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DESCARTES AND SOME PREDECESSORS ON THE DIVINE CONSERVATION OF MOTION*

ABSTRACT. Here I reexamine Duhem's question of the continuity between medieval dynamics and early modern conservation theories. I concentrate on the heavens. For Aristotle, the motions of the heavens are eternally constant (and thus mathematizable) because an eternally constant divine Reason is their mover. Duhem thought that impetus and conservation theories, by extending sublunar mechanics to the heavens, made a divine renewer of motion redundant. By contrast, I show how Descartes derives his law of conservation by extending Aristotelian celestial dynamics to the earth. Descartes argues that motion is intrinsically linear, not circular. But he agrees that motion is mathematically intelligible only where divine Reason moves bodies in a constant and eternal motion. Descartes strips bodies of active powers, leaving God as the only natural mover; thus *both* celestial *and* sublunar motions are constant, and uniformly mathematizable. The law of conservation of the *total quantity* of motion is an attempt to harmonize the constancy derived *a priori* with the phenomenal inconstancy of sublunar motions.

1. INTRODUCTION

The physicists of the seventeenth century destroyed one system of the world and replaced it with another. The old system, which Galileo called Ptolemaic but which is equally Platonist and Aristotelian, posited a finite spherical universe with the heavenly bodies moving around the circumference and the earth at rest in the center. According to this system, the heavenly bodies must have an eternally uniform rotary motion, both because they are eternal and incorruptible by nature, and because they are moved by separate incorporeal movers; in contrast, the sublunar elements are naturally corruptible, and move only a limited distance up or down before they are destroyed and changed into other elements. The new physics of the seventeenth century denied this fundamental contrast between celestial and sublunar things: it posited only a single kind of matter present everywhere in the universe, whose various configurations and motions must produce all the phenomena of nature. Thus it becomes a fundamental problem to find simple and universal laws of motion underlying the phenomena. The seventeenth-century physicists all hold some form of the doctrine

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of the conservation of motion: at a minimum, they hold what has misleadingly come to be called the principle of inertia, that a body in motion tends to remain in motion, and does not naturally come to rest. The apparent tendency of sublunar bodies to slow and stop must be explained, like all other phenomena, through the reciprocal impacts of a system of moving bodies. This 'principle of inertia' distinguishes the philosophers of the seventeenth century from their Aristotelian predecessors, and serves as an emblem for their revolution in physics.

It was Pierre Duhem, in his *Studies on Leonardo da Vinci*,¹ who opened the question: what sources did this revolutionary science of motion have in the older tradition? Duhem found a key part of the answer in studying scholastic discussions of projectile motion. Aristotle had held that no motion could exist at any time without an external mover contiguous to the moved body; he had thus been forced to bizarre expedients to explain how a projectile could continue to move after leaving the hand of the thrower. But Duhem found that in addition to Aristotle's theory there was an alternate account, according to which the thrower imparts a certain *impetus* to the projectile: this impetus remains naturally in the projectile, and is sufficient to account for its continued motion. Duhem traced the doctrine of impetus from the Christian neo-Platonist John Philoponus in the sixth century to the students of the scholastic master John Buridan in the fourteenth century; and he tried to indicate the subsequent stages by which the doctrine of impetus developed, taking on increasing mathematical precision, into the dynamics of Galileo and his contemporaries, founded on the natural preservation of motion.

Duhem's work has been challenged by Anneliese Maier. While she agrees that impetus theory provided the historical point of departure for the discovery of the law of inertia, she argues that Duhem has read the scholastic sources too "charitably", and so exaggerated the agreement between impetus theory and seventeenth-century mechanics. Maier argues convincingly that Duhem misread the views of Buridan and his school on the permanence of impetus in the projectile: while Buridan entertains the hypothesis that a celestial impetus might last forever, he and all scholastics agree that any impetus in a sublunar body would perish through the natural resistance of matter. Maier thinks that this indicates a fundamental difference between the scholastic conception of impetus and the modern conception of inertial motion; impetus in a kind of energy which the thrower

deposits in the projectile, and which converts itself into motion at each instant until it is depleted; on the modern conception, by contrast, motion is a naturally persisting state of the body and does not need to be explained by reference to any moving force. Thus Maier argues, against Duhem, that the scholastic theory of impetus needed more than just mathematical precision to become modern dynamics; a further conceptual revolution was needed to produce the concept that the motion imparted by a finite agent to a sublunar body is intrinsically permanent.²

