Anima* for the functions of the soul. By observing

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\(^{59}\) Ptolemy *On the Kritērion*, La6.

\(^{60}\) Ptolemy *Harmonics* 3.4, D95.21.

the movements that the soul causes in the body, one apprehends the nature of the soul. Ptolemy describes the movements the soul causes in the body and, in general, these include thinking (διανοεῖσθαι) as well as “sensory and all other movements (τὰς τε σιθητικὰς καὶ τὰς ἀλλὰς πάσας κινήσεις).”

Like Galen after him, Ptolemy at first maintains an agnostic position in On the Kritērion with respect to the question of whether the human soul is a type of body. For the sake of consistency in relation to his indifference towards nomenclature, he refrains from calling the soul a type of body:

This is not the place to bother whether we ought also to call this part ‘body’. As we have said, we are not at present discussing the names to give to the natural objects (φύσεων) before us; what we are investigating is the actual difference between these things, a difference which we recognize as being unchangeable in reality even if one alters the nomenclature a thousand times, or at one time says that the soul is incorporeal (ἀσωματων), following those who lay it down that what is known (γνώριμων) by sense perception is to be called ‘body’, and at another time that it is body, following those who define body as that which can act and be acted upon (κατὰ τοῦ το ποιῆσαι καὶ παθεῖν ὁ ὁμοὶ τὰ σώμα ὁριζομένους).

Ptolemy does not go so far as to identify the soul as a type of body, but he still calls the soul a natural object (φύσις), which acts on and can be acted upon by body. While calling the soul a φύσις does not signify that the soul is physical, by appropriating a Stoic definition of body, as that which acts and acts upon, and applying it to the soul, Ptolemy insinuates that the soul consists of matter.

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62 Ibid., La11.
63 See Galen De placitis Hippocratis et Platonis 3.1.1, 7.1.1.
64 Ptolemy On the Kritērion, La11, after Liverpool/Manchester Seminar on Ancient Philosophy.
65 Alexander of Aphrodisias calls the soul a φύσις in his De Anima 28.10.
66 Boll (87) notes that this definition of body is Stoic and provides numerous citations in support of this identification.
For Ptolemy, the judgment of whether the soul is a type of body is a semantic debate.

Having exemplified his agnostic position in relation to nomenclature, he proceeds to characterize the physical properties of the human soul, and, as in the *Tetrabiblos*, he depicts the soul as consisting of fine particles, or elements, that scatter when released from the body:

The soul is so constituted as to scatter immediately to its proper elements (τὰ οἴκεια στοιχεῖα), like water or breath (πνεῦμα) released from a container, because of the preponderance of finer particles (λεπτομερεῖς)...the body, on the other hand, although it stays in the same state for a considerable time because of the thicker consistency of its matter (τὸ τῆς ὕλης πολύμερες)...67

In other words, the difference between soul and body is merely a matter of degree. The soul consists of finer particles than does body, and these finer particles are so small that they are not perceptible.68 Furthermore, Ptolemy affirms that the soul consists of matter (ὕλη) in the following:

Further, if soul consists not of one and the same but of different kinds of material (ὕλη), it will be the individual characteristics of these different materials that shape the parts of the body which contain each of them to suit the properties of their own nature and so make them able to cooperate with the powers (δύναμεις) of the soul. If, on the other hand, the underlying nature of the whole soul is one and the same, the variety of its powers (δύναμεων) will be produced by the differences in the surrounding parts of the body...69

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67 Ptolemy *On the Kritērion*, La12, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
68 Boll (88) remarks that Ptolemy’s portrayal of the soul as a substance finer and more movable than body is evidence for his materialism. The Liverpool/Manchester Seminar on Ancient Philosophy notes that Ptolemy’s terminology, in describing the soul as consisting of fine particles (λεπτομερεῖς), is more Epicurean than Stoic. Indeed, Epicurus uses the terms λεπτομέρεια and πολύμερες in his letters to Herodotus and Pythocles, and he depicts the soul as a body consisting of fine particles (ἡ ψυχὴ σῶμα ἐστὶ λεπτομερεῖς) in Diogenes Laertius’ *Lives* 10.63.3, 6. Ptolemy’s use of these terms does not signify that he was an atomist. Rather, he simply appropriated the terms for his own physics. For the comments of the Liverpool/Manchester Seminar on Ancient Philosophy, see Liverpool/Manchester Seminar on Ancient Philosophy, “Ptolemy: On the Kriterion and Hegemonikon.” In *The Criterion of Truth: Essays written in honour of George Kerferd together with a text and translation (with annotations) of Ptolemy’s On the Kriterion and Hegemonikon*, ed. Pamela Huby and Gordon Neal (Liverpool: Liverpool University Press, 1989), 223.
69 Ptolemy *On the Kritērion*, La12, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
While Ptolemy admits that the soul consists of matter, he maintains some degree of agnosticism in this passage. He provides two options for the nature of the soul: either it consists of different kinds of matter or its matter is homogeneous.

Ptolemy chooses one of these options later in the text. He claims that the human soul consists of three elements: air, fire, and aether. Adhering to Aristotle’s five-element theory, he describes each of the five elements as passive, both passive and active, or entirely active:

Earth and water are more material and altogether passive, fire and air are more capable of causing movement (κυνητικώτερα) and are both passive and active, aether is always in the same condition and is active only. Among the compounds too, we apply the term ‘body’ properly to what is more material and less active and ‘soul’ to what moves both itself and body. It is therefore reasonable that the body should be classed in accordance with the elements of earth and water and the soul in accordance with the elements of fire, air, and aether.70

In this passage Ptolemy states that the soul should merely be classed (τετόχθαι) in accordance with fire, air, and aether, but, shortly after making this statement, he clarifies that the soul is composed of these three elements: “It will also be a consequence of this that the actual substance (οὐσίαν) of the soul has a distinctive nature akin to the elements of which it is composed (τοῖς ποιῶσιν αὕτην στοιχείοις); its nature will be both passive and active (πάσχειν καὶ ποιεῖν) in its proper movements in proportion to the air and fire, but active only in proportion to the aether.”71 Thus, Ptolemy ultimately claims that the soul consists of air, fire, and aether.

In this account of the soul’s composition, Ptolemy presents a different model of the elements’ qualities than he offers in the *Almagest* and *Tetrabiblos*. In *Almagest* 1.1, he advances a dichotomy between the sublunary elements that move towards the center of the cosmos and the sublunary elements that move away from the center. The elements that move towards the center, presumably earth and water, are heavy and passive (παθητικῶν); the elements that move away

70 Ptolemy *On the Kritêrion*, La19, after Liverpool/Manchester Seminar on Ancient Philosophy.  
71 Ibid., La20.
from the center, presumably air and fire, are light and active (ποιητικόν). In *Tetrabiblos* 1.5, Ptolemy describes the four qualities, rather than the elements, as passive or active. In this regard, he follows Aristotle’s *On Generation and Corruption*, but, in his application of the terms to the qualities, he strays from Aristotle. While Aristotle portrays hot and cold as active principles, Ptolemy, in reference to the four humors, designates hot and moist as active (ποιητικά) and cold and dry as passive (παθητικά). This description of the qualities as active or passive is inconsistent with the account in *On the Kritêrion* of the elements as active and/or passive. One could argue that Ptolemy merely contrasts the four sublunary elements, by virtue of their qualities, as wholly passive or active, as opposed to passive and/or active, when he examines them in isolation from the fifth element. This argument, however, is contradicted by *Almagest* 1.1, wherein Ptolemy asserts that the mathematician distinguishes the corruptible elements from the incorruptible, or the sublunary elements from the aether, based on whether they move rectilinearly or circularly. The direction of the sublunary elements’ rectilinear motion then indicates whether they are wholly active or wholly passive. In other words, in the *Almagest*, Ptolemy’s description of the four elements as either active or passive follows his distinction of the corruptible elements from the incorruptible. Consequently, one is left with the distinct impression that Ptolemy did not adhere to a single, authoritative schema for the activity and passivity of the elements and their qualities.

According to the Liverpool/Manchester Seminar on Ancient Philosophy, Ptolemy’s particular ascription in *On the Kritêrion* of passivity and activity to the five elements is neither

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72 Ptolemy *Almagest* 1.1, H7.
74 Ptolemy *Tetrabiblos* 1.5, Cam19.
Instead, Ptolemy combines Aristotle’s five-element theory with a Stoic conception of the passivity and activity of elements. Like the Stoics, who adhered to a four-element theory, Ptolemy portrays air and fire—which are the constituents of the Stoics’ *pneuma*—as active in comparison to earth and water, which the Stoics and Ptolemy depict as passive. Yet, because Ptolemy appropriates Aristotle’s fifth element, he labels the aether as active, whereas air and fire, as sublunary and changeable, are passive as well as active. Hence, Ptolemy adapts a materialist view of the soul to an Aristotelian theory of five elements. His portrayal of the soul as consisting of air and fire stems from the Stoic conception of *pneuma*, and his inclusion of aether as an elemental component of the soul proceeds from the Peripatetic tradition following *Generation of Animals* 2.3, as explicated above. Having espoused a materialist view, Ptolemy then adapts the Stoic ascription of the elements’ activity and passivity to an Aristotelian five-element theory.

### 4.3 The Three Faculties of the Human Soul in *On the Kritêrion and Hêgemonikon*

Ptolemy goes on to assign the five elements to the individual faculties of the soul. The soul is tripartite and consists of the following three faculties (δυνάμεις): the faculty of thought (διανοητικόν), the faculty of sense perception (αἰσθητικόν), and the faculty of impulse (ιστηκόν). The faculty of sense perception is around (περί) the passive elements, earth and water, the faculty of impulse is around the elements that are both passive and active, namely air

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75 Liverpool/Manchester Seminar on Ancient Philosophy, 226.
77 Boll (89) also suggests that, by asserting that the soul is composed of air, fire, and aether, Ptolemy amalgamates the Stoic’s *pneuma* with Aristotle’s fifth element, the aether. Boll, however, does not contextualize how Ptolemy conceived of aether in the sublunary realm.
and fire, and the faculty of thought is around the element that is only active, or the aether.\textsuperscript{78}

Furthermore, Ptolemy divides the faculty of impulse into two parts: the appetitive (\textit{ōrēktikōn}) and the emotive (\textit{θυμικόν}). The former has more air in its composition (\textit{āerōeiδεστερον}), and the latter has more fire (\textit{puroeιδεστερον}).\textsuperscript{79} Following the \textit{Timaeus}, Ptolemy locates each of these faculties of the soul in a distinct area of the human body. In general, the soul exists in greater proportion in areas of the body that are more hot and moist.\textsuperscript{80} Ptolemy explains as follows:

\begin{quote}
It is also reasonable to suppose that the greatest admixture of soul with body is matched by the preponderance of heat and moisture in the body, and the smallest by the preponderance of cold and dryness. That is why there is no psychic power in tendons or bones or in anything cold and earthy, while there is in flesh and blood and things which have a greater share in moisture and heat.\textsuperscript{81}
\end{quote}

In particular, the location of each of the soul’s faculties is inferable by means of the observation of the motions in the body caused by the faculties.\textsuperscript{82}

The faculty of impulse (\textit{ōrēmtikōn}), because it consists of two distinct parts, exists in two areas of the body. The emotive part (\textit{θυμικόν}) is located around the heart and liver. The appetitive part (\textit{ōrēktikōn}) is around the stomach and abdomen. The term Ptolemy uses for the faculty of impulse, \textit{ōrēmtikōn}, derives from the Stoics’ conception of impulse, which, according to A.A. Long, is the faculty of animals and human beings which allows them to conduct purposeful movements in relation to desires and aversions.\textsuperscript{83} The term \textit{ōrēmtikōn} became common intellectual property by the second century. The Platonic and Peripatetic traditions, for

\textsuperscript{78} Ptolemy \textit{On the Kritērion}, La20.
\textsuperscript{79} Ibid., La21.
\textsuperscript{80} The association of the soul, or the principle of life, with heat and moisture was a standard view in Greco-Roman philosophy.
\textsuperscript{81} Ptolemy \textit{On the Kritērion}, La19-20, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
\textsuperscript{82} Ptolemy \textit{On the Kritērion}, La21.
\textsuperscript{83} Long, 245.
instance, appropriated the term to signify a power, or δύναμις, of souls. In the Didaskalikos, Alcinous, roughly a contemporary of Ptolemy, portrays the ὀρμητικόν as a δύναμις in the souls of gods which transforms into the θυμοειδές of human souls upon embodiment. In his De Anima, Alexander of Aphrodisias, a Peripatetic philosopher writing in the late second century C.E., labels the ὀρμητικόν a practical δύναμις linked to the ὀρεκτικόν—a term which Aristotle uses for the appetitive faculty in the De Anima, Eudemian Ethics, and Nicomachean Ethics. Ptolemy appropriates the ὀρμητικόν and its association with the ὀρεκτικόν for his own tripartite model.

