



Introduction

Overview of the Project

The main object of this book is to study how the understanding of physical motion in ancient Greek thought developed before and up to Aristotle. It investigates which logical, methodological, and mathematical foundations had to be in place to establish a fully fledged concept of motion that also allows for comparing and measuring speed.¹ Given that physical motion is the core concept of natural philosophy, this study thereby also seeks to reconstruct in rough outlines how natural philosophy came to be established as a proper scientific endeavour in ancient Greece.²

According to a prevailing picture, scientific investigation of physical motion and change started properly in the West with Aristotle but only achieved its true form in modern times, with the overthrow of central Aristotelian doctrines. In the early modern period, so runs the narrative, Aristotelianism was rejected and the basis laid for what today we consider the science of physics.³ This account is at least doubly misleading. Undoubtedly, great achievements were realised in early modern times, but if we take a step further back in history, we can also discern an alternative narrative. This broader perspective allows us to see, first, that Aristotle marked a high point in an extended investigation of motion that started a long time before him and, second, that when this earlier way of doing science is included in our perspective, there is strong continuity between Aristotle and modern natural philosophy and science. Many basic concepts that Aristotle introduced in reaction to earlier natural philosophy remain fundamental for how science is done today (for example, the idea that time and space can be treated as structured in similar ways). This continuity on the basic conceptual level is too often overlooked,

¹ I will only be able to cover some of these foundations of motion, by no means all of them. And these foundations are not necessarily explicitly formulated in the thinkers discussed, but sometimes only implicitly used.

² As a first pass we should understand natural philosophy as being concerned with the theoretical basis for doing physics in general. For a discussion of the notion of natural philosophy, see Chapter 1.

³ So, for example, Theodor Gomperz 1912, p. 108 and Alexandre Koyré 1968, pp. 90–1.

however, as a result of our focus on the important ‘paradigm shifts’ in the conception of nature that occurred after antiquity and mainly since the Renaissance.

Readers who do not follow the prevailing picture and do not think that scientific investigation of motion started only with Aristotle, holding that natural philosophy had already been established by the Presocratics, for example, may well wonder why I would even claim that it took until Aristotle for natural philosophy to be established as a ‘proper scientific endeavour’. We will see, however, that for the study of the natural realm to become what we might call a ‘scientific enterprise’,⁴ not only certain logical, ontological, and methodological developments were required but also the integration of central mathematical notions into philosophical discussion. These developments and this integration have become part of the fundamental framework with which we conceptualise nature as an object of science today, but they were first formulated in the way that is familiar to us by Aristotle.

The basic conceptual framework for natural philosophy was essentially shaped by the philosophers in the fifth and fourth centuries BCE on whom I will concentrate in this book: Parmenides of Elea and his fellow Eleatic Zeno, followed by the atomists Leucippus and Democritus, and finally Plato and Aristotle. For reasons of space I will have to leave out other important thinkers who contributed to the development of this framework in the period investigated, individuals such as Heraclitus, Empedocles, Anaxagoras, and Gorgias. Nor will there be space to look at the Milesian thinkers Thales, Anaximander, and Anaximenes, who endeavoured to explain natural phenomena in rational terms in a manner traditionally associated with the birth of both philosophy and science.

I begin with Parmenides for two reasons: first, Parmenides introduced strict criteria for philosophy and science that made them possible as truly rational endeavours;⁵ and, secondly, Parmenides was the first philosopher to develop a system of basic logical or conceptual tools that implicitly determine the domain of possible objects for rational inquiry.⁶ To begin with Parmenides means to begin with his questioning of the very possibility of natural

⁴ I will show what we may understand by a ‘scientific enterprise’ in Chapter 1.

⁵ Hence, we can say that Parmenides is also the first philosopher where we find second-order thoughts about philosophy, thoughts like ‘What counts as a proper inquiry and why?’ Kahn 1994 has argued for understanding Anaximander as the inventor of models of explanation and Gregory 2016 claims that we find such second-order thoughts also in Anaximander, for example, in the decisions he makes about what he takes as evidence. But this is implicit in Anaximander. There is no hint of any explicit discussion of such questions, as we find, I argue in the second chapter, for example, in Parmenides’ fragment 7.