The history of the laws of motion is extremely complex. We have no reason to suppose that there is a single linear path which leads from Aristotelianism through impetus theory to the principle of inertia; on the contrary, it is clear that different seventeenth-century physicists held different and incompatible laws of conservation of motion, and that these laws did not all share the same historical genealogy. Here I propose to test Duhem's claim of continuity, and Maier's counterclaim of discontinuity, by looking at the particular case of *Descartes's* law of the conservation of motion. Descartes is an interesting case, both because he holds a strong and precise (though false) principle of conservation, and because he justifies this principle by an argument from natural theology. This argument might seem at first to be an *ad hoc* justification, but I will show that it has deep roots in older Aristotelian and Platonist philosophy. I will thus trace one of the many paths which led from the medieval discussions of motion to the modern consensus that motion is conserved; and I will hope to shed light on the meaning of one seventeenth-century version of the law of conservation.

The path which I will indicate from medieval to modern physics is not quite the same as the path which Duhem had suggested. Maier proves, against Duhem, that the impetus-theorists did not think of motion as a permanent being which could remain stable without the continued influence of a moving cause; she therefore concludes that they did not possess the principle of inertia. But, as we will see, Descartes also did not think of motion as stable in this sense; thus Maier's argument cannot be sufficient to demonstrate a break between medieval and early modern discussions of motion. Without in any way diminishing the importance of the modern abrogation of the distinction between heaven and earth, we can uphold Duhem's insight that (at least some of) the theories of inertial motion continued a

scholastic discussion; but for Descartes, at least, it was not the concept of a permanent impetus in sublunar projectiles that was his starting point. My results on the particular case of Descartes will thus confirm Duhem's main contention against Maier, while disconfirming some of his subsidiary theses.

2. ARISTOTLE AND SOME SUCCESSORS ON CONSTANT ETERNAL MOVERS

In examining the medieval antecedents of Descartes's law of conservation of motion, I want to bear in mind Maier's remark that "the scholastic analogue to inertial motion", the only "constant velocity motion occurring in the absence of resistance", is celestial motion (Maier 1982, p. 99). In this section I will indicate some themes from the history of Aristotelian and Platonist thought about the nature and causes of celestial motion; in the next section I will turn to Descartes's discussions of the law of conservation. I will try to show how Descartes's theological argument for the conservation of all motion, celestial or terrestrial, continues and transforms the Platonist and Aristotelian discussion of celestial motion. I will emphasize the ways in which the older tradition gave Descartes a point of departure for thinking about the laws of motion and the intelligibility of nature, but I will also try to bring out the depth of the disagreement between Cartesian and Aristotelian-Platonist philosophy.

All Aristotelians, and almost all Platonists,³ claim that the motions of the heavenly spheres are constant and eternal. They confirm this claim by reasoning from the effects, the apparent positions of the planets observed by the astronomers, but they think that the true certainty of the claim lies in the *causes* which necessitate the uniformity of celestial motion. Since Aristotelians and Platonists (like Descartes) assume that all motion requires a mover, the cause of the uniformity of celestial motion must lie in the nature of the movers: a mover which itself varies will produce a variable motion, but a mover which remains constant in itself and always moves a body will produce an always constant motion in that body.

But what is this constant mover which produces the constant motion of the heavens? It is surprisingly difficult for the Aristotelian to answer this basic question, because in different texts Aristotle gives at least

two and perhaps three different answers, which may or may not be consistent with each other (some modern commentators believe that they can trace a development in Aristotle's views). In Books I and II of the *De Caelo* Aristotle argues that the heavens are moved circularly around the center of the world by their own nature, in the same way that earth is moved toward the centre and fire away from the centre. But in *Metaphysics* XII (and in other works) Aristotle maintains that the heavens are moved by one or more incorporeal movers separate from the heavens themselves: in the *Metaphysics* the mover at least of the outermost sphere is described as *nous* or Reason.⁴ *Nous* moves its sphere only as a final or exemplar cause, by being the good which the sphere desires to attain or imitate by its motion. This seems to imply that the efficient cause of the sphere's motion must be a soul which animates the sphere and desires its good, and so produces a voluntary motion in its body. Thus the basic problem of celestial dynamics for later Aristotelians is to make simultaneously intelligible the statements that nature is the cause of celestial motion, that soul is the cause of celestial motion, and that *nous* is the cause of celestial motion.

This picture of the heavens does not at first seem promising for scientific progress. The heavens are pictured as divine living beings, moving in desire of further divine powers. Duhem regarded these Aristotelian Movers as pagan, animistic, and unscientific, and he thought that John Buridan had made decisive progress by proposing to bury them.⁵ Duhem was not all wrong: there are certainly elements of fantasy in the doctrine of the separate movers. But I will try to show that beneath the fantasy this doctrine contained important philosophical ideas, which could be useful even for a philosopher who, like Descartes, had rejected the system of the spheres and the priority of circular motion.