The ὀρμητικόν, for Ptolemy, is composed of two irrational parts, which evoke the emotive and appetitive parts in the Timaeus. Concerning the latter, Plato, like Ptolemy, places the appetitive part (ἐπιθυμητικὸν) lowest in the body. It is in the area between the midriff and the boundary toward the navel (τὰ μεταξὺ τῶν τε φρενῶν καὶ τοῦ πρὸς τὸν ὁμφαλὸν ὄρου), where the liver resides. For Ptolemy, the appetitive part (ὀρεκτικόν) is situated slightly lower in the body. It is around the stomach and abdomen (περὶ τὴν γαστέρα καὶ τὸ ἄτρομον), and its motions occur in the area below the ‘inward parts’ (ὑπὸ τὰ σπλάγχνα). According to the Timaeus, the spirited part, or “the part of the mortal soul that exhibits courage (ἐνθριακὸς) and spirit (θυμοῦ), the ambitious (φιλόνικος) part,” is located between the neck and midriff, and the heart resides in the guardhouse of this area. Similarly, for Ptolemy the emotive part (θυμικὸν) is located around the heart. Moreover, it is the chief cause, or ἱγεμονικός, of living. Ptolemy states, “Now the most important part of the soul as regards mere life is that located

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86 Plato Timaeus 70d-71b.
87 Ibid. 70a, after Donald J. Zeyl (Indianapolis: Hackett Publishing Company, 2000).
about the heart (τὸ περὶ τὴν καρδιὰν)....”88 Ptolemy’s description of the emotive part as the *hégemonikon* of life stems from a tradition—Platonic, Peripatetic, and Stoic—of depicting the heart as the source of a vital substance.89 For example, when portraying the emotive part of the soul in the *Timaeus*, Plato discusses the role of the heart in circulating blood: “The heart, then, which ties the veins together, the spring from which blood courses with vigorous pulse throughout all the bodily members, they set in the guardhouse.”90 Similarly, Aristotle describes the heart as the ἀρχή of an animal, because it is the first part of an embryo to develop and, once developed, it provides nourishment to the growing animal in the form of blood.91 Philosophers contemporary with Ptolemy used these arguments to justify their identification of the heart as the seat of the *hégemonikon* or the source of a vital substance. For instance, in his *De Anima*, Alexander of Aphrodisias argues that the *hégemonikon* resides in the heart because, as the container of blood, it is the source of nutriment for the body.92 Galen, on the other hand, while he places the *hégemonikon* in the head, he describes vital *pneuma* as emanating from the heart.93 Hence, Ptolemy’s placement of the spirited part of the soul around the chest follows Plato’s *Timaeus*, and his characterization of this part as the *hégemonikon* of living echoes the standard view of the heart as the source of a vital substance.

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88 Ptolemy *On the Kritêrion*, La22, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
89 Boll (92) traces Ptolemy’s portrayal of the heart as the location of the *hégemonikon* of living to the Stoic placement of the *hégemonikon* in the heart. In addition, Boll claims that Ptolemy’s adoption of two *hégemonika*, one in the heart and one in the brain, stems from the Pythagorean tradition. In support of this claim, he cites Aëtius *De placitis reliquiae* 4.5: περὶ τού ἁγμονικοῦ· Πυθαγόρας τὸ μὲν ζωτικὸν περὶ τὴν καρδιὰν, τὸ δὲ λογικὸν καὶ νοερὸν περὶ τὴν κεφαλῆν.
90 Plato *Timaeus* 70a-b, trans. Donald J. Zeyl.
92 Alexander of Aphrodisias *De Anima* 39.21-40.3.
Like the faculty of impulse, the faculty of sense perception (αἰσθητικόν)—which is one of Aristotle’s faculties of the soul in the *De Anima*—is multiple in location and capacity (δυνάμεις).\(^{94}\) Ptolemy identifies five senses, each with their own location within the body.\(^{95}\)

Touch, as more material (ὐλικῶτέραν), extends through all of the flesh and blood. The remaining four senses exist in the parts of the body that are more easily penetrated and moist. The more easily activated and valuable (τὰς μὲν μᾶλλον εὐκινητότερας καὶ τιμωτέρας) senses are sight and hearing. Because of proximity, they are closely connected to the faculty of thought, which is the *hégemonikon* of living well. Because of this connection, sight and hearing are together the secondary *hégemonika* of living well. The other senses—presumably taste and smell—exist, according to Ptolemy, lower in the body than do sight and hearing. As a result, they are more closely related to the faculty of impulse. In general, the faculty of sense perception governs the contact of the sense organs with perceptible bodies and the transmission of sensory impression, or *phantasia*, to the intellect (νοῦς). Ptolemy maintains that the soul of irrational animals, or non-human animals, extends only to the impression, transmission, and conception (ἐννοια), or retention and memory, of *phantasia*.\(^{96}\)

The faculty of thought (διανοητικόν) is the most valuable of the human soul’s faculties. As such, it is the *hégemonikon* in regard to both life and living well.\(^{97}\) Before pronouncing the faculty of thought the *hégemonikon*, Ptolemy ponders the following:

> If we give the name *hégemonikon* to what is the best absolutely and the most valuable (τὸ βέλτιστον ἀπλῶς καὶ τιμιώτατον), it will be located in the brain. We have given sufficient proof that the faculty of thought has a higher degree of worth and divinity (τιμιώτερον καὶ θειότερον), both in power and in substance.

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\(^{94}\) Ptolemy *On the Kritērion*, La16.

\(^{95}\) Ibid., La20-21.

\(^{96}\) Ibid., La5.

\(^{97}\) Ibid., La22. Tieleman (xxv) notes that Galen identifies the *hégemonikon* with the λογιστικόν in *De placitis Hippocratis et Platonis* 2.3.4.
In this passage, Ptolemy asserts that the faculty of thought is more valuable and more divine than the other faculties of the human soul, just as the heavens are more divine than the sublunary realm. This comparison, of the part of the human soul in the head with the heavens, alludes to Plato’s account in the *Timaeus* of the kinship between the immortal part of the human soul and the heavens. *Timaeus* portrays the encasement of the immortal part of the soul in the body accordingly: “Copying the revolving shape of the universe, the gods bound the two divine orbits into a ball-shaped body, the part that we now call our head. This is the most divine (θειότατον) part of us, and master of all our other parts. They then assembled the rest of the body and handed the whole of it to the head, to be in its service.”

By classifying the faculty of thought as divine and comparable to the heavens, Ptolemy adopts a Platonic analogy. His term for the faculty of thought, δινοτικόν, however, was not school-specific during the second century.

According to Ptolemy, the faculty of thought is undivided in substance. As a result, it exists in only one area of the body: the head. Like Plato—who in the *Timaeus* depicts the

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98 Ptolemy *On the Kritêrion*, La22, after Liverpool/Manchester Seminar on Ancient Philosophy.
100 Ibid. 90a-b.
immortal part of the soul as residing in the head—Ptolemy states, “The faculty of thought is undivided in substance (ὁμέριστον ὄν τῇ ὑσίᾳ) and has its seat in the head, i.e. in the area of the brain (ἐν τῇ κεφαλῇ καὶ περὶ τὸν ἐγκέφαλον).” While the faculty of thought is single in location, it is multiple in capacity, like the faculties of impulse and sense perception. Ptolemy states, “The faculty of thought…exhibits different capacities. It exhibits a capacity for forming opinions (δοξαστικῆ) through its connections with the senses, and a capacity for knowledge (ἐπιστημονικῆ) through its independent re-examination of external objects.” In this way, Ptolemy associates the faculty of thought (διανοητικῶν) with its movement, internal logos, or διάνοια, which he defines earlier in the text. Having described the faculty of sense perception as concerned with the sense organs and phantasía, Ptolemy introduces the rational faculty (λογικῶν), which encompasses thought (διάνοια) and speech (διάλεκτος): “To the rational faculty, by which the special property of human beings is defined, belong thought and speech. Thought is internal logos, a kind of analysis and repetition and differentiation of what has been remembered. Speech is the vocal symbols through which thoughts are revealed to other people.” Ptolemy proceeds to depict speech as secondary to thought, as an image is to the original: “And generally, uttered logos is an image of internal logos.” This dichotomy between internal and external discourse was standard in ancient Greek philosophy. Plato and Aristotle distinguish between the two, as in Sophist 263e and Posterior Analytics 76b24-26, and the Stoics developed the distinction between internal and external logos, specifically.

101 Plato Timaeus 44d.
102 Ptolemy On the Kritêrion, La21, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
103 Ibid.
104 Ibid., La6.
105 Ibid.
106 See Sextus Empiricus Adversus mathematicos 7.275, 8.275.
portraying uttered *logos* as an image (*εἰκόνα*) of internal *logos*, Ptolemy utilizes a distinctively Platonic metaphor. He adds that thought is sufficient for the intellect’s judging of objects, whereas speech makes no contribution to the criterion: “The internal *logos* of thought is itself sufficient for judging things and discovering their natures: uttered *logos* makes no contribution to the process. Rather, it disturbs and distracts our investigations if it comes into operation, just as the motions of the senses do.”107 The intellect (*νοῦς*), as the agent of judgment, uses thought, or internal *logos*, as the means by which it judges, and it makes judgments within two fields of inquiry: the theoretical and the practical. As a result, it has two capacities (*δύναμεις*), one for each of these fields. Ptolemy asserts, “intellect is indivisible in essence, though making use of two primary faculties, the theoretical and the practical (*τῇ τε θεωρητικῇ καὶ τῇ πρακτικῇ*).”108

Thought, which intellect applies in its judging, also takes two forms: opinion and knowledge. Ptolemy classifies these forms as capacities (*δύναμεις*) of the faculty of thought (*διανοητικῶν*). He explains, “Internal *logos* takes two forms. Its simple (*ἀπλὴ*) and unarticulated apprehension of conceptions is opinion (*δόξα*) and supposition (*οἰσίς*); when its apprehension is skillful and incontrovertible, it is knowledge and understanding (*ὁ δὲ τεχνικὴ καὶ ἀμετάπιστος ἐπιστήμη καὶ γνώσις*).”109 Therefore, Ptolemy portrays internal thought, or *διάνοια*, as the movement of the faculty of thought, *διανοητικῶν*. The former takes the form of either opinion or knowledge, and the latter has the capacity (*δύναμις*) for both within the domains of the theoretical and the practical.

### 4.4 The Models of the Human Soul in the *Harmonics*

107 Ptolemy *On the Kritērion*, La8, trans. Liverpool/Manchester Seminar on Ancient Philosophy.
108 Ibid., La16.
109 Ptolemy *On the Kritērion*, La6, after Liverpool/Manchester Seminar on Ancient Philosophy.
Ptolemy presents three, alternative models of the human soul in *Harmonics* 3.5. A.A. Long claims in his article “Ptolemy on the Criterion: An Epistemology for the Practising Scientist” that, at least as concerns Ptolemy’s divisions of the intelligent part of the soul, the models in *Harmonics* 3.5 and *On the Kritērion* match exactly: “Ptolemy also develops a scheme of correspondences between musical intervals and the divisions of the intelligent part of the soul; these divisions conform exactly to his analysis of the constituents of thought in *On the Criterion*.”\(^{110}\) While Long is correct in highlighting certain similarities between the two accounts, he does not mention the significant differences between them. Most obviously, in *On the Kritērion* Ptolemy presents a single, coherent model of the human soul, but in the *Harmonics* he puts forward three models: an Aristotelian, a Platonic, and one which combines elements of the preceding two. Each of the models depicts the soul as tripartite; however, at least in the Aristotelian and Platonic models, each of the three parts has several species, which Ptolemy does not treat as constituents of the human soul in *On the Kritērion*. Furthermore, in *On the Kritērion* Ptolemy labels the faculties of the soul δυνάμεις, but in *Harmonics* 3.5 the parts are μέρη and their subsections are species (εἰδῆ). Hence, in *On the Kritērion* Ptolemy uses Aristotelian language to describe faculties of the soul, but in the *Harmonics* he uses Platonic language for the parts and species. One explanation for this distinction is his professed indifference towards terminology, which he describes in *On the Kritērion*.\(^{111}\) A more convincing and substantial explanation draws on the dissimilar aims of the two texts. In *On the Kritērion*, Ptolemy emphasizes the perceptibility of the effects the soul’s capacities have on the body. By observing


\(^{111}\) Ptolemy *On the Kritērion*, La9-11.
the bodily movements caused by the soul, one gains knowledge of the nature and structure of the soul. Ptolemy’s empiricism, then, founded as it is on Aristotle’s theory of perception, may have led him to adopt Aristotle’s terminology from the *De Anima* for the faculties of the human soul.