⁶ I will explain in the first chapter what I understand by logical tools and the broad notion of logic at work here.

philosophy and science, however.⁷ In their response to this challenge, his successors laid the foundations for a scientific investigation of nature.

One centrally important criterion that Parmenides employed systematically is consistency. This requirement both imposed a central condition of rationality on inquiry into nature and became a central engine of Parmenides' challenge to the possibility of such rational enquiry. Parmenides and Zeno after him, through his generation of a series of well-known paradoxes, argue that motion, time, and space – essential to any science of nature – cannot be given accounts which satisfy the requirement of consistency. This is not to say that Parmenides or Zeno deny that we have experience of things as changing, enduring, and located. What they do deny, I argue, is that these phenomena that we experience are available for rational enquiry.⁸ Denying this possibility is the reason that Parmenides and Zeno end up creating important challenges for the development of a natural science. One crucial reason why Parmenides and Zeno cannot accommodate motion, time, and space within their requirement of consistency is that, as I will demonstrate, the logical framework they established, though an important start, is too narrow to form a basis for natural science.

The next act in the story I reconstruct thus calls for significant expansion of this underlying methodological and logical framework. This takes place, I argue, in two separate stages. On the one hand, the logical apparatus and the criteria for philosophy themselves are expanded by distinctly articulating aspects that were run together in Parmenides.⁹ On the other hand, mathematical concepts begin to be imported into this logically inspired framework, as a result of recognising that Parmenides' conceptual framework on its own cannot give us the terms we need for an analysis of nature. First in the work of the atomists and later in Plato's *Sophist* we find the necessary expansion of the underlying logical and methodological framework that allows for the development of a natural science and philosophy. However, only once this development is combined with mathematical notions that are brought into the description of natural phenomena are we close to having a real foundation for natural philosophy to capture the phenomena of time, space, and motion. This

⁷ With Parmenides we will see how the specific form taken by his criteria and his logical tools contributes to ruling out natural philosophy as a field of strict and systematic inquiry. That it is worthwhile even so to investigate Parmenides for a discussion of the beginning of natural philosophy can also be seen from Aristotle's discussion of Parmenides in *Physics* I, chapters 2 and 3, and Aristotle's explicit claim in 185a17 ff. that while Parmenides and Melissus do not investigate nature as such, they nevertheless raise problems for natural philosophy.

⁸ Similarly, some of us may not want to deny the existence of certain astrological, naturopathic, or theological phenomena, but also may not think that they are proper objects for scientific enquiry.

⁹ For example, Parmenides does not separate operators and operands, as we will see in the first two chapters.

combination happens, I argue, in Plato's *Timaeus* and, partly in response to Plato, in Aristotle's *Physics*.

The central focus in our analysis of the conceptualisation of motion in this period will be speed. Certainly, ancient Greeks, Parmenides and Zeno included, could determine who won a race at Olympia. But this context for considering speed – namely, determining which competitor is the fastest at the Olympic Games – crucially controls two of the complex of notions that make up our modern understanding of speed: both distance and start time are fixed. If these factors are not controlled – if, for instance, the distance that each competitor covers is different – then they cannot measure and compare the two speeds. For speed involves a relationship between distance covered and time taken to cover that distance, but laying the conceptual basis for such a relationship (and not just for time and distance each on their own) is, as we will see, highly problematic for most of the period I am investigating.

By using a logical apparatus and criteria of inquiry that leave motion, space, and time outside the realm of rational enquiry, Parmenides and Zeno challenge the very possibility of conceptualising speed. A framework for the conceptualisation of speed requires an account of time and space¹⁰ in which they form a relationship that is quantifiable (i.e., that admits of measurement) for we want to answer the question how fast something is moving, that is, how much space is covered in how much time. The conceptual foundation for a quantifiable relation between time and space was the mathematical notion of a continuum and its incorporation into accounts of both time and space; that step, as we shall see, is taken by Aristotle,¹¹ who provides the end point of the development under investigation.