I will try to show this by elucidating some views of the problem of celestial dynamics that were current within the Aristotelian and Platonist tradition. First I will review some of the main data of the problem as posed by the assertions of Aristotle (and also of Plato); then I will show how some major figures of the later Aristotelian and Platonist tradition, in harmonizing Aristotle's different statements with each other (and often also with Plato or with revealed scriptures), were forced to develop Aristotle's theory further than Aristotle himself had done, yielding results of lasting philosophical interest.⁶

I may begin at the top, with the *nous* which is for Aristotle the highest cause of the celestial motions. Some translators render *nous* as ‘mind’ or ‘intellect’, but this is often inadequate. The word *nous* sometimes means the act, sometimes the habit, and sometimes the faculty, of intellectual perception; but often (as in the common phrases *noun echein* or *noun kektesthai*, to be reasonable; cp. French *avoir raison*), it means that which we possess or share in when we do or think something rationally. Following Ralph Hackforth, I will translate *nous* in this sense as ‘Reason’.⁷ Reason is not a ‘mind’, in the sense of a rational soul: it is what souls participate in, in order to think rationally or rightly. If we are to say that Reason ‘thinks’, it does not think in the same way that rational souls think, but rather by being the standard by which thought is measured, according to which thought can be called rational or irrational, right or wrong. When St. Augustine wishes to find a Latin equivalent for the Greek word *nous* as used in Plotinus, he sometimes says ‘intellectus’ but more usually ‘veritas’, truth: I will not use this rendering, but it is helpful to recall that it is possible.⁸

Plato says in the *Philebus* (28C) that “all the wise agree that *nous* is king of heaven and earth”; and he means, not a rational soul, but Reason itself. There is an objective rational order in bodies, especially in the heavenly bodies, which can be grasped by the rational faculty in us; Plato believes that we can explain the existence of this order only by supposing that there is a separate *nous*, a Reason-itself, and that this Reason has the power to impose at least some degree of rational order on bodies. Plato fills out this account in the *Timaeus* with a hypothetical story of how Reason, as the ‘demiurge’ or craftsman of the physical world, might impose sufficient order on an originally chaotic matter to produce something like the world we now inhabit. Aristotle too asserts, in *De Anima* III, 5, that there is a separate *nous* or Reason which is the source of intellectual knowledge to the soul, and he follows Plato in asserting that *nous* is king, not directly of the earth, but at least of the heavens. Sublunar motions are not rational or constant enough to be the object of a mathematical science; but celestial motions are, and they must therefore somehow proceed from Reason. Aristotle’s disagreement with Plato concerns the means by which Reason communicates rational order to bodies.

Plato’s demiurge sometimes resorts to violent means in rationalizing bodies, imposing numerical constraints on a resisting matter. Aristotle,

in rejecting these means, is continuing Plato's own critique of Anaxagoras. Anaxagoras too had claimed to derive the world from *nous*, but Plato charges that Anaxagoras' actual explanations relied on merely mechanical constraints, and not on rationality and the best order of things. Aristotle continues this critique by insisting that Reason cannot cause order in things by forcing them to move to their proper positions, but only by being the good or the model which the things aspire to or imitate.

But Plato had already offered a less violent account of how rational order descends from *nous* to bodies, and this Aristotle finds more acceptable. *Nous* cannot directly move bodies, because bodies cannot directly participate in Reason; but souls can participate in Reason, and souls can move their bodies. Plato thinks that souls have an innate internal motion, which becomes rational and orderly when the soul participates in Reason. When the soul communicates this motion to its body, it regularizes and rationalizes the body. Aristotle rejects Plato's doctrine that the soul moves itself, but he accepts that the soul moves the body. Aristotle can therefore give an essentially Platonic answer to the question of the sources of rationality and constancy to the celestial motions: the ultimate source is Reason itself, but this rationality can only communicate itself to the heaven by being first received in the rational soul which immediately moves the heavens. Once this soul grasps Reason as its goal or model, it will not pass back and forth between right and wrong thoughts, but will remain eternally in a constant state of thought and will, and therefore eternally produce a constant motion in its body.