In the *Harmonics*, Ptolemy’s aim is to account for the structure of the human soul in mathematical, namely harmonic, terms. As a result, he uses language that applies to the relationships in music as well as in the human soul; the term species (ἐίδη) is applicable as a technical term in both harmonics and psychology. This term is also Platonic, as Plato uses it to denote the parts of the human soul in both the *Timaeus* and *Republic* 4. Moreover, the specific parts and species of the soul in *Harmonics* 3.5 differ in name and description from the faculties in *On the Kritērion*. I will argue below that these differences—like the use of the terms μέρη and ἐίδη instead of δυνάμεις—resulted from Ptolemy’s distinct aim in the *Harmonics* to apply a harmonic framework to the structure of the human soul.

The first model Ptolemy presents in *Harmonics* 3.5 is mainly Aristotelian. Again, the soul consists of three parts (μέρη): the intellectual (νοερόν), the perceptive (αἰσθητικόν), and the part that maintains a state (ἐκτικόν). The terms for the first two parts of the soul are Aristotelian, while the third term is Stoic, as it is the adjective derived from ἔκτις, which refers to the function of *pneuma* to bind objects into a cohesive form. The intellectual part of the soul has the greatest degree of simplicity, equality, and stability. As Plato and Aristotle maintain, the existence of the lower part(s) in a living being does not imply the coexistence of the higher part(s), but the existence of the higher part(s) does indicate the coexistence of the lower part(s).

Ptolemy states, “Now things that have *hexis* do not always have perception, and neither do things that have perception always have intellect: things that have perception, conversely, always do

113 Ptolemy *Harmonics* 3.5, D96.2.
have *hexis*, and things that have intellect always have both *hexis* and perception.”114 Hence, Ptolemy appropriates the names of two parts of the soul from Aristotle and the hierarchical structure of the soul from Aristotle as well as Plato, but he uses a Stoic term for the lowest part of the soul.

Each part of the human soul has several species ([εἰδη]). Just as the octave has seven species, the intellectual part of the soul has at most seven species, which Ptolemy lists as the following seven: imagination (*φαντασία*), intellect (*νοῦς*), reflection (*ἐννοια*), thought (*διάνοια*), opinion (*δόξα*), reason (*λόγος*), and knowledge (*ἐπιστήμη*). While in *On the Kritêrion* Ptolemy identifies the principle movement of the faculty of thought as internal *logos*, or διάνοια, and he treats opinion and knowledge as capacities of this faculty, in this model διάνοια, δόξα, λόγος, and ἐπιστήμη all exist on the same level, as different species of the intellectual part of the soul. Similarly, in *On the Kritêrion* Ptolemy describes *phantasia* as a medium, which transmits sensory impressions from the sense organs to the intellect. Yet, according to this model in *Harmonics* 3.5, *phantasia* is a species of the intellectual part, specifically. What these seven species have in common, however, is their use in *On the Kritêrion* as components of the criterion of truth.115 After listing the aspects of sense perception that contribute to the criterion, Ptolemy lists each of these seven, including *phantasia* as well as the obviously intellectual items, as components of the criterion.116 Ptolemy lists *phantasia* as an intellectual, rather than a perceptive, species in the *Harmonics* presumably because he aims in the *Harmonics* to list exactly seven species of the intellectual part of the soul. In this way, the number of the intellectual part’s and octave’s species matches.

114 Ibid., D96.7-9, after Andrew Barker (Cambridge: Cambridge University Press, 1989).
115 Boll (105) observes that Ptolemy lists these seven terms as components of his criterion in *On the Kritêrion*.
116 Ptolemy *On the Kritêrion*, La6-7.
According to Ptolemy, the perceptive part of the soul is nearer to the intellectual part than
the part that maintains a state. Like the intellectual part, it engages in a kind of apprehension
(κατάληψις). Ptolemy is most likely alluding here, in *Harmonics* 3.5, to the role of sense
perception in the criterion of truth. While the intellectual part of the soul has seven species,
however, the perceptive part has only four. Ptolemy explains, “The perceptive part has four,
equal in number to those of the concord of the fifth, related respectively to sight, hearing, smell,
and taste (if we treat the sense of touch as being common to them all, since it is by touching the
perceptibles in one way or another that they produce our perceptions of them).”117 This claim—
that touch need not be counted as a sense, since the four senses have it in common—does not
cohere with Ptolemy’s description of the faculty of sense perception in *On the Kritêrion*. Again,
in this text, Ptolemy distinguishes touch, as a sense, from the other four senses. He states, “Of
the senses, touch is more material and extends over the whole of the flesh and blood in the body,
while the others are restricted to the parts that are more easily penetrable and more moist (the
passages).”118 Despite this distinction of touch, as extending over the entire body, Ptolemy still
maintains that touch is a sense, along with the other four. Barker attempts to explain the
reductionist claim of *Harmonics* 3.5 by suggesting a possible Stoic and/or Epicurean influence:
“The idea that every sense is a form of touch was rejected by Aristotle, who had found it in
Democritus. Versions of it were revived by both Stoics and Epicureans.”119 Notwithstanding the
materialism of the Stoics, none argued that four of the senses are reducible to touch. Conversely,
while the Epicureans may have advanced this position, on the whole Ptolemy adopts few

117 Ptolemy *Harmonics* 3.5, D96.17-21, after Andrew Barker.
118 Ptolemy *On the Kritêrion*, La20, trans. Liverpool/Manchester Seminar on Ancient
Philosophy.
119 Andrew Barker, *Greek Musical Writings, Volume II: Harmonic and Acoustic Theory*
Epicurean concepts. More likely is the explanation Franz Boll introduces in his “Studien über Claudius Ptolemäus.” Boll traces Ptolemy’s association of sense perception with the number four to Pythagorean number symbolism. This symbolism drove Platonists, such as Theon of Smyrna, to claim that only four senses exist and touch is common to these four. Theon states, “All of the senses operate according to touch, since touch is common in a fourfold manner.” Therefore, the best explanation for Ptolemy’s claim that touch is common to the other four senses is that—as with the species of the intellectual part of the soul—Ptolemy has fit the data to the model. Just as he ascribes phantasia to the intellectual part of the soul in order that the part have seven species, here, in order that four species belong to the perceptive part of the soul, he rejects his affirmation in On the Kritèrion that five senses exist and adopts the Platonic tradition’s argument for the existence of only four senses.

The third part of the soul, that which maintains a state (ἐκτικόν), has three species. Ptolemy describes it simply: “One can say that the part of the soul that maintains a state has three species, equal in number to the species of the fourth, related respectively to growth (σύγχρονον), maturity (ἀκμήν), and decline (φθισίν)—for these are its primary powers (πρῶται δυνάμεις).” While the term for this part of the soul is Stoic, Ptolemy’s description of its species is Aristotelian. Aristotle lists these three species—growth, maturity, and decline—as definitional aspects of living beings in De Anima 411a30-b1 and 434a24-25. In the latter passage, he proclaims, “Everything then that lives and has a soul must have a nutritive soul, from birth until death; for anything that has been born must have growth, maturity, and decline, and

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120 Boll, 105.
121 Theon of Smyrna On Mathematics Useful for the Understanding of Plato, H97.24. Boll (105) provides the Greek text.
122 Ptolemy Harmonics 3.5, D96.15-17, after Andrew Barker.
123 Boll, Düring, and Barker all identify this passage as comparable to Ptolemy’s list of the three species of the part of the soul that maintains a state.
these things are impossible without nourishment.”124 While Ptolemy does not utilize Aristotle’s term for the most basic capacity of the soul, θρεπτικήν, he does adopt Aristotle’s description of the nutritive soul. Just as Aristotle’s nutritive soul supports the growth, maturity, and decline of all living beings, so Ptolemy’s part of the soul that maintains a state has three species: growth, maturity, and decline.

After presenting this Aristotelian model of the soul, Ptolemy puts forward an alternative, Platonic model. He introduces the Platonic model accordingly: “Our soul is also divided in another way, into the rational (λογιστικόν), the spirited (θυμικόν) and the appetitive (ἐπιθυμητικόν).”125 Ptolemy undoubtedly derives these terms from the Platonic tradition. After all, Plato uses the terms λογιστικόν, θυμοειδές, and ἐπιθυμητικόν to denote the three parts of the soul in Republic 4.126 Instead of using the term θυμοειδές, however, Ptolemy follows the contemporary Platonic tradition in choosing to describe the spirited part of the soul as the θυμικόν, the same term Alcinous uses in the Didaskalikos.127 While in the Aristotelian model Ptolemy lists a number of species, which correspond to the species of the octave, the fifth, and the fourth, in the Platonic model he distinguishes species of virtues (ἀρεται), specifically. Before listing these virtues, he defines virtue as a melodiousness (ἐμμελές) of souls and vice as an unmelodiousness (ἐκμελές). Comparing the use of virtue and vice as descriptive of the relations in music and in the human soul, Ptolemy explains, “virtue among souls is a melodiousness belonging to them, while vice is an unmelodiousness. A feature common to both classes is the attunement (ἡμοσυμένον) of their parts, when they are in a condition conforming to nature, and lack of attunement (ἀνάρμοστον) when they are in a condition contrary to

125 Ptolemy Harmonics 3.5, D96.27-28, trans. Andrew Barker.
126 See Plato Republic 440e-441a.
127 See Alcinous Didaskalikos 17.4, H173.13; 29.1, H182.21.
nature." In describing the relations between the parts of the soul in harmonic terms, Ptolemy follows both the Platonic and the Stoic traditions. For example, in Republic 4, Socrates speaks of harmonizing the parts of the soul:

> One who is just does not allow any part of himself to do the work of another part or allow the various classes within him to meddle with each other. He regulates well what is really his own and rules himself. He puts himself in order, is his own friend, and harmonizes the three parts of himself like three limiting notes in a musical scale—high, low, and middle. He binds together those parts and any others there may be in between, and from having been many things he becomes entirely one, moderate and harmonious (\( \eta \rho \mu o\sigma \mu \epsilon \nu o\)).

A.A. Long argues in his paper “The harmonics of Stoic virtue” that the Stoics perpetuated this Platonic metaphor of the soul’s attunement. Discussing Ptolemy’s use of this metaphor in his third model of the soul, which I examine below, Long maintains, “This is precisely what my hypothesis about Stoicism implies—the conception of a mind that is in complete harmony with nature as being directly analogous to a well-tuned musical instrument.” Thus, for his Platonic model of the soul, Ptolemy derives the terms for the three parts of the soul and the metaphor of the soul’s harmony from the Platonic tradition. The Stoic tradition’s adaptation of this metaphor of the soul’s harmony may have influenced Ptolemy’s application of it as well.

After defining virtue and vice in harmonic terms, Ptolemy lists the species of virtue belonging to each part of the soul. First, just as the octave and the intellectual part of the soul in the Aristotelian model have seven species, the rational part of the soul in the Platonic model has seven species of virtue: acuteness (\( \delta \xi \tau \pi \zeta \)), cleverness (\( \epsilon \upsilon \phi \varsigma \alpha \)), shrewdness (\( \alpha \gamma \chi \iota \nu o\iota \alpha \)), judgment (\( \epsilon \upsilon \beta \omicron \lambda \iota \iota \alpha \)), wisdom (\( \sigma \omicron \phi \iota \alpha \)), prudence (\( \phi \rho \omicron \nu \iota \sigma i \zeta \)), and experience (\( \epsilon \mu \pi \epsilon \iota \rho \iota \alpha \)). Second, just as the concord of the fifth and the perceptive part of the soul in the Aristotelian

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128 Ptolemy Harmonics 3.5, D97.3-8, after Andrew Barker.
130 Long, 1996, 220.
model have four species, the spirited part of the soul in the Platonic model has four species of virtue: gentleness (πραότης), fearlessness (ἀφοβία), courage (ἀνδρεία), and steadfastness (καρτερία). Third, just as the concord of the fourth and the part of the soul that maintains a state in the Aristotelian model have three species, the appetitive part of the soul in the Platonic model has three species of virtue: moderation (σωφροσύνη), self-control (ἐγκράτεια), and shame (αἰδώς). By providing a list of virtues, Ptolemy follows a typically Hellenistic trend, which has a precedent in Aristotle’s corpus. In his definitions and relations of the virtues, however, Ptolemy follows the Platonic tradition.