This book thus deals with a crucial stage in the long process that was the birth of physics as a science of motion. As such my project examines factors that shape how we still approach the natural sciences today, offering a philosophical explanation as to why mathematics and logic are intimately connected in our picture of science. In giving an account of the historical process that established the connections between these different realms that characterise our enquiry into nature, I show that our understanding of time and space as related in the notion of motion is not a given, but rather an achievement. This picture of motion as a unity of time and space was not available in the early Greek tradition. By demonstrating the extent to which the conceptualisation of complex notions such as speed depended on developments of the criteria used for philosophical investigation,¹² on innovations in

¹⁰ I will talk about 'space' as a shorthand, while often we only need an account of place or of the distance covered. I offer a detailed discussion of the relationship between the different spatial notions in my book manuscript *Conceptions of Space in Ancient Greek Thought*.

¹¹ At least we only have systematic evidence for Aristotle doing so, though Eudoxus may sometimes be in the background; see chapters 8 and 9.

¹² As, for example, changes in the understanding of the law of non-contradiction.

logic, and on the introduction of mathematical notions into the philosophical framework, I show how antiquity prepared the path for the manner in which we conceive of speed today, and for our ability to calculate speed and perform mathematical operations within the field of natural philosophy and science.¹³

In this account of the concept of motion I will not be able to do any justice to neighbouring notions such as the those of cause¹⁴ or force. There are also some more general concepts that may arise in an investigation like the one I envisage, to which, again, I will not be able to give the space they deserve, such as truth or knowledge.¹⁵ In general, I will only look at basic foundational issues in natural philosophy and not be able to deal with a lot of the metaphysical and epistemological underpinnings that are in play here.¹⁶ No doubt some readers will be disappointed not to see these notions or other thinkers discussed in this book. Their absence should not be read as a verdict of insignificance, but be taken simply as evidence that we are finite beings who can deal only with a finite number of things.

Methodology, Treatment of Sources, and Relationships of Thinkers Investigated

In Chapter 1 I will say much more about what I understand by the criteria for philosophy, logical operators, and the mathematical notions introduced into natural philosophy, providing systematic coverage of all the main concepts that are of importance for this book. (It would therefore be helpful to read the first chapter before turning to the chapters on individual thinkers.) But before I move to the first chapter, let me first, in this current section, address my relationship to the scholarly literature and how I shall handle the ancient texts, before, in the final section of this introduction, providing a brief overview of the chapters that follow.

(a) Methodological Remarks and Treatment of the Sources Some readers may be surprised by the argumentative and logical tools I will use for my

¹³ This is not to say that there were no other interesting streams that were lost – I deal with some of these in my book manuscript *Ancient Notions of Time*.

¹⁴ Even though the notion of a cause of a motion is obviously important for an investigation of motion also in antiquity, causation can only be hinted at in the chapters on Plato and in the investigation of the principle of sufficient reason.

¹⁵ Aristotle's theory of knowledge and of demonstration, for example, seems to be important for his idea of the possibility of natural philosophy, but I will only be able to hint at it in the chapters on Aristotle. The distinction between *epistêmê* and *doxa*, and what their respective objects can be, will to some degree come into the discussion of Parmenides and Plato.

¹⁶ I will also not debate the distinction between what is often seen as Plato's quantitative account of physics versus Aristotle's qualitative account; indeed I will be dealing with aspects of Aristotle that are very much on the quantitative side.

analysis of the ancient thinkers. They are meant to help translate the seemingly familiar, but in fact often rather different conceptual frameworks of the ancient Greek thinkers into a language and terminology that is accessible to a modern reader. Our modern, substantially enlarged, toolbox for doing philosophy may, if used prudently, allow us to figure out what is going on in these ancient texts in a clearer way.

Using in part modern logical and argumentative tools to understand ancient thoughts bears the risk, however, of altering or even distorting the ancient views, as these tools may include assumptions that the ancient thinkers do not share. And this may feed into a dangerous tendency in the scholarship of the history of philosophy to make the ancients less unwieldy and to assimilate them simply to our own thinking – a tendency that I think is harming us not only as historians of philosophy but also as philosophers, since it reduces our investigation to looking for confirmation, rather than for alternative ways of understanding the world.¹⁷

The use of modern tools often seems necessary, however, to make ancient thoughts understandable for us (and if we do not make the modern tools we use explicit, so much the worse, for the chances are high that they will creep in implicitly). Thus, we will have to think about these tools, what alternatives to them there might have been in ancient contexts, and accordingly, we will often work with a somewhat wider or different understanding of these tools than contemporary philosophers would. And if we do this in a conscious and responsible way, we may thus also learn something about how our modern toolbox came into being and why certain distinctions may be distinctions on which, deep down, we still base our philosophical activities.¹⁸