Thus far it is not so difficult to harmonize Aristotle with himself and (up to a point) with Plato. It is a greater challenge to harmonize *Metaphysics* XII with Aristotle's assertion in the *De Caelo* that the heavenly bodies move around the center by their own nature. In *De Caelo* II, 1, Aristotle explicitly rejects the contention that the heavens remain in their circles because of a "psychic constraint" (*ananke empsuchos*). Aristotle's language here echoes Plato's critique of Anaxagoras (like Plato at *Phaedo* 99C, he describes his opponents as seeking a new Atlas to keep the heavens up), but it is clear to any unbiased reader that Aristotle's prime target is Plato. Plato had said (*Timaeus* 36E) that the soul which turns the heaven enjoys an "unceasing [*apaustos*] and intelligent [*emphron*] life for all time". Aristotle too says here that the motion of the heaven is "unceasing [*apaustos*] for

infinite time”, but he insists that if a soul is needed to constrain a body “which is naturally moved in some other way” (as it would be if, as Plato says, the heavens are made mostly of fire), then this soul must devote itself to violent effort, and will have no “intelligent [*emphron*] leisure”; its ceaselessness will not be a blessing but a curse.

Aristotle’s conclusion is that the heaven is moved, not by the constraint or necessitation of a soul, but by its nature. It might seem difficult to harmonize this, not just with Plato, but even with *Metaphysics* XII. But, as all harmonistic commentators note, Aristotle does not deny in the *De Caelo* that the heavens are *moved* by souls, but only that they are *constrained* (*anankazesthai*) by souls. Perhaps they might be moved by souls without violence or constraint, if it is also true that they are moved in circles by their natures. Different commentators, in different ways, try to harmonize the *De Caelo* with the *Metaphysics* by bringing together the statements that *nous* and soul are causes of celestial motion and also that nature is a cause of celestial motion. As we will see, they tend through time to give greater emphasis to the separate movers, and to devalue nature as a cause of celestial motion.

We must first point out that, for an Aristotelian, the nature of a body is not the same as the body: it is the form immanent within the body. To say that a body is moved naturally is to say that it is moved by its form. Since Aristotle holds that a soul is the form of a living body, the obvious way to reconcile the *De Caelo* with the *Metaphysics* is to identify the natures of the heavens with their souls. This is the solution of Alexander of Aphrodisias, but it is rejected by the later Greek commentators, who are trying to reconcile Aristotle with Platonism. The harmonizers of Plato and Aristotle agree that ‘natures’ are forms which are immanent within bodies and are therefore destroyed with their bodies. If rational souls were natures then they would be mortal at least in principle (although those souls inhabiting immortal bodies would never actually die), and this is unacceptable.⁹

Consequently, such philosophers as Proclus and Simplicius must posit not two but three distinct causes, *nous*, soul, and nature, all working in harmony to produce the motion of the spheres. According to Proclus’s scheme, *nous* is an unmoved mover, soul is a self-moved mover, nature or immanent form is a moved mover, and body is a moved nonmover (see Proclus 1968, p. 60 and elsewhere). Proclus goes beyond what we have already seen mainly in his account of the

different ways in which soul and nature are causes of motion to bodies. While natures or other immanent forms are said to be the immediate movers of bodies, in fact soul becomes the principal mover, and nature moves bodies only in a peculiar sense. Natures and other immanent forms receive their being from souls, and they can move bodies only when they themselves are first moved by souls: thus they merely communicate motion from souls to bodies. Invoking a distinction from Aristotle (*Physics* VIII, 4), Proclus and his followers say that nature is a principle of being-moved (*arche tou kineisthai*), while only soul is a principle of moving-something (*arche tou kinein*). Nature is a principle of being-moved by endowing the body with an *epitedeiotes*, a preparedness or disposition to be moved; but no actual motion occurs unless some soul initiates it. The heavens, in particular, have a nature which disposes them to be moved circularly (and Proclus endeavours to show that Plato as well as Aristotle believed this); if they did not possess this nature, then when a soul moved them circularly in would move them violently and contrary to nature, as when a human being throws a stone upward; such violent motion could not be regular or eternal, as is the motion of the heavens. This satisfies Aristotle's concerns in the *De Caelo*, while diminishing the role of nature, and preserving soul as the principal cause of motion. Simplicius summarizes the harmonious causality of *nous*, soul, and nature as follows:

If someone asks which local motion of the heaven comes from nature and which from soul, we say that soul, through the mediation of nature, makes the heaven move [*kineisthai*] in a circle, and that it is one and the same motion. But it has from nature the connatural and unforced disposition [*epitedeiotes*], according to its very form, for being moved [*kineisthai*]; while from soul it has the actuality [*energeia*] of motion towards which it was disposed by nature. So, too, it has from *nous* its turning always and in the same way and according to the same and about the same and in the same [expanding on *Timaeus* 34A]. For by these things, under the leadership of *nous*, the psychic motion which is impressed through nature in body is constituted, and stabilized in the likeness of the activity [*energeia*] of *nous*. Whence also that divine man, having asked why the heaven moves in a circle, says that it is because it imitates *nous*.¹⁰

The neo-Platonic doctrine that natures, and more transient immanent forms, are intermediate movers, the agents of soul in bodies, is the background for scholastic discussions of *impetus* or *vis impressa*. I will not try to summarize these discussions here: but I want to cite one

particular text, from Avicenna in the early eleventh century, on the causes of celestial motion.