By describing virtues as belonging to distinct parts of the soul, as opposed to the soul in general, Ptolemy joins a tradition evident in De passionibus—attributed to Andronicus, the first-century B.C.E. Peripatetic philosopher—and the Didaskalikos of Alcinous, roughly a contemporary of Ptolemy. In the former, Andronicus assigns one virtue to each part of the soul: φρόνησις is a virtue of the λογιστικόν, πραότης is a virtue of the θυμοειδές, and σωφροσύνη is a virtue of the ἐπιθυμητικόν. For Ptolemy, these three virtues belong to the same three parts of the soul. Similar to Andronicus, Alcinous distinguishes virtues that are peculiar to each part of the soul. After defining virtues as perfections of each part of the soul, he asserts that the perfection of the λογιστικόν is φρόνησις, the perfection of the θυμικόν is ἀνδρεία, and the perfection of the ἐπιθυμητικόν is σωφροσύνη. While Andronicus and Alcinous differ on which virtue they assign to the spirited part of the soul, Ptolemy’s account, because he includes more than one virtue for each part of the soul, agrees with both. As a point

131 Boll (106) mentions the influence of Andronicus on Ptolemy’s Platonic model of the soul but only in his definitions of the virtues, not in their allocation to the parts of the soul.
132 Andronicus De passionibus 2.1.3.
133 Ibid. 4.4.1.
134 Ibid. 6.1.1.
135 Alcinous Didaskalikos 29.1, H182.
of interest, in a polemic against Chrysippus, Galen comments in *De placitis Hippocratis et Platonis* that only one virtue can belong to each capacity of the soul, and it is impossible that many virtues belong to one capacity.\textsuperscript{136} In assigning virtues to distinct parts of the soul, as opposed to the entire soul, Ptolemy follows the Platonic tradition shared by Andronicus, Alcinous, and perhaps Galen. Ptolemy, however, strays from this tradition by allocating several virtues to the parts of the soul rather than only one. His motivation for this deviation must have been, at least in part, his aim to produce a model of the soul, wherein each part has the same number of species as its musical counterpart, whether the homophone, the fifth, or the fourth.

Ptolemy not only lists the virtues but provides short definitions of them as well. The closest philological match to these definitions is found in the pseudo-Platonic *Definitions*, composed during the early third or late fourth century and most likely developed incrementally over the centuries. Franz Boll\textsuperscript{137} first drew attention to the potential influence of the *Definitions* on Ptolemy’s list of virtues, and Düring later agreed that not only does a great deal of overlap exist between the two texts, but, furthermore, this overlap cannot be accidental.\textsuperscript{138} Every single virtue that Ptolemy lists is included in the text of the *Definitions*. Many of the virtues have their own definitions, but those virtues that are not defined in the *Definitions* are still included in the definitions of other terms. For example, acuteness (\(\Delta \varepsilon \zeta \omicron \upsilon \tau \gamma \zeta\)) does not have its own definition, but it—like cleverness (\(\varepsilon \upsilon \phi \nu \iota \alpha\)), which Pseudo-Plato does define—is used in the definition of shrewdness (\(\Delta \gamma \chi \iota \omicron \omega \iota \alpha\)), another virtue of Ptolemy’s rational part of the soul. Furthermore, obvious terminological overlap exists between several of the definitions Pseudo-Plato and Ptolemy provide. For instance, according to Ptolemy, wisdom (\(\sigma \omicron \phi \iota \alpha\)) has to do with the

\textsuperscript{136} Galen *De placitis Hippocratis et Platonis* 5.5.39.
\textsuperscript{137} Boll, 106.
\textsuperscript{138} Ingemar Düring, *Ptolemaios und Porphyrios über die Musik* (Göteborg: Elanders Boktryckeri Aktiebolag, 1934), 271.
theoretical (θεωρητικόν), and, according to Pseudo-Plato, it is “non-hypothetical knowledge; knowledge of what always exists; knowledge which contemplates (θεωρητική) the cause of beings.”139 Similarly, both Ptolemy and Pseudo-Plato define gentleness (πρασότης) in relation to anger (ὀργή)140 and courage (ονδρέια) in relation to dangers (κίνδυνοι).141 In addition, both Ptolemy and Pseudo-Plato use the phrase “endurance of hardships” (ὑπομονή πόνων) in their accounts of steadfastness (καρτερία). Ptolemy defines it as “the endurance of hardships (τοῖς ὑπομονοῖς τῶν πόνων),”142 and Pseudo-Plato describes it as follows: “endurance (ὑπομονή) of pain for the sake of what is admirable; endurance of hardships (ὑπομονή πόνων) for the sake of what is admirable.”143 Concerning Ptolemy’s virtues of the appetitive part of the soul, both Ptolemy and Pseudo-Plato define moderation (σωφροσύνη) in relation to pleasures (ἡδονή),144 characterize self-control (ἐγκράτεια) as a type of enduring (ὑπομονή),145 and use forms of the term ἐλαβεῖα to define shame (αἰδός).146 Hence, a considerable amount of textual overlap exists between Ptolemy’s definitions of the Platonic soul’s virtues and the virtues’ definitions in the pseudo-Platonic Definitions. It is possible, of course, that Peripatetic and Stoic accounts of the virtues influenced Ptolemy’s definitions,147 but the textual correspondences between Ptolemy’s and Pseudo-Plato’s accounts suggest a Platonic source. Ptolemy may have used a Platonic handbook, such as the Definitions, when composing this section of the Harmonics, or,

140 Ptolemy Harmonics 3.5, D97.13-14; Pseudo-Plato Definitions 412d6-7.
141 Ptolemy Harmonics 3.5, D97.15; Pseudo-Plato Definitions 412a7.
143 Pseudo-Plato Definitions 412c1-2, after D.S. Hutchinson.
144 Ptolemy Harmonics 3.5, D97.10-11; Pseudo-Plato Definitions 411e6-7.
145 Ptolemy Harmonics 3.5, D97.11; Pseudo-Plato Definitions 412b3.
146 Ptolemy Harmonics 3.5, D97.11-12; Pseudo-Plato Definitions 412c9-10.
147 For instance, Boll (106-108) emphasizes the possible influence of Andronicus’ De passionibus, in addition to the pseudo-Platonic Definitions, on Ptolemy’s definitions of the virtues.
perhaps more likely, he may simply have drawn these definitions from his earlier education.

Either way, it is fitting that Ptolemy should use Platonic definitions of the virtues when delineating the species of a Platonic model of the human soul.

After listing the species of virtue, Ptolemy comments on how the three parts of the soul relate to one another. Referring to both the Aristotelian and Platonic models, he asserts, “so also in souls it is natural for the intellectual and rational parts (τὰ νοητικὰ καὶ λογιστικὰ μέρη) to govern the others, which are subordinate, and they [i.e., the former] need greater accuracy in the imposition of correct ratio, since they are themselves responsible for the whole or the greater part of any error among the others.” Barker observes that this idea—of the rational or intellectual part of the soul governing the other parts—was common to the Platonic tradition, as in Republic 4, as well as the Aristotelian and Stoic traditions. Ptolemy also borrows from Republic 4 when he describes the best condition of the entire soul as resulting from the relation of its parts. Applying the harmonic metaphor to the soul, he proclaims, “The best condition of the soul as a whole, justice (δικαιοσύνη), is as it were a concord between the parts themselves (τῶν μερῶν συντονεῖ) in their relations to one another, in correspondence with the ratio governing the principal parts…. In Republic 4, Socrates, too, defines justice as a relation between the parts of the soul: “Then, isn’t to produce justice (δικαιοσύνη) to establish the parts of the soul in a natural relation of control, one by another, while to produce injustice is to establish a relation of ruling and being ruled contrary to nature?” Therefore, Ptolemy adheres to Republic 4 when depicting the relations between the parts of the soul.

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149 See Plato Republic 441e.
151 Ptolemy Harmonics 3.5, D97.27-29, trans. Andrew Barker.
152 Plato Republic 444d, trans. G.M.A. Grube.
In the context of portraying the best condition of the soul as a whole, Ptolemy presents a third model of the human soul, which combines elements of the Platonic and Aristotelian models. The soul is again tripartite, and it consists of the following three parts: (1) the part concerned with goodwill (εὐνοια) and right reckoning, or rationality (ἐυλογιστία); (2) the part concerned with good perception (εὐαισθησία) and good health (εὐεξία), or, alternatively, courage (ἀνδρεία) and moderation (σωφροσύνη); (3) the part concerned with “the things that can produce and the things that participate in harmoniai (τὰ ποιητικὰ καὶ τὰ μετέχουτα τῶν ἀρμονιῶν).” Barker explicates this model as follows:

The three ‘parts’ here considered are conceived as: (a) the faculty whereby we understand, in the abstract, what excellence consists in, (b) the faculty whereby we identify it in particular instances, together with the disposition to pursue it, and (c) the practical capacity to create it, once it is understood, identified and pursued. The reference to the harmoniai is not here purely musical: the capacity is that of making in things external to us, and building in our own character, structures conforming to the ‘harmonious’ patterns discerned by reason.

Barker adds that this third model of the human soul is an attempt to combine the first two models, the Aristotelian and Platonic, that Ptolemy presents: “…it is possible that he intends the third classification, which is complex and difficult, to combine the two others, as a preparation for his comparison of the best human condition with the complete systēma. But the way in which the three analyses are to be coordinated remains less than clear.” While Barker is correct in his portrayal of this third model as an attempt to combine the previous two, he is too quick to belittle the model’s consistency with the other two.

The language Ptolemy chooses for the three parts of the soul in this combination model amalgamates the terms he uses in the Aristotelian and Platonic models. Concerning the first part

153 Ptolemy Harmonics 3.5, D97.32-33, trans. Andrew Barker.
155 Ibid.
of the soul, the term εὐνοια, as it is related to νοῦς, implies its relation to the intellectual part of the soul (νοερόν) in the Aristotelian model. Likewise, the term εὐλογιστικόν, the term he uses for the rational part of the soul in the Platonic model. As for the second part of the soul, εὐσκηνικόν refers to the perceptive part of the soul (αἰσθητικόν) in the Aristotelian model, and εὐεξία may refer to the health of the body to sustain sense perception.

Ptolemy provides an alternative description of the second part of the soul as concerning courage (ἀνδρεία) and moderation (σωφροσύνη). In his Platonic model, he portrays courage as a virtue belonging to the spirited part of the soul and moderation as a virtue of the appetitive part of the soul. Correspondingly, in the Didaskalikos Alcinous describes courage as the perfection of the spirited part of the soul and moderation as the perfection of the appetitive part.156 While Ptolemy does not create a hierarchy of the species of virtue in his Platonic model, by highlighting courage and moderation in this third, combination model, he implies that courage and moderation—as in the contemporary Platonic tradition—are the principal virtues of the spirited and appetitive parts, respectively. Ptolemy’s third part of the soul in the combination model—concerning “the things that can produce and the things that participate in the harmoniai”157—may relate to the part of the soul that maintains a state (ἐκτικόν) in the Aristotelian model, as it is the part of the soul which preserves the form or state of an object or living being, whether or not its form be in a harmonious relation. Ptolemy does not refer here to the appetitive part of the soul, because he has already combined it with the spirited part in the second part of the soul. This combination is not surprising, as Ptolemy also joins the spirited and appetitive parts in On the Kritērion when characterizing the faculty of impulse (ὀρμητικόν).158 Indeed, combining the spirited and

156 Alcinous Didaskalikos 29.1, H182.
157 Ptolemy Harmonics 3.5, D97.32-33, trans. Andrew Barker.
158 Ptolemy On the Kritērion, La21.
appetitive parts of the soul into a single part was a common practice from the early Academy onward. Ptolemy, however, does not propound a bipartition of the soul into rational and irrational parts, as was a traditional interpretation of the Platonic model. Instead, he joins spirit and appetite into a single part existing within a tripartite model. He combines them in this way here, in *Harmonics* 3.5, as well as in *On the Kritêrion* and *Tetrabiblos* 3.13.