The ancient sources we will look at are of very different kinds – from Plato's dialogues, where we possess a (comparatively) safe and complete textual basis, to fragments of Parmenides, Zeno, and the atomists. Especially with the atomists we often have only snippets of their original works or have to rely on the summarising accounts of other, not necessarily sympathetic, thinkers. One problem that thus arises concerns the methodology of how to deal with these sources, especially the fragments.¹⁹ In general, I will treat the sources we have very seriously and believe them, if possible – an approach I would regard as methodological carefulness. A source may be

¹⁷ Cf. Sattler 2014.

¹⁸ I will thus try to combine what are sometimes called historic and rational reconstructions of ancient thought; cf. Makin 1988.

¹⁹ For a fuller treatment of the problems with which we are faced when dealing with Presocratic fragments, cf. Mansfeld 1999, Runia 2008, and Sattler 2013. In the current book, all fragments are numbered according to Diels-Kranz. In addition, other collections of the Presocratic fragments will be used if they contain more evidence, as, for example, Lee's edition of Zeno's paradoxes, or Taylor's collection of the atomist fragments. Citations of editions, translations, and commentaries are to editors', translators', and commentators' names only, without dates.

deemed questionable with respect to a particular fragment, however, if it gives conflicting reports about a theory without explicitly making it clear that the author reported on does indeed hold conflicting views.²⁰ While this criterion is, I assume, relatively uncontested, the situation is more problematic when a source reports a view that conflicts with a view reported by another source.²¹ In such cases the first step is to see whether the different accounts may hold in different respects or on different levels (for example, the phenomenal level and the level of what truly is for the atomists). Only if this step is unsuccessful will I proceed to a discussion of which source is more likely to be confused and thus should not be followed.

Plato (to some degree), Aristotle, and their commentators remain our earliest and most important sources on which most other sources rely. We therefore need very good reason not to trust their *report*.²² Their status does not mean, however, that we must necessarily follow their *interpretation* – not that it is always easy to distinguish report clearly from interpretation.²³

Ever since Harold Cherniss, there has been a tendency to dismiss Aristotle as an untrustworthy witness of Presocratic philosophy and to take the accounts of Presocratic philosophy that were written before Cherniss as uncritically Aristotelian.²⁴ Against this trend, in general I take Aristotle very seriously (though not uncritically) as a witness, because I do not think that we have been shown real alternatives. After all, it is not as if we can turn to an authorised edition of the Presocratics, and without Aristotle and his tradition very few reports would be left for us. Additionally, more often than not, it seems to me, such a general suspicion of Aristotle is based, at least partly, on misunderstanding him. In the chapters that follow I argue in specific instances that Aristotle should be taken as a serious witness.²⁵

²⁰ According to Makin 1993, p. 63, we find such a case with Aetius. Another case may be Simplicius' report on the partlessness of atoms: in *In Phys* 82.1 he reports that the atoms of Democritus have parts, while in 925.14 ff. he tells us that they were seen as being partless.

²¹ An example of this would be the testimonies on weight in the atomists.

²² Curd and Graham 2008, for example, reject Plato and Aristotle as reliable witnesses because the ancient reports of Parmenides as being a monist of sorts do not fit Curd's and Graham's understanding of Parmenides as not rejecting change and plurality (cf. also Osborne 2006, p. 227). While it seems uncontroversial to me that the ancients may have seen Parmenides with other eyes than we see him, turning the ancients thus into unreliable witnesses on such a fundamental point seems to me too high a price to pay for making sure that Parmenides does not violate contemporary preferences for pluralism.

²³ One example where we can clearly make such a distinction is Plato's *Symposium* 187a, where we are given a report of Heraclitus' fragment B51 first and then (in a consciously humorous form) a rather idiosyncratic interpretation and correction of it by the character Eryximachos.

²⁴ Cherniss 1935. This tendency seems to have become even more of a trend recently with Palmer 2009.