Avicenna occupies a key juncture in the history of reflection about the causes of motion. For the Latin scholastics Avicenna becomes, after Averroes, the most authoritative interpreter of Aristotelian philosophy. But Avicenna is a rather loose Aristotelian, as the Greek Platonizing commentators had been: while he is not fully committed to harmonizing Aristotle with Plato, often (sometimes for religious reasons) he preserves Platonizing interpretations of particular Aristotelian doctrines. In particular, he takes up the neo-Platonist interpretation of Aristotle's doctrine of the causes of celestial motion, and he transmits to the West his revised version of this doctrine. Looking at Avicenna allows us to see how the theory of impetus, especially in the celestial case, develops out of the Aristotelian and Platonist concerns we have been discussing. The text of Avicenna I will cite is helpful because it has close echoes with both Simplicius and Buridan, and also with Descartes: Avicenna is certainly one of the key links in the development and transmission of impetus theory (although I make no attempt here to trace all the links in the chain), and he also illustrates very clearly the way a whole tradition thought about how incorporeal movers move bodies.¹¹

Avicenna modifies the neo-Platonist doctrine of nature, soul and *nous* in a number of ways (most notoriously by accepting a hierarchy of Reasons shared in by different levels of souls), but his most important modification for our purposes is in his conception of nature. Avicenna does not accept the full neo-Platonist hierarchy of being: he asserts that all souls are the forms of their bodies, and he denies that there can be two substantial forms, soul and nature, within the same body. For this reason, Avicenna goes even further than Proclus and Simplicius in devaluing the role of nature as a cause of celestial motion: he will not identify the natures of the heavens with their souls, but he also cannot accept them as substantial forms inferior to souls, so that they seem to be squeezed out of his system. And yet he must preserve the doctrine of the *De Caelo* that the heavens are essentially different from sublunar things and that they rotate by their nature.

Avicenna devotes a chapter of the *Shifa'* to the proposition "that the proximate mover of the heavens is neither a nature nor a *nous* but a soul, and that the more remote principle is a *nous*".¹² He begins

by denying that the rotation of the heavens is “natural”, in the sense of proceeding from a nature; he then adds that the motion is “by nature” in a looser sense, in that “its presence in its body is not contrary to the determination of any other nature in its body: for the thing which moves it, even though it is not a natural power, is something natural to this body and not alien to it; it is as if it were its nature”.

But Avicenna wishes to find a more positive sense in which the rotation proceeds from a nature. He solves the problem, in essentially neo-Platonic terms, as follows:

Furthermore, every power moves only by the mediation of some inclination [*mayl*], and the inclination is the thing [*ma'na*] which is perceived in the moved body: even if it is forced to rest this inclination will still be perceived in it, resisting the obstacle and seeking motion even while it is at rest. This is doubtless something other than the motion, and other than the moving power, for the moving power still exists when it has completed the motion, and the inclination does not. Similarly, too, in the case of the first motion, its mover does not cease to generate inclination after inclination in its body. Nothing prevents this inclination from being called a nature: for it is not a soul, nor is it from without, nor does it have will or choice, nor can it not move, or move in other than a definite direction; nor, further, it is contrary to the determination of an alien nature in this body. And if this thing [*ma'na*] is called a nature, then you may say that the heaven is moved by nature; but its nature is an emanation from soul, which is multiplied in accordance with the soul's activity of thinking. And it is already clear that the principle of the sphere's motion is not a nature [accepting a variant reading]; and it is already clear that it is not violence; it is therefore doubtless from will.

It is this theory which, in one or another variant, is accepted by Buridan and his school in the fourteenth century. As Duhem noted, Buridan went beyond earlier thinkers in proposing an *imaginatio* according to which all incorporeal movers inferior to God would be eliminated, but for Buridan this was only an *imaginatio*, while the theory of moving *intelligentiae* was the truth.¹³ The fourteenth-century Parisians, then, when beyond Avicenna chiefly in the possibilities they considered, not in what they really believed. But even their *imaginatio*es were, in the fourteenth-century context, a natural step beyond Avicenna's position. Duhem rightly stressed the importance for these physicists of theological voluntarism: it was open to them (as it had not been to Avicenna) to consider scenarios in which God would do by himself what he is normally thought to do through secondary causes. But it was easy and painless for them to modify Avicenna's scheme in this way, because he had already effectively eliminated the