After listing the three parts of the soul in his combination model, Ptolemy again advances the analogy between the harmonic relations in music and the relations of the parts of the soul:

> The whole condition of a philosopher is like the whole *harmonia* of the complete *systêma*, comparisons between them, part by part, being made by reference to the concords and the virtues, while the most complete comparison is made by reference to what is, as it were, a concord of melodic concords and a virtue of the soul’s virtues, constituted out of all the concords and all the virtues.\(^\text{160}\)

Having provided a model of the soul that combines the Aristotelian and Platonic models, Ptolemy summarizes the correspondences that exist between the relations in music and the parts of the human soul. The harmonic state in music is a concord of melodic pitches, while the harmonic state of the soul is a virtue of the all of the virtues. Therefore, while Ptolemy combines his Platonic and Aristotelian models in his third model, he ultimately portrays the harmonious state of the soul in Platonic terms. The Platonic model of the soul is characterized by species of virtue, and the harmonious condition of a philosopher’s soul depends on the relation of virtues.

Having diligently outlined the parts and species of the soul in *Harmonics* 3.5, Ptolemy discusses the genera in *Harmonics* 3.6. These genera, however, are not the genera of the three parts of the soul but of the species of virtue, which belong to the parts of the soul. Ptolemy gives this chapter the title “A comparison between the genera of attunement and the genera to which

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\(^{160}\) Ptolemy *Harmonics* 3.5, D97.33-98.4, trans. Andrew Barker.
the primary virtues belong.”161 With this emphasis on virtues, Ptolemy could be alluding to the Platonic model of the soul, but he is more likely alluding to his combination model, with which he closes *Harmonics* 3.5 and whose harmony rests on the relation of virtues. As in *Almagest* 1.1 and *On the Kritêrion*, Ptolemy differentiates the theoretical from the practical. In *On the Kritêrion* the theoretical and the practical are δυνάμεις, but here each is a principle (δραχής) with three genera. The theoretical is divided into the physical, mathematical, and theological, and the practical is divided into the ethical, domestic, and political. Ptolemy proclaims that for each ἀρχή, the theoretical or the practical, the genera do not differ in capacity, because the same virtues apply in each. He says, “These do not differ from one another in capacity (δυνάμεις), since the virtues of the three genera are shared, and dependent on one another; but they do differ in magnitude and value and in the compass of their structure.”162 This claim that the same virtues apply in both the theoretical and the practical contradicts Ptolemy’s distinction in *Harmonics* 3.5 between wisdom and prudence, as the virtues having to do with the theoretical and the practical, respectively. Yet, Ptolemy is no longer concerned with the models of the soul but rather their application. Having put forward a combination model, which loosely amalgamates the parts of the soul in the Aristotelian and Platonic models, he moves on to examine the virtues of the soul as applied in external situations, whether these situations be their exercise in the six genera or in the crises of life, which he elaborates in *Harmonics* 3.7.

Thus, Ptolemy presents several models of the human soul. While he uses different terminology in these models, he maintains the same general structure and exercises the same theoretical preferences. In each model, the soul is tripartite, and the names of the parts derive from Platonic, Aristotelian, and Stoic psychology. In *On the Kritêrion* Ptolemy does not employ

161 Ibid. 3.6, D98.5, after Andrew Barker.
162 Ibid., D98.9-11.
mathematics in his study of the nature and structure of the human soul, but in the *Harmonics* he argues that the soul has a harmonic structure. As a result, he alters his previous model—the model of *On the Kritêrion*, which he most likely completed before the *Harmonics*—and adapts it to a harmonic framework. Ptolemy depicts the soul’s structure as hierarchical, consisting of parts as well as species, and he manipulates which faculties of the soul, from *On the Kritêrion*, count as species of the soul, in order that his psychological model have the same structure as the complete systêma in music. Moreover, in the *Harmonics* Ptolemy employs Platonic terminology for the parts (μέρη) and species (ἐἴδη) of the soul. This choice to use Platonic terminology—as opposed to the Aristotelian terminology of *On the Kritêrion*—results from the disparate aims of the two accounts. In *On the Kritêrion*, Ptolemy emphasizes the empirical basis of his psychological model. By observing the movements the soul causes in the body, one determines what the faculties of the soul are. In the *Harmonics*, Ptolemy applies harmonics to the study of the soul’s structure, and because Platonic terminology is applicable in both harmonics and psychology, he uses Platonic rather than Aristotelian terms. Therefore, Ptolemy’s use of Platonic terminology follows from his method in the *Harmonics* of applying harmonics to psychology, or, more generally, mathematics to physics.

### 4.5 Celestial Souls and Bodies in *Planetary Hypotheses* 2

Ptolemy examines the nature of celestial souls and bodies in Book 2 of the *Planetary Hypotheses*. Unfortunately, only part of the first book exists in the original Greek. The second of the two books and the rest of the first book exist only in a ninth-century Arabic translation, as
well as a fourteenth-century Hebrew translation from the Arabic.\textsuperscript{163} In addition to the obvious difficulties involved in interpreting a text that exists only in translation, the poor quality of the Arabic translation hampers the reading of Book 2. Andrea Murschel, in her article “The Structure and Function of Ptolemy’s Physical Hypotheses of Planetary Motion,” remarks that the translation is of such poor quality, that it is likely that neither Arabic nor Greek were the first language of the translator.\textsuperscript{164} Consequently, both the ideas and the logical order of the text appear disrupted, as if the first part of Book 2 were translated out of sequence.\textsuperscript{165} Despite these difficulties, Ptolemy’s aim in writing \textit{Planetary Hypotheses} 2 as well as the general concepts and analogies he conveys in the text remain discernible.

In the \textit{Planetary Hypotheses}, Ptolemy aims to provide a physical representation of his astronomical models. This project involves calculating the absolute distances of the planetary systems from the earth, describing the physical characteristics of the heavenly bodies, and, in general, expounding a theory of celestial physics. In his endeavor to depict his astronomical models in physical terms, Ptolemy continues the project he starts in his earlier, astronomical texts. In the \textit{Almagest}, he calculates the relative distances of the planets and the absolute distances of the sun and moon. In Book 1 of the \textit{Planetary Hypotheses}, he proceeds to list the absolute distances of every planetary system. While he modifies the \textit{Almagest}'s astronomical models in the \textit{Planetary Hypotheses}, other than in his latitude theory, which differs drastically between the texts, his mathematical models of heavenly motion remain similar. Celestial bodies revolve through the heavens on eccentric and epicyclic circuits.

\textsuperscript{164} Ibid.
\textsuperscript{165} Ibid., 37.
Basing his physical hypoteseis on astronomical models, Ptolemy employs the same method he utilizes in the Harmonics and the Tetrabiblos. In order to give a physical account of some phenomena, he first examines them in mathematical terms. In the case of the Planetary Hypotheses, in order to explicate the nature and characteristics of the aethereal spheres, he first expounds astronomical models of the celestial movements. Ptolemy presents these astronomical models in the Almagest, and he continues this project in Book 1 of the Planetary Hypotheses. In Planetary Hypotheses 2, he finally makes his heavenly models physical by describing the material of the heavenly bodies, the position and absolute size of each heavenly body, and the causes of the bodies’ movements. In chapter 2.2, he characterizes this physical account of heavenly phenomena as hypothetical rather than certain. In her book Ptolemy’s Universe, Liba Taub references Stephen Toulmin and Ernan McMullin as suggesting “that this caution may be a veiled reference to the ‘likely account’ described by Timaeus at 29d.”166 It is also possible, and more likely, that this emphasis on the hypothetical status of the account rather than its certainty is a reference to physics’ status as conjecture rather than knowledge. After all, Ptolemy calls physics conjectural in both Almagest 1.1 and Tetrabiblos 1.2. That he should do the same here when embarking on a physical account of the heavens would be consistent.

In Planetary Hypotheses 2.2, Ptolemy goes on to explain that the conditions and relationships of the heavenly bodies are examinable in two respects: the physical and the mathematical. Having devoted Book 1 of the Planetary Hypotheses to the mathematical, he here analyzes the physical aspects of heavenly bodies. He begins his physical account in Planetary Hypotheses 2.3 with an account of superlunary aether that is consistent with Aristotle’s accounts in the De Caelo and Metaphysics Lambda 8. According to Ptolemy, every heavenly movement

166 Liba Taub, Ptolemy’s Universe: The Natural Philosophical and Ethical Foundations of Ptolemy’s Astronomy (Chicago: Open Court, 1993), 167.
belongs to a distinct aethereal body. Each aethereal body is unique in its periodicity and in its position in the heavens. Despite the existence of several aethereal bodies, these bodies do not hinder one another. The only change they experience is uniform, circular motion from place to place, which does not hinder the motion of any other aethereal body. Hence, the aether does not experience any change which might result from mechanistic causes.

Ptolemy contrasts the aether as different in kind from the four sublunary elements. According to *Planetary Hypotheses* 2.3, the natural movement of the four elements consists in their rising and falling. When displaced from their natural places but unobstructed, they move briskly toward their natural places. When in their natural places, they rest. This claim is in stark contrast to the element theory of *On the Elements*, wherein Ptolemy is purported to have stated that the elements may rest or move circularly in their natural places. Concerning aether, in *Planetary Hypotheses* 2.3 Ptolemy explains that, instead of moving rectilinearly, it has uniform, circular motion, and, unlike the four elements, it never confronts obstacles, which would impede its natural motion. In addition, aethereal bodies have various rates of rotation, and, according to *Planetary Hypotheses* 2.8, the parts of aether that compose a larger body are free and loose to move to any place within the body, as long as their movement remains uniform and circular.

As in *Almagest* 1.3, Ptolemy affirms in *Planetary Hypotheses* 2.3 that the aether consists of parts that are similar to one another. Yet, his search for a cause of the aethereal spheres’ rotation—or a cause of the spheres’ order, orientation, and velocity, as opposed to simply their natural, circular motion—leads him to posit some physical variation in the aether. In *Planetary Hypotheses* 2.5, Ptolemy explains that this variation is not in density, as one might suppose in order to explain the spheres’ poles, which he rejects. Rather, the aether varies in power. The
stars are ensouled, as the Platonic tradition claims, and, by means of the stars’ powers, the spheres move voluntarily. No doubt Ptolemy states here, as he does in the *Tetrabiblos*, that the stars and planets have *dunameis*. While in the *Tetrabiblos* he describes celestial *dunameis* as affecting sublunary bodies, in the *Planetary Hypotheses*, these *dunameis* cause and direct the movements of the aethereal spheres. In *Planetary Hypotheses* 2.3, Ptolemy asserts that each unique, heavenly body has its own motion, which is caused by the power of the planet or star(s) directing it. According to *Planetary Hypotheses* 2.5, these powers maintain the stars’ and planets’ rays. Again, if one draws a parallel between Ptolemy’s language in the *Tetrabiblos* and *Planetary Hypotheses*, one may assume that in the latter Ptolemy refers to the rays (ἀκτίνες) which he posits in the former. In *Planetary Hypotheses* 2.3, he explains that the power of celestial bodies disperses, by means of rays, and permeates bodies, presumably aethereal and sublunary, without the rays being hindered or influenced in any way. These rays permeate bodies in the same way that the human soul’s powers of sight and intellect permeate and cause movements in human bodies. Thus, Ptolemy’s physical account of the aethereal spheres is animistic.

In order to advance an animistic theory of celestial physics, Ptolemy finds it necessary to disprove a mechanistic account. While in *Planetary Hypotheses* 2.1, he claims that his present task is not to correct the *hypotheseis* of the ancients, he devotes a considerable portion of the first part of Book 2 to disproving Aristotle’s mechanical model of the heavenly spheres, as conveyed in *Metaphysics* Lambda 8. In *Planetary Hypotheses* 2.5, Ptolemy cites Aristotle by name and attributes to him the theory that the motion of the heavenly spheres has its cause in the spheres’ poles, which are fixed on the spheres surrounding them. Indeed, Aristotle mentions the poles

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167 See Plato *Timaeus* 38e-42e; *Epinomis* 982c-984b.
(πόλοι) of the several heavenly spheres in *Metaphysics* Α8.1073b. Rejecting the view that the poles cause the spheres’ rotation, Ptolemy argues that it is not only unnecessary to account for the spheres’ rotation in terms of poles, but it is also impossible to give an account of poles which is consistent with the principles of celestial physics and explains how the poles differ from the spheres, how they are physically attached to the spheres, and how they cause the spheres’ motion.