²⁵ Cf., for example, Chapter 4, where I deal with Sedley's 1982 claim that Aristotle's testimony is of little historic value for the atomists' notion of a vacuum.

(b) The Relationships between the Thinkers Investigated To date we have no agreed overall narrative about how motion, change, and processes came to be established as proper objects of scientific enquiry in antiquity. We do have overviews of the development of ancient philosophy as a whole,²⁶ and there is a fairly standard chronology for the main thinkers – Parmenides, Zeno, the atomists, Plato, and Aristotle – that I will follow.²⁷ But there is nothing specific on the development of the concept of motion all the way from the Presocratics through to Aristotle.²⁸

We do, however, have accounts of parts of this story²⁹ and of the broader relationships between some of its actors. With respect to the Presocratics, I will go against two current trends in the scholarly literature to some degree:³⁰

- A) I will group Parmenides, Zeno, and Melissus as the ‘Eleatics’. Although that grouping has been questioned in recent years, I will show the extent to which Zeno (and to some degree Melissus too) can be deemed to have developed Parmenides’ main line of argumentation.
- B) The relationship between Parmenides and his non-Eleatic successors has been variously interpreted. Did Parmenides issue a challenge to his successors? Or did his successors continue Parmenides’ thought? Or is their relationship characterised by indifference, with Parmenides’ successors not influenced by him? Traditionally, Parmenides’ philosophy has been conceived as a challenge posed to natural philosophers, to which the thinkers who succeeded him responded.³¹ Recently, however, this interpretation has been questioned, and the current trend is to place greater

²⁶ Found in histories such as Guthrie 1962–81 or Überweg 1983–2018.

²⁷ Where exactly to place Melissus is somewhat more difficult, see Chapter 4. I should also note that I take Philolaos to be earlier than Democritus.

²⁸ Such investigation as there has been regarding ancient Greek conceptions of motion, space, and time (for instance, in Sorabji 1983 and 1988) has not integrated accounts of time, space, and motion and has not paid sufficient attention to the increasing incorporation of mathematical notions into philosophy.

²⁹ Books that deal with part of this story tend to concentrate either on the Presocratics (as, for example, recently Curd 1998 and Graham 2006), on Plato (recently Gregory 2000 or Broadie 2012), or on Aristotle (Bostock 2006), each treated individually; or on the relationship between Plato and the Presocratics (for instance, Dixsaut and Brancacci 2002 or Palmer 1999), between Aristotle and the Presocratics (Cherniss 1935), or between Plato and Aristotle (Cherniss 1944). But the continuity within and stages of the development all the way from the Presocratics up to Plato and Aristotle has not been the object of a single, unified philosophical study.

³⁰ What I give here is a general overview – I will deal with the secondary literature on individual thinkers in detail in the individual chapters.

³¹ Guthrie 1965, for example, sees Parmenides as dividing Presocratic philosophy into two halves and the philosophers following him as reacting to his anti-cosmological move. McKirahan 2011, p. 157 understands Parmenides as introducing a different philosophical style (including rigorous proofs) and different conclusions.

stress on the continuity from Parmenides to his non-Eleatic successors³² – either by seeing Parmenides as less revolutionary than he was seen before,³³ or by understanding his successors as more Eleatic. Rejection of the traditional narrative has also led to claims that Parmenides had no considerable effect on his successors at all.³⁴

In this book I want to show that there is both a challenge put up by Parmenides for the natural philosophers succeeding him and also important continuity. On the one hand, the post-Parmenidean thinkers do indeed endorse important aspects of his philosophy. However, these thinkers are endorsing not findings on the monism/pluralism front, as is often assumed, but rather Parmenides' criteria for philosophical investigations, in some sense his basic logical operators, and, to an important degree, also most of the main features (*sêmata*) that he claims are possessed by what truly is. On the other hand, Parmenides' austere ontology and his rejection of natural philosophy did indeed set up a challenge for succeeding natural philosophers to which these thinkers did react.³⁵ By showing how the atomists responded while at the same time taking up essential criteria and operators introduced by Parmenides, I will also demonstrate why the third possibility, that Parmenides did not have any effect on succeeding Presocratic philosophers, appears to me indefensible.³⁶ Even if Parmenides' successors during the period under investigation did not react to him identifying him by name,³⁷ we see enough of his basic thoughts and arguments taken up and modified to appreciate that his non-Eleatic successors dealt with his position

³² So, for example, by Sedley 2008. Palmer 2009 even sees Parmenides in continuity with both the Milesians and Plato's account in *Republic V* (for my assessment of this claim, see Sattler 2014).