heavenly bodies and their natures as causes of celestial motion. The real mover for Avicenna is the soul, which looks to Reason, then wills the body to move and so produces in it an inclination disposing it to motion: the body itself cooperates only negatively, by not having the form of a sublunar body which would resist a rational circular motion. If we abolish soul and Reason as separate entities, and have God step in to fill their roles, we may retain the basic structure of the doctrine of celestial motion. If soul and Reason are immutable enough to guarantee the rationality and constancy of celestial motion, then *a fortiori* God provides the same guarantee. What has remained is the doctrine that an immutable incorporeal mover, which has rationality intrinsically and of itself, will produce an eternally constant motion which can be the object of a mathematical science. As we will see, this is also the fundamental doctrine of Descartes's dynamics.

3. DESCARTES ON THE DIVINE CONSERVATION OF MOTION

Descartes is not a part of the Aristotelian and Platonist tradition I have been describing. He rejects any essential distinction between celestial and sublunar bodies; indeed, he rejects immanent forms, the finite universe, the celestial spheres, and the priority of circular motion. This is well-known and unsurprising. What is more surprising is the extent to which Descartes is able to use themes from the older tradition in constructing his new physics. Descartes draws his metaphysics (on which his physics is to be based) largely from the Platonizing doctrines of St. Augustine, and he is trying to persuade readers nurtured on scholastic Aristotelianism. It is thus natural for Descartes to call up themes from the Aristotelian and Platonist discussion of the causes of motion; we will see how he uses and transforms them.¹⁴

Descartes always sets out his philosophy in a definite order, beginning with metaphysics and then turning to physics. Metaphysics concerns God and the soul; physics concerns bodies, their essence and existence and their various motions. Descartes's metaphysics follows the discipline of ascending from the soul of God which Descartes had taken from Augustine, Augustine from Plotinus, and Plotinus, ultimately, from Aristotle's *De Anima* III, 5: first we consider ourselves as rational souls, as potential knowers, and then we raise our sights to consider God as Reason or Truth, as the source of our rationality and the

standard by which we judge that we are thinking rightly. Descartes's physics begins with this knowledge of God, and descends to infer a knowledge of the creatures which proceed from him. Descartes uses premises about God to argue that the essence of body consists only in extension, then that a world of bodies actually exists; then, finally, that bodies obey certain universal laws of motion, from which particular physical phenomena are derived.

We may schematically contrast the way physics and metaphysics fit together for Descartes with the way they fit together for Aristotle. Starting from two different parts of his philosophy, the psychology and the celestial physics, Aristotle leads us up to contemplate the divine Reason: in *De Anima* III he takes us from the potential reason in ourselves to Reason absolutely, while in *Physics* VIII and *Metaphysics* XII he takes us from the constancy of the primary celestial motion to immutable Reason as its source. When Descartes ascends, in the *Meditations* or in Part One of the *Principles*, from the human mind to God, he is following the path *De Anima* III (at least as it is interpreted by Plotinus, and taken over by Augustine); but when Descartes descends, in Part Two of the *Principles*, from God to bodily motion, he is reversing the path of *Metaphysics* XII, arguing from the immutability of God to the constancy of the motion which proceeds from him.

This attempt to reverse Aristotle's order, descending from God to bodies, has important implications for Descartes's philosophy. An Aristotelian may simply observe by watching the skies that the celestial motions are constant; or again, he may begin with the fact of inconstant motion and argue that it must be contained and measured by a constant motion. In either case, he discovers God only as the cause of the primary constant motion and not of all motion. Descartes, by contrast, has sought to think away all experience of the physical world in constructing his knowledge of God, and he has no grounds for restricting God's causality to one region of space rather than another. Abstracting from all evidence of the senses, Descartes finds the essence of body to be a uniform spatial extension, lacking any outermost limit: he is therefore led, together with such contemporaries as Galileo, to abolish the distinction between celestial and sublunar physics. Descartes concludes that not only celestial but also sublunar motions are constant, because they all proceed equally from God: they are therefore all equally objects of mathematical physics.