After rejecting poles as in any way significant in celestial physics, Ptolemy is able to posit aethereal bodies that do not have poles. These bodies are the sawn-off pieces he introduces in *Planetary Hypotheses* 2.4. Having discussed the physical nature of the aether in 2.3, in this chapter he moves on to a mathematical consideration of the aethereal bodies and lists their various shapes. He claims that two possible kinds of aethereal bodies exist, and these two kinds are capable of producing the same phenomena. The first kind is the complete sphere, which is either hollow, like the spheres that surround other spheres or the earth, or solid, like the epicyclic spheres. The second kind is a thin, equatorial section of a sphere, or a sawn-off piece. Like a complete sphere, a sawn-off piece is either solid or hollow. When solid, its shape is that of a tambourine; when hollow, its shape is similar to a bracelet or a whorl. While Ptolemy cites Aristotle when rejecting the theory of heavenly poles, Ptolemy cites Plato when accepting the theory of heavenly whorls. Plato explicates his model of the cosmological whorl in *Republic* 10:

> The nature of the whorl was this: Its shape was like that of an ordinary whorl, but, from what Er said, we must understand its structure as follows. It was as if one big whorl had been made hollow by being thoroughly scooped out, with another smaller whorl closely fitted into it, like nested boxes, and there was a third whorl inside the second, and so on, making eight whorls altogether, lying inside one another, with their rims appearing as circles from above, while from the back they formed one continuous whorl around the spindle, which was driven through the center of the eighth.\(^{168}\)

\(^{168}\) Plato *Republic* 616c-d, trans. G.M.A. Grube.
Having rejected the mechanistic, Aristotelian theory that poles cause the spheres’ rotation, Ptolemy adopts a Platonic account of heavenly bodies, wherein some of these bodies, namely the sawn-off pieces, do not have poles. In other words, not only do the sawn-off pieces rotate independently of any mechanistic cause such as the poles would provide, but these pieces, as thin, equatorial sections of spheres, do not even have a place where the poles would reside.

In addition to critiquing Aristotle’s poles, Ptolemy rejects Aristotle’s model of counter-rolling spheres. In *Metaphysics* Lambda 8, Aristotle argues that because the outer heavenly spheres cause the inner spheres to rotate, counter-rolling spheres must exist in order that the movements of the spheres only affect the planet to whose system they belong. After presenting Eudoxus’ and Callippus’ models, Aristotle puts forward his argument for counter-rolling spheres:

But it is necessary, if all the spheres combined are to explain the phenomena, that for each of the planets there should be other spheres (one fewer than those hitherto assigned) which counteract those already mentioned and bring back to the same position the first sphere of the star which in each case is situated below the star in question; for only thus can all the forces at work produce the motion of the planets.169

In *Planetary Hypotheses* 2.5, Ptolemy cites Aristotle by name and asserts that counter-rolling spheres do not exist because they are unnecessary explanatory devices, which, in fact, do not explain the movements of the planetary spheres. According to *Planetary Hypotheses* 2.6, not only is it impossible to deduce a mechanistic cause of the counter-rolling spheres’ rotation, but, even more problematically, these spheres do not contribute to the observable movements of celestial bodies. Ptolemy explains in chapter 2.5 that the theory of counter-rolling spheres assumes that aethereal bodies are like sublunary bodies, in that obstacles may hinder and affect

their movement. In opposition to this assumption, he reaffirms that superlunary nature is different in essence and effect from the sublunary. The aether’s motion is unobstructed, and aethereal bodies do not hinder each other’s movement. Because they do not hinder one another, the natural philosopher need not posit the existence of counter-rolling spheres.

Ptolemy’s argument against counter-rolling spheres emphasizes the physical distinction between sub- and superlunary bodies. As in *Almagest* 13.2, he declares repeatedly in the first part of *Planetary Hypotheses* 2 that one should not infer the nature and effects of heavenly bodies from the corresponding properties of sublunary bodies. Yet, in *Planetary Hypotheses* 2, he uses several analogies which describe heavenly phenomena in terms of sublunary bodies. Murschel observes this apparent inconsistency in her article “The Structure and Function of Ptolemy’s Physical Hypotheses of Planetary Motion.” She states, “Nevertheless, Ptolemy also uses terrestrial examples to explain the structure of the heavens….Notwithstanding his criticism of the Peripatetics, Ptolemy himself apparently believed his analogies to be free from the dangers of imposing any sort of terrestrial physicality on the heavens.”170 Ptolemy, however, does not use analogies in the same way as the philosophers he criticizes. He argues that these philosophers use sublunary analogies in order to infer the physical properties of heavenly bodies. Ptolemy, on the other hand, only uses sublunary analogies once he has already deduced his physical *hypothesis* from the general principles of superlunary physics he outlines in *Planetary Hypotheses* 2.3.

For instance, in *Planetary Hypotheses* 2.5, Ptolemy argues that aethereal bodies do not vary in density. He contends that if the poles, which Aristotle posits, differed from the spheres surrounding them in density, then the aether that composed them would sink and move rapidly

170 Murschel, 38.
toward the center of the cosmos. In other words, this variance in density would cause the denser, and therefore more heavy, aether to have a natural motion downward toward the center of the cosmos. Only once Ptolemy has established that the aether must have uniform density does he proceed to offer three mundane analogies. First, he mentions birds as an example of bodies which move at high elevations; however, he admits that birds are not a perfect analogy for aethereal bodies because, unlike the latter, they differ from their environment in density. Nevertheless, Ptolemy mentions two sets of mundane bodies that, unlike birds, do not vary in density from their surroundings. In dry weather, clouds differ from the air surrounding them only in color, and two liquids that have the same density may vary only in color, like the clouds in the atmosphere. Hence, after arguing that the aether has a uniform density, Ptolemy presents three mundane analogies to illustrate this property of superlunary bodies.

Similarly, in *Planetary Hypotheses* 2.3, Ptolemy compares the aethereal spheres to the parts of a universal animal. He first states that stars move the aethereal spheres by means of their powers, presumably *dunameis*. Having proclaimed that the cause of the aethereal bodies’ motion is animistic, he then introduces the analogy between the heavens and an entire, or universal animal (*al-hayawân al-kullî*). This analogy between the cosmos and an animal was standard in ancient Greek philosophy. For instance, in the *Timaeus*, Plato portrays the cosmos as a living thing, which encompasses all other living things. Timaeus states the following:

> Rather, let us lay it down that the world resembles more closely than anything else that Living Thing of which all other living things are parts, both individually and by kinds. For that Living Thing comprehends within itself all intelligible living things, just as our world is made up of us and all the other visible creatures. Since the god wanted nothing more than to make the world like the best of the intelligible things, complete in every way, he made it a single visible living thing, which contains within itself all the living things whose nature it is to share its kind.171

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171 Plato *Timaeus* 30c-31a, trans. Donald J. Zeyl.
Plato depicts the cosmos as a living thing, or an animal (ζῶν), and he describes it in animistic terms. It has a soul, the world soul, composed of Being, the Same, and the Different.\textsuperscript{172} Aristotle uses this same analogy of the animated heavens in \textit{De caelo} 2.2. Commenting on the Pythagorean convention of assigning a left and a right side to the heavens—which Aristotle identifies with the cosmos in this passage\textsuperscript{173}—he explains that, in order to assign directionality to any object, one must compare the objects’ movements to animal motion. Aristotle asserts, “As for our own position, we have already decided that these functions are found in whatever contains a principle of motion, and that the heaven is ensouled (ἐνσώματος) and contains a principle of motion, so it is clear that the heaven possesses both upper and lower parts, and right and left.”\textsuperscript{174} Thus, Ptolemy adopts a common analogy in describing the heavens as an animal, and he introduces this analogy after asserting that the aethereal spheres move by means of animistic causes.

In order to illustrate how celestial bodies’ powers control the movements of the aethereal spheres by means of rays, in \textit{Planetary Hypotheses} 2.7 Ptolemy compares the spheres’ movements to the motion of a flock of birds. He has already used a bird analogy when describing the relation of poles to the aethereal spheres in chapter 2.5. Here, in chapter 2.7, Ptolemy discusses the individual movements involved in the resultant motion of both birds and aethereal spheres. To begin with, he proclaims that this analogy which compares birds to heavenly bodies is a common analogy. Like the portrayal of the heavens as an animal, the

\textsuperscript{172} Plato \textit{Timaeus} 35a.

\textsuperscript{173} In \textit{De Caelo} 1.9, Aristotle delineates three meanings of οὐρανός, the last of which is the cosmos as a whole, τὸ πᾶν. In \textit{De Caelo} 2.2, amidst his discussion of directionality in the heavens (οὐρανός), he mentions the shape of the whole: τὸ σχῆμα τοῦ παντός. Therefore, in \textit{De Caelo} 2.2, Aristotle seems to be using οὐρανός to signify the cosmos as whole.

juxtaposition of heavenly bodies and birds appears in Plato’s *Timaeus*. After labeling the cosmos a living thing, Timaeus lists the four types of living creatures in the cosmos: “Now there are four of these kinds: first, the heavenly race of gods; next, the kind that has wings and travels through the air; third, the kind that lives in water; and fourth, the kind that has feet and lives on land.” One type of animal exists in relation to each of the four elements. In relation to fire and air, the two, outermost elements, the living beings residing in the heavens are the celestial bodies, or gods, and the animals flying through the air are winged animals, or birds. Timaeus again mentions birds near the end of the text. Examining the metempsychosis of human souls into animals, he explains, “As for birds, as a kind they are the products of a transformation. They grow feathers instead of hair. They descended from innocent but simpleminded men, men who studied the heavenly bodies but in their naivety believed that the most reliable proofs concerning them could be based upon visual observation.” In other words, astronomers who limit their understanding to the visual observations of heavenly bodies, rather than knowledge of the Forms, are reborn as birds. Hence, Plato associates birds, as the occupants of the atmosphere, with heavenly bodies, and Ptolemy appropriates this analogy for his own use in the *Planetary Hypotheses*.

In chapter 2.7, Ptolemy explicates how the movement of a bird, within a flock of birds, comes about. The movement has its source in the bird’s vitality, and from this vitality arises an impulse. This impulse moves the bird’s nerves, and the nerves move the bird’s feet or wings. The movement comes to an end at the bird’s extremities, as the impulse involved in the bird’s motion does not affect the air surrounding the bird or the other birds in the flock. Ptolemy explains that a planet’s system of aethereal spheres functions in the same way. Each celestial

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175 Plato *Timaeus* 39e-40a, trans. Donald J. Zeyl.
176 Ibid. 91d-e.
body is animated and moves itself as well as the spheres in its system. By means of rays, a planet moves the aethereal body closest to it, or the epicycle. Then it moves the eccentric body and the body whose center point is the center of the cosmos as a whole. Each aethereal body has its own movement, just as the various powers in animals have their own movements. In human beings, the power of the intellect differs from the power of impulse, and these powers are distinct from the powers of the nerves and feet.

Ptolemy’s opposition of the powers of the intellect and impulse in Planetary Hypotheses 2.7 recalls his model of the human soul in On the Kritêrion. As explained above, according to On the Kritêrion, the human soul has three faculties: the faculties of thought (διανοητικόν), sense perception (αἰσθητικόν), and impulse (ὀρμητικόν). The juxtaposition of the intellectual and impulsive powers in the Planetary Hypotheses suggests that in this text Ptolemy is contrasting the first faculty of the soul—labeled variously as the intellectual part, the rational part, and the faculty of thought in the Harmonics and On the Kritêrion—with the third, lowest faculty of the soul, the faculty of impulse portrayed in On the Kritêrion. In the Planetary Hypotheses, Ptolemy lists these two powers among the powers, psychic and somatic, of animals, and he compares them to the powers of celestial bodies. As stated earlier, in Planetary Hypotheses 2.3, he claims that the rays, emanating from celestial bodies and maintained by their powers, disperse through bodies in the same way that the powers of sight and intellect move through the human body. In comparing celestial powers and rays to the human powers of intellect, sight, and impulse, Ptolemy suggests that celestial bodies have the same three psychic faculties—thought, perception, and impulse—as attributed to human souls in On the Kritêrion.