³³ For example, by understanding him as a pluralist in the way Curd 1998 does.

³⁴ So Osborne 2006.

³⁵ Even scholars who are deeply committed to the continuity thesis usually see what continuity there is in metaphysics, not in natural philosophy. Such a clear distinction between cosmology on the one hand and the metaphysical realm on the other is new with Parmenides.

³⁶ Osborne 2006, p. 224 thinks that in the traditional story the post-Parmenideans meet Parmenides' challenge by positing a plurality, which contradicts his monism. But, according to Osborne, given that they provide no systematic argument to defend it, nothing of what Parmenides said had any effect on them. Curd seems to deal with this problem by making Parmenides himself not a real monist; but then, as Osborne holds, there is nothing revolutionary about him. I will challenge Osborne's position by showing how the atomists defend their pluralism by taking up and extending the logical operators and criteria of Parmenides, which shows that his philosophy did indeed have an important effect on them. I should, however, mention that Osborne's scepticism mainly holds for Empedocles and Anaxagoras, about whom I will not make any claims here.

³⁷ Osborne 2006, pp. 244–5 herself points out that philosophical interaction need not have taken place in the way contemporary philosophers expect.

intensively. We will see that the main reactions to Parmenides from the atomists seek to show that natural philosophy could still be done, but that it required, as Parmenides demonstrated, a new method and rigour.³⁸

However, Presocratic interaction is only part of the narrative I give here, which also includes Plato and Aristotle. The breadth of my account brings additional interpretative problems – the relationship between Plato and Aristotle, for example, or that between Plato and Parmenides.³⁹ In the latter case recent literature has adopted two extremes: on the one hand, Parmenides has been seen as closely prefiguring Plato,⁴⁰ on the other hand, Plato has been seen as misunderstanding and distorting Parmenides.⁴¹ I select a middle way between these two extremes, suggesting that while Plato did understand Parmenides quite well, he saw that Parmenides' position lacked a middle ground for contingent things, those things that are in some ways but are not in others, which Parmenides cannot conceive with his logical tools. We will see how Plato decisively develops Parmenides' logical tools; the lovers-of-sight-and-sound passage in *Republic* V can be understood as precisely such a development.⁴²

In this book, I aim not only to show previously unrecognised connections and developments over the whole period I am considering, but also to offer novel readings of the work of each of the actors in my story, as will be evident in the overview of the chapters. Let us thus move on to this outline of what I seek to achieve in the individual chapters.

³⁸ For some readers, the Presocratic part of the story I tell may sound comparable to some parts of Guthrie's *A History of Greek Philosophy*. While I am sympathetic with the broad outline of Guthrie's account of the Presocratics, this book can be read completely independently of the reader's stance on Guthrie for at least three reasons: (1) while I think Guthrie is right in understanding Parmenides as a watershed in Presocratic philosophy, I will not rely on this; (2) none of the main points I follow in the development of this story – the logical operators, the criteria of philosophy, and the introduction of mathematical concepts – are found in Guthrie; (3) finally, my interpretation of the individual thinkers differs markedly from Guthrie's – to give just one example, Guthrie takes Parmenides to claim that everything apart from the One Being is mere appearance, a position I explicitly argue against in Chapter 2.

³⁹ It may also be seen as a problem that the atomists, in contrast to the Eleatics, are materialists, and that we are moving from a mechanistic account of motion in the atomists to a teleological one in Plato and Aristotle. While these different starting points for understanding motion pose different requirements on the explanation of motion, I will concentrate on the basic structures that are relevant to all these positions.

⁴⁰ So Palmer 2009, who understands Parmenides' threefold division of necessary, contingent, and impossible being as immediate preparation for the lovers-of-sight-and-sound passage in *Republic* V.

⁴¹ So Cordero 2011, who claims that the assimilation of Parmenides to Plato has led to a wrong ordering of the fragments and that Plato himself did not understand Parmenides.

⁴² *Republic* 476a ff.