As Duhem would surely have suggested, Descartes's divergence from the traditional Aristotelian view is rooted (at least in part) in a Christian rejection of pagan limitations on the power of God. But it is insufficient to say that Descartes refuses (as any Christian would) to restrict God's power to only the outermost portion of the universe. This would still be compatible with a broad acceptance of the Aristotelian system. For any even moderately Platonizing Aristotelian, there is nothing in the nature of divine Reason which prevents it from ruling over the whole world of bodies; the obstacle comes rather from the nature of bodies, which are not all capable of receiving the divine ordering without resistance and distortion. On an Aristotelian view, the natures of sublunar bodies incline them to move a finite distance and then stop, if they are not first corrupted; such mutable things can receive order only to the extent of observing a rough periodicity in their transformations. Only the heavens receive constant circular motion without resistance, because (as Simplicius says), only they have a natural disposition to receive it, or even more negatively because (as Avicenna says) only they have no other nature which could resist it. Thus for Descartes to assert, against such Aristotelians as these, that God produces a constant motion in sublunar as well as celestial bodies, it is not enough for him to modify their conception of God; he must modify their conception of body as well.

We may contrast Descartes's conception of corporeal nature with Avicenna's conception. Avicenna denies that the heavenly bodies have an intrinsic source of natural motion and concludes that they do not resist the constant motion. Descartes, however, denies that any bodies have an intrinsic source of natural motion and concludes that no bodies resist the constant motion. This follows from Descartes's conception of body as pure extension, which is designed precisely to strip bodies of any natures, immanent forms, or active powers. Only human and angelic minds, exceptional beings within the natural world, remain to counteract the divine determination of bodies toward a constant motion.

This elimination of natures from bodies depends on a theological voluntarism much more radical than Buridan's: it is connected with Descartes's doctrine of the creation of the eternal truths. In a famous passage from a letter to Mersenne, Descartes declares that the eternal truths "have been established by God and depend on him entirely, as

much as do all other creatures” (Descartes 1964, vol. I, p. 145):

Indeed, it is speaking of God as of a Jupiter or Saturn, and subjecting him to Styx and the fates, to say that these truths are independent of him. I beg you, be bold to assert and proclaim everywhere that it is God who has established these laws in nature, as a king establishes laws in his kingdom. (ibid.)

Descartes is here rejecting the Aristotelian view that there is a radical plurality of essences or natures which make each body the kind of thing it is, and so govern its behavior: rather, all bodies are governed by universal laws, and these laws are immutable because God is immutable. Descartes’s voluntarism is not an irrationalism: God’s laws are not tyrannical whims, but rational truths, proceeding from a God who is the source of truth and rationality. We might therefore derive these laws from a knowledge of God’s nature, reversing the procedure of *Metaphysics* XII.

Descartes is applying this principle in Part Two of the *Principles of Philosophy*, art. 36 and following, where he sets out to derive the laws of motion.¹⁵ Descartes begins by saying that God is the universal and primary cause of all motion, and this is in itself not controversial; but Descartes then goes on to assert that the secondary causes of the particular motions of bodies are not bodies themselves, nor forms immanent in bodies, but certain laws proceeding from God. When God preserves and governs the world through his ordinary concurrence (as opposed to miracles), he “conserves all that matter in [or by] the same *modus* and the same *ratio* in which he previously created it” (art. 36), or “by the same action and with the same laws with which he created it” (art. 42). In both of these parallel passages (and a third, earlier in art. 36), the conclusion is immediately drawn that, in conserving the totality of matter, God “also always conserves the same amount of motion in it” (art. 36). The argument seems to be that motion is constant because it proceeds from God, or more precisely because it proceeds from the *modus*, *ratio*, action, or laws by which God governs the totality of matter: for “we understand the perfection to be in God, not only that he is immutable in himself, but also that he operates in a supremely constant and immutable *modus*” (art. 36). Because bodies have no active natures of their own, all their motions are governed solely by this constant *modus* or *ratio* of God’s operation, and therefore

all their motions are constant. The only possible exception would be for motions proceeding from human and angelic minds, and Descartes explicitly refuses to explore this exceptional case (end of art. 40), reserving it for a treatise *De Homine*, which he was never to write.

All this seems too easy. Three questions arise: what is this *modus* or *ratio*, or what are these laws? How do they decide whether bodies move in straight lines or in circles? Finally, how will Descartes meet the obvious Aristotelian objection, that the sublunar motions we ordinarily experience do not remain constant, but change and stop?

The first question has two obvious answers, both of which I find unsatisfactory. The first is that there is no entity which is this *modus*: the *modus* is just the manner of God's operation, and manners should not be reified. I think this answer is wrong: it cannot account for the parallel passage in art. 42, which has *actio* and *leges* instead of *modus* and *ratio*.¹⁶ Descartes recognizes a special ontological status for non-subsistent entities, which are not strictly things but are also nothing: sometimes he calls these entities eternal truths, but *ratio* and *lex* are also among his favorite terms for this kind of being. Thus Descartes says (at Descartes 1964, vol. VII, p. 435) that there is nothing which does not depend on God: "not just nothing subsistent, but also no order, no law, and no *ratio* of truth or goodness". Orders, laws, and *rationes* of truth or goodness are not subsistent things, but they are norms or standards by which things are measured and which serve to guide or channel God's operation among the things. These laws do not subsist in God, as accidents in his substance; rather, they proceed from God, both toward the minds which know them and toward the bodies which obey them. In particular, the *ratio* or *lex* of God's conservation of matter proceeds from God towards the bodies, and, being immutable, always produces in them the same amount of motion.