The principal function of these celestial powers is to initiate and maintain the voluntary movement of the aethereal spheres. In Planetary Hypotheses 2.3, Ptolemy ascribes reason and
desire to the aether and declares that the aether experiences no shifting or change in intent, which would alter its uniform, circular motion. Hence, Ptolemy describes celestial bodies as ensouled as well as desiring. Considering that Ptolemy accepts Aristotle’s Prime Mover, as I argue in Chapter 2, it is plausible to assume that the ensouled celestial bodies of the *Planetary Hypotheses* move uniformly and circularly because of their desire for the Prime Mover. After all, the Prime Mover acts as a final cause in Aristotle’s *Metaphysics* Lambda, and, if Ptolemy accepted Aristotle’s notion of the Prime Mover, as *Almagest* 1.1 and *Optics* 2.103 indicate, then it is consistent to conclude that the Prime Mover acts as the final cause of aethereal motion in Ptolemy’s cosmology. In her analysis of the *Planetary Hypotheses*, Murschel claims that Ptolemy rejected the Prime Mover: “He also ridicules the Aristotelian notion of the prime mover. Ptolemy, like Aristotle, maintains that motion is transmitted by contact, yet the prime mover touches only the outermost of all the celestial bodies. Thus, only the outermost sphere would rotate with its proper motion, because it could hardly transmit their own particular motions to the other celestial bodies.”

Liba Taub expresses a similar view in *Ptolemy’s Universe*: “In chapter five, Ptolemy implicitly argued against Aristotle’s Unmoved Mover as well, restating that the source of the motion of the spheres lies within the spheres themselves.” Ptolemy does dismiss the idea that the Prime Mover acts as an efficient or mechanistic cause of aethereal motion, but he does not reject the possibility of its role as a final cause. Moreover, Ptolemy’s descriptions of the Prime Mover in *Almagest* 1.1 and *Optics* 2.103 demonstrate that he believed that the Prime Mover exists. To posit the Prime Mover’s role as a final cause of heavenly motion in Ptolemy’s

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177 Murschel, 39.
178 Taub, 116.
cosmology elucidates why he describes it as “the first cause of the first motion of the universe” \(^{180}\) in the *Almagest* as well as “that which moves first” \(^{181}\) in the *Optics* but rejects a mechanistic account of the aethereal bodies’ movements. Furthermore, Ptolemy’s ascription of souls to celestial bodies may serve to explain how it is that stars and planets desire the Prime Mover. Aristotle states in the *De Anima* that desire is a function of the parts of the soul \(^{182}\) and that every desire must be for the sake of something. \(^{183}\) Accordingly, the celestial bodies’ desire must be for the sake of some end, such as the Prime Mover.

Several of the arguments and styles of argumentation Ptolemy advances in the *Planetary Hypotheses* are evident in his other texts. For instance, after presenting his latitude theory in *Almagest* 13.2, Ptolemy denounces the use of mundane analogies as the bases of *hypotheseis* of heavenly phenomena. When making this argument, as in the *Planetary Hypotheses*, he depicts the physical nature of sub- and superlunary bodies as different in kind:

> Now let no one, considering the complicated nature of our devices, judge such *hypotheseis* to be over-elaborated. For it is not appropriate to compare human [constructions] with divine, nor to form one’s beliefs about such great things on the basis of very dissimilar analogies. For what [could one compare] more dissimilar than the eternal and unchanging with the ever-changing, or that which can be hindered by anything with that which cannot be hindered even by itself? \(^{184}\)

As in the *Planetary Hypotheses*, Ptolemy contrasts the aether—the eternal, unchanging element, whose bodies do not hinder one another—to the four sublunary elements, which can be hindered and, as a result, are ever-changing. Having reiterated this distinction between superlunary and sublunary elements, Ptolemy asserts that it is best to construct and use the simplest *hypotheseis* of heavenly phenomena possible. While his latitude theory, especially, appears unduly

\(^{180}\) Ptolemy *Almagest* 1.1, H5, trans. G.J. Toomer.

\(^{181}\) Ptolemy *Optics* 2.103.

\(^{182}\) See Aristotle *De Anima* 432b3-8.

\(^{183}\) Ibid. 433a15-16.

\(^{184}\) Ptolemy *Almagest* 13.2, H532, after G.J. Toomer.
complicated, he argues that the judgment of what is simple is different according to whether one judges superlunary or sublunary phenomena. Because the aether experiences no hindrance, the aethereal spheres glide past one another without hindering one another’s motion. Sublunary instruments meant to represent heavenly movements, however, cannot demonstrate this lack of friction, because the instruments’ parts hinder one another’s motion. Consequently, Ptolemy proclaims the following:

Rather, we should not judge ‘simplicity’ in heavenly things from what appears to be simple on earth, especially when the same thing is not equally simple for all even here. For if we were to judge by those criteria, nothing that occurs in the heavens would appear simple, not even the unchanging nature of the first motion, since this very quality of eternal unchangingness is for us not [merely] difficult, but completely impossible. Instead [we should judge ‘simplicity’] from the unchangingness of the nature of things in the heaven and their motions. In this way all [motions] will appear simple, and more so than what is thought ‘simple’ on earth, since one can conceive of no labor or difficulty attached to their revolutions.185

Hence, in Almagest 13.2, Ptolemy argues against using mundane analogies when constructing hypotheseis of heavenly phenomena, he insists that these hypotheseis should be the simplest possible, he reiterates the physical distinction between super- and sublunary elements, and he claims that, because of this distinction, simplicity in the heavens differs from simplicity in the sublunar realm.

Ptolemy also demonstrates this preference for simplicity—and the economy of nature, in particular—in the Planetary Hypotheses. As stated above, he posits the existence of sawn-off pieces, as well as complete spheres, in the heavens. In chapter 2.6, he argues that, despite the mathematical equivalence of the two models, it is preferable to assume that other than for the sphere of fixed stars—which must be a complete sphere, because the stars are visibly scattered around the entire sphere—the remaining aethereal bodies which enact the planets’ movements

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185 Ibid., H533-534.
are sawn-off pieces. To hypothesize that complete spheres, gigantic in size as they must be, rotate through the heavens in order to produce the movement of the planets is senseless and useless. To hypothesize that only equatorial sections of these spheres move, however, reduces the amount of aether that must move in order to produce each planets’ movements. As a result, this model is simpler. According to the conclusion of *Planetary Hypotheses* 2, sawn-off pieces are “the better and the natural” choice.\(^\text{186}\) While Ptolemy’s preference for simplicity recalls his argument in the *Almagest* for utilizing the simplest hypotheses, his preference for a natural model recalls his predilection in the *Tetrabiblos* for natural theories and methods.

Ptolemy also tries to eliminate useless aspects of his models for the sake of economy when establishing the order of the planets. In particular, he argues that Mercury and Venus lie between the moon and sun, even though, as he admits in *Almagest* 9.1, no observations had yet been made of their, or any other planet’s, occultation of the sun. Ptolemy presents the same planetary order in the *Planetary Hypotheses* as in *Almagest* 9.1. In the latter, the only argument he advances in support of the order is aesthetic. If Mercury and Venus lie between the moon and sun, then the sun will separate those planets which always remain in its vicinity, or Mercury and Venus, from the planets which are observed to have any elongation. In *Planetary Hypotheses* 1, Ptolemy adds that, according to this order, the two celestial bodies with the most complicated astronomical models, or Mercury and the moon, are adjacent. Hence, the two most complicated aethereal systems lie closest to the sublunary sphere of ever-changing bodies, while the simplest system, the spheres enacting the movements of the fixed stars, resides at the periphery of the cosmos. Ptolemy introduces further evidence for this planetary order with his model of nested spheres. According to this model, the minimum absolute distance of a planet’s aethereal system

\(^{186}\) Murschel, 51.
is equal to the maximum distance of the planet’s system lying below it, or the next system that is
closer to the earth. As a result, each planetary system is adjacent to the next, and no gaps exist
among the spheres enacting the planets’ movements. If one places Mercury and Venus above the
sun, so Ptolemy argues, a large space of seemingly useless aether would reside in a gap between
the moon’s and sun’s systems. By placing Mercury and Venus between the moon and sun,
however, Ptolemy eliminates this gap and maintains his hypothesis of nested spheres. In
Planetary Hypotheses 2.6, Ptolemy revisits this choice to place Mercury and Venus between the
moon and sun, and he affirms that this model of the planets’ order eliminates gaps in the aether
which would be useless, as if forgotten and deserted by nature.

Ptolemy also demonstrates his desire for an economical model in his polemic against
Aristotle’s counter-rolling spheres. Again, in chapter 2.5, he remarks that the counter-rolling
spheres do not account for the motions of the planets; rather, they merely counteract other
spheres’ motions in a mechanical model. Because Ptolemy’s cosmological model explains the
heavens’ motion animistically, the counter-rolling spheres become superfluous and he rejects
them. In chapter 2.6, Ptolemy observes that the same foolishness, which results from positing
gaps between planetary systems, arises from positing counter-rolling spheres. After all, these
spheres are unnecessary for the planets’ movements, and they needlessly increase the number of
spheres residing in the heavens as well as the size of the heavens overall. In Metaphysics
Lambda.1074a, Aristotle declares that, with the counter-rolling spheres, the heavens consist of up to
fifty-five spheres. In the Planetary Hypotheses, Ptolemy posits the existence of either forty-one
spheres, if each aethereal body is a complete sphere, or twenty-nine aethereal bodies, if the
heavens consist of complete spheres as well as sawn-off pieces and the body of loose aether,
which remains after the complete spheres have been truncated into sawn-off pieces.\(^\text{187}\) Hence, Ptolemy’s penchant for economy led him to advance a model with nearly half the number of aethereal bodies as Aristotle’s model of the heavens.

Murschel argues that, despite Ptolemy’s stated preference for economy, certain spheres in his model—namely, the movers, which enact each planet’s diurnal rotation—are useless. She bases her argument on Ptolemy’s incorporation of mechanistic causation in his model. Under certain circumstances, an aethereal sphere may move another. Murschel lists two such circumstances: “(1) a spherical body will move another spherical body lying within it if their mathematical axes are \textit{not} collinear; (2) a spherical body may be moved by another, larger spherical body if it is entirely contained within the latter, just as, for instance, an epicycle is entirely enclosed in its deferent shell or a planet in its epicycle.”\(^\text{188}\) Murschel deduces from these two principles of mechanistic causation that the mover of the sphere of fixed stars should cause all of the spheres below it, whose axes are not collinear with it, to rotate diurnally. She declares the following:

Since no other body other than a mover shares its axis with the axis of the outermost sphere, every body in the celestial region must necessarily experience daily rotation regardless of the individual movers. Ptolemy certainly recognized that his physics could accommodate the diurnal rotation without the planetary powers, but he does not provide an explanation for their inclusion.\(^\text{189}\)

In making this argument, Murschel forgets that Ptolemy explains in \textit{Planetary Hypotheses 2.7} that, as in flocks of birds, the powers of celestial bodies affect neither their environment nor the movements of bodies outside their systems. In other words, just as the impulse which causes a bird’s wings to fly does not affect the air through which it flies nor the flight of another bird, a

\(^{187}\) Ibid., 50.

\(^{188}\) Ibid., 41.

\(^{189}\) Ibid., 43.
celestial body’s rays do not cause spheres in other planetary systems to rotate. Therefore, Ptolemy must include movers in his planetary systems, because his model is thoroughly animistic. Each planet needs a mover, because the movements of the fixed stars’ spheres do not cause the rotation of any other planet’s spheres. Thus, Ptolemy’s model of twenty-nine aethereal bodies—including complete spheres, sawn-off pieces, and loose aether—is the simplest and most economical model possible given the principles of his superlunary physics.

4.6 Conclusion

In both the *Tetrabiblos* and *Planetary Hypotheses* 2, Ptolemy echoes his claim in *Almagest* 1.1 that physics is conjectural but the application of mathematics to physics produces significant results. In his natural philosophical investigations, Ptolemy applies geometry to element theory, harmonics to astrology and psychology, and astronomy to astrology and cosmology. As a consequence of this scientific method, at least in the case of his psychological models, Ptolemy distorts the physical data in order to fit it to the mathematical model. Many of the changes he makes in his psychological model from *On the Kritêrion* to the *Harmonics* result from his application of harmonics to psychology. In order that the human soul’s parts have the same number of species as the homophone and concords, Ptolemy manipulates which faculties of the soul count as species of the various parts. Presumably because he does not apply any branch of mathematics to psychology in *On the Kritêrion*, his description of the soul’s faculties in this text represents an empirically based model, founded, so he claims, on the observation of the movements the soul causes in the body. The question naturally arises, then, as to why Ptolemy does not apply mathematics to physics in *On the Kritêrion*. In every other text where he studies physical objects, he describes the phenomena first in mathematical terms before characterizing
the objects physically. Given that his description of physics as conjectural and dependent on mathematics is consistent through the rest of his corpus, the most plausible explanation of this methodological deviation of *On the Kritêrion* is chronological. *On the Kritêrion* appears to be Ptolemy’s earliest extant text. Therefore, he does not apply any branch of mathematics to psychology in it, because he had not yet devised the scientific method he follows in the remainder of his corpus. In every other text, Ptolemy treats mathematics alone as productive of knowledge—whether absolute or qualified—and physics as dependent, in theory and practice, on mathematics.
Chapter 5

Conclusion

In the introduction to the *Almagest*, Ptolemy makes a claim unprecedented in the history of ancient Greek philosophy. He declares that physics and theology are conjectural and mathematics alone yields sure and incontrovertible knowledge. This claim derives from his general philosophical stance. Recent scholars have labeled Ptolemy an eclectic,¹ and, indeed, this label accurately reflects his appropriation of Platonic, Aristotelian, and to a lesser extent, Stoic and Epicurean ideas. Eclecticism was common in the second century, and Ptolemy’s eclecticism is consistent with the philosophical approach of Middle Platonic philosophers and Aristotelian commentators. Nevertheless, simply calling Ptolemy an eclectic does not do justice to the originality of his contribution. The components of his philosophical theories derive from his predecessors, but the manner in which he blends and applies these ideas in his scientific practice is extraordinary. Therefore, a more fitting description of Ptolemy’s philosophy is one that evokes his philosophical heritage as well as his originality. The appellation I would like to offer is ‘Platonic empiricism’. At the foundation of Ptolemy’s scientific method is his criterion

of truth, grounded in what later came to be labeled empiricism and designed to differentiate opinion from knowledge, a distinction which he expresses in Platonic terms. This criterion serves as the means by which Ptolemy categorizes every object in the cosmos, determines the epistemic success of the theoretical sciences, and establishes a scientific method aimed at producing knowledge.

In *Almagest* 1.1, Ptolemy invokes Aristotle by name and appropriates his tripartite division of theoretical philosophy into the physical, mathematical, and theological. Ptolemy’s definitions of the three theoretical sciences, while not Aristotle’s, are still Aristotelian. He defines the sciences by describing which set of objects existing in the cosmos each science studies, and he defines these sets by means of epistemic criteria derived from Aristotle’s theory of perception. How and whether an object is perceptible determines which science studies it. In *Almagest* 1.1, Ptolemy portrays physical objects as material qualities existing mainly in the sublunary realm. His examples of these qualities are ‘white’, ‘hot’, ‘sweet’, and ‘soft’. Each is perceptible by only one sense and, as such, is classifiable as a special-object in Aristotle’s theory of perception. Ptolemy’s mathematical objects, on the other hand, are common-objects, perceptible by more than one sense. He lists the subject matter of mathematics as forms and motion from place to place as well as shape, number, size, place, time, etc. Unlike physical and mathematical objects, the object of theology, the Prime Mover, is imperceptible. While Aristotle defines the objects of the sciences according to their share in two ontological dichotomies—whether they are separate or inseparable, and whether they are movable or immovable—Ptolemy employs a single, epistemological criterion: whether and how the objects are perceptible.

Ptolemy’s characterization of physics, mathematics, and theology is not limited to *Almagest* 1.1. Concerning theology, his reference to the Prime Mover in *Optics* 2.103 and his
rejection of mechanical causation in the heavens as well as his portrayal of desiring celestial souls in the *Planetary Hypotheses* indicate that Ptolemy appropriated Aristotle’s notion of the Prime Mover. For Ptolemy, as for Aristotle, the Prime Mover is the final cause of aethereal bodies’ motion, and, in this way, it is “the first cause of the first motion of the universe.”2 As imperceptible, the Prime Mover is ungraspable. Yet, through the application of mathematics, and astronomy in particular, one can make a good guess at its nature. The astronomer makes an inference from his observation of celestial bodies. While celestial bodies are eternal and unchanging, inasmuch as the only change they experience is periodic movement from place to place, the Prime Mover is eternal and unchanging in an absolute sense. In proposing that it is possible to infer the nature of a metaphysical object, in this case the Prime Mover, from the study of heavenly bodies, Ptolemy adheres to the tradition following *Republic* 7, wherein Socrates argues that the study of astronomy guides the philosopher-king towards understanding of metaphysical reality.

Concerning physics, Ptolemy echoes his claim in *Almagest* 1.1 that physics is conjectural in both the *Tetrabiblos* and the *Planetary Hypotheses*. In *Tetrabiblos* 1.2, he declares that any field of inquiry that investigates the quality of matter is conjectural, and in *Planetary Hypotheses* 2.2 he describes his cosmological account as hypothetical rather than certain. Despite the inherent epistemological limitation of physics, the natural philosopher is able to produce significant results through the application of mathematics. In *Almagest* 1.1, Ptolemy asserts that mathematics can contribute significantly to physics, and he demonstrates this claim in his many texts by applying geometry to element theory, harmonics to psychology and astrology, and astronomy to astrology and cosmology. The only natural philosophical text in which Ptolemy

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does not employ this method is *On the Kritêrion and Hêgemonikon*. I argued in Chapter 4 that the reason for this variance is chronological. After all, it is probable that *On the Kritêrion* is one of the earliest—perhaps the earliest—of Ptolemy’s extant texts. As a result, Ptolemy does not apply harmonics, or any other branch of mathematics, to psychology in *On the Kritêrion* as he does in the *Harmonics* because, at the time of writing *On the Kritêrion*, he had not yet formulated this scientific method. Once he embraced the notion that physics is conjectural and dependent on mathematics to produce significant results, he applied harmonics to psychology, as he does in the *Harmonics*. This application forced Ptolemy to manipulate his model of the human soul in order that the faculties he describes in *On the Kritêrion* translate to the correct number of species in a harmonic model. Therefore, at least in the case of his psychological models, Ptolemy’s scientific method forced him to manipulate data to fit the model.

Ptolemy claims in *Almagest* 1.1 that mathematics, unlike theology and physics, yields sure and incontrovertible knowledge. Nevertheless, his practice of mathematics in his texts reveals a more nuanced position. While the *Harmonics* indicates that Ptolemy believed in the truth and precision of his harmonic models, he divulges in *Almagest* 3.1 that, though he believed that his astronomical hypotheses were as precise as possible, he considered only certain aspects of the hypotheses to be true. Ptolemy provides empirical and dialectical arguments confirming the existence of eccentric and epicyclic spheres in the heavens; however, the exact periods of these spheres, so he argues, are unknowable. These data depend solely on observation, and observation, according to Ptolemy, is inherently subject to a degree of error. He explains in the *Harmonics* that observation relies on reason for accuracy, and, without reason, perceptions are rough and approximate rather than precise and true. Consequently, because Ptolemy’s criterion of truth depends on the interplay of reason and perception, he considers only those hypotheses
constructed from this interplay to be true. He deems his harmonic *hypothesēs* as well as his *hypothesēs* of the eccentric and epicyclic spheres true, because both reason and perception contribute to their formulation. In addition, these true *hypothesēs* derive from an indisputable mathematical tool. Harmonics utilizes arithmetic ratios, and the eccentric and epicyclic spheres that Ptolemy posits in his astronomical *hypothesēs* employ geometry. Accordingly, *hypothesēs*’ dependence on an indisputable mathematical tool corresponds to their claim to truth.

Conversely, because the periods of celestial phenomena are determinable by means of only observation, without the guidance of reason or geometry, they are subject to a degree of error and, therefore, are knowable only to an approximate degree.

For Ptolemy, the study of astronomy is ultimately an ethical endeavor. He begins *Almagest* 1.1 with a justification for devoting most of his time to the study and teaching of theoretical philosophy, and mathematics in particular. He concludes the chapter with a proclamation of the merits of studying and teaching astronomy. Hence, an ethical motive underlies the practice of astronomy. Ptolemy delineates astronomy’s ethical benefits in the following:

> With regard to virtuous conduct in practical actions and character, this science, above all things, could make men see clearly; from the constancy, order, symmetry and calm which are associated with the divine, it makes its followers lovers of this divine beauty, accustoming them and reforming their natures, as it were, to a similar spiritual state. It is this love of the contemplation of the eternal and unchanging which we constantly strive to increase, by studying those parts of these sciences which have already been mastered by those who approached them in a genuine spirit of enquiry, and by ourselves attempting to contribute as much advancement as has been made possible by the additional time between those people and ourselves.³

³ Ibid., H7-8.

Astronomy is ethically beneficial more than any other science because of its epistemic value. When practiced skillfully and rigorously, astronomy, as a branch of mathematics, produces
knowledge, whether qualified or absolute. What distinguishes it from the other branches of mathematics is its object of study; it is the only branch that examines objects which are eternal and relatively unchanging. As such, aethereal bodies are divine and characterized by ethically virtuous qualities, such as constancy, symmetry, order, and calm. By studying aethereal bodies, astronomers are able to model their behavior on the intelligible divine—as opposed to the conjectural divine, or the Prime Mover. Thereby, they reform their nature to a spiritual state similar to the heavenly one, perhaps that of celestial souls.

In *Ptolemy’s Universe*, Liba Taub identifies the Platonic roots of Ptolemy’s ethical motivation for studying astronomy. She traces elements of his ethical statement to three of Plato’s texts: the *Symposium*, *Republic*, and *Theaetetus*. In relation to the *Symposium* and the *Republic*, Taub emphasizes Ptolemy’s devotion to the study and teaching of beautiful theories:

Ptolemy’s stated intention to devote himself to the teaching of beautiful theories, with a view to achieving a noble and orderly condition, recalls the views expressed by Diotima. A similar idea is expressed in the *Republic*, in the description of the ascent from the Cave by the would-be philosopher-rulers. Those who have succeeded in the training so far will be brought to the final goal, the ordering of the state and the education of others. Not only must the philosopher discern Beauty for himself, he must teach it to others as well.4

I explained in Chapter 3 that Ptolemy’s valuing of harmonic and astronomical objects as the most beautiful and rational in the cosmos stems from the tradition following *Republic* 7. Here Taub discerns that Ptolemy’s emphasis on the teaching as well as the study of these objects derives from the Platonic tradition. Furthermore, she stresses the influence of the *Theaetetus* on Ptolemy’s affinity for contemplating the divine. Commenting on the common ancient Greek philosophical practice of studying the divine in order to become godlike, Taub states, “This same ideal was spoken of by Socrates in the *Theaetetus* (176b), where he stated that man should

4 Liba Taub, *Ptolemy’s Universe: The Natural Philosophical and Ethical Foundations of Ptolemy’s Astronomy* (Chicago: Open Court, 1993), 32.
become as much like the divine as possible, and that this is accomplished by becoming righteous through wisdom.\textsuperscript{5} The main difference for Ptolemy, of course, is that wisdom is not of a theological object; it is the study of divine mathematical beauty that produces knowledge. While the Platonic tradition emphasized the utility of astronomy as a means for contemplating metaphysical reality, the Prime Mover for Ptolemy is ungraspable. Because it is imperceptible, even with the aid of mathematics, one can merely make a good guess at its nature. Therefore, only contemplation of the visible divine, aethereal bodies, furnishes the philosopher with a divine exemplar on which to model his behavior. Observation of the constancy, order, symmetry, and calm of celestial movements makes astronomers lovers of divine beauty. By modeling their behavior after the movements and configurations of heavenly bodies, astronomers conduct themselves virtuously and attain a state resembling the divine.

For Ptolemy, this virtuous state is a harmonious one. The best condition of the human soul is justice, and the condition of a philosopher as a whole is analogous to the *harmonia* of the complete *systêma* in music. Each part of the human soul has a series of virtues associated with it, and a philosopher applies these virtues in two domains: the theoretical and the practical. In *Harmonics* 3.6 as well as in *Almagest* 1.1, Ptolemy differentiates the theoretical and the practical. In the former, he divides each into three genera: the theoretical into the physical, mathematical, and theological, and the practical into the ethical, domestic, and political. The study and teaching of mathematics, and astronomy in particular, is the most ethically beneficial intellectual activity. As in the *Timaeus*,\textsuperscript{6} the analysis of celestial bodies’ harmonious motion brings about this same harmony within the astronomer’s soul. The astronomer, then, achieves an ethical and psychological transformation by conducting himself virtuously, according to the virtues

\textsuperscript{5} Ibid., 33.
\textsuperscript{6} See Plato *Timaeus* 47b-c, 90c-d.
associated with each part of the human soul. Thereby, he brings the parts of his soul into a harmonious arrangement. Thus, not only does the study of mathematics, such as astronomy, produce theoretical knowledge, whether absolute or qualified, but it also provides human beings with a practical exemplar for their ethical behavior. Astronomy, then, is, as Ptolemy affirms in *Tetrabiblos* 1.1, desirable in itself.
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