We can now see what is wrong with the second obvious answer: namely, that the *ratio* and the laws are simply the three 'rules or laws of nature' which Descartes deduces, in art. 37 and following, from the general principle of divine immutability. Descartes says that the rules or laws of nature are "the secondary and particular causes of the various motions which we observe in individual bodies" (art. 37). But Descartes does not intend to suggest that propositions are causes, though he may speak loosely as if they were. Laws or *rationes* or eternal truths may be causes, but eternal truths are not ultimately propositions: they are the real essences that are the subject matter of the propositions and

make the propositions true.¹⁷ The laws which cause motion are not Descartes's three propositions, but the reality which those three propositions describe.

I think the true answer is that Descartes conceives the law by which God moves bodies to be something very much like Avicenna's "inclination to motion", which proceeds to the heavenly bodies from their separate movers, and which substitutes for an active nature in the bodies themselves. In various passages Descartes speaks about such an inclination to motion, in terms similar to Avicenna's. Thus in a letter to Henry More, Descartes agrees that "matter left freely to itself, and receiving no impulse from elsewhere", (Descartes 1964, vol. V, p. 404) will remain at rest; but in fact "it is impelled by God, who conserves in it as much motion or translation as he put in it from the beginning". The impulse to motion does not come from the nature of matter, but, Descartes immediately adds, the motion is "no more violent to matter than rest is", because bodies have no contrary action or positive force with which to resist it; motion proceeding from the divine impulse can therefore be said to be natural to matter.

If we understand this similarity between Descartes and the older philosophical tradition (of which Avicenna is a representative), we can also understand the divergence which comes in their answers to our second question: how do the laws (whatever they are) determine whether bodies should move in straight lines or in circles?

Descartes believes that the divine impulse to motion leads bodies to move in straight lines, because only rectilinear motion is rational motion:

One must say that God alone is the author of all the motions which there are in the world, inasmuch as they *are*, and inasmuch as they are straight, but that it is the various dispositions of matter which render them irregular and curved; just as the theologians teach us that God is also the author of all our actions, inasmuch as they *are*, and inasmuch as they have some goodness, but that it is the various dispositions of our wills which can render them vicious. (Descartes 1964, vol. XI, pp. 46–7)

Now the older tradition had maintained, in very similar terms, that only rational motions proceeded from divine Reason, and that deviations from rational motion were due to the incapacity of matter; but Aristotelians and Platonists identify the rational motion as circular motion.

Descartes, unlike Avicenna, unlike Buridan, and unlike Galileo,

cannot possibly regard circular motion as the rational motion; this is ruled out by his abstract consideration of body as bare geometrical extension, without limit or center. Descartes agrees with Avicenna that the will of the divine mover “does not cease to generate inclination after inclination in its body” (Avicenna, as quoted above); these inclinations last only for a moment and pass immediately out of existence, but are continually replaced by equivalent inclinations, because the will of the divine mover is constant. Because of the “immutability and simplicity of the operation through which God conserves motion in matter” (art. 39), God always conserves motion “precisely as it is in that same moment of time in which he conserves it, having no regard [*nulla habita ratione*] to what perhaps it was a little while before”. Avicenna would say that the conservation of circular motion satisfies this condition: the sun’s mover always gives the sun an inclination to move westward around the earth, and it always reproduces this inclination in the same direction, westward, without referring to the sun’s previous history. But we can say that this inclination is in ‘the same direction’ from moment to moment only by referring it to the center of rotation, which is (for Avicenna) the center of the universe. For Descartes, however, the universe has no center, and any reference to a center of rotation is extrinsic to the inclination to motion. Thus

of all motions, it is only the straight which is entirely simple, and whose whole nature is comprehended in an instant: for to conceive it, it is enough to think that a body is in the act of moving in a certain direction, which occurs in each of the instants which can be picked out while it is in motion. Whereas, to conceive circular motion, or any other there may be, one must consider at least two of its instants, or rather two of its parts, and the relation between them. (Descartes 1964, vol. XI, pp. 44–45)

Descartes knows that no actual motion, rectilinear or otherwise, can take place in an instant; but he insists that “all that is required to produce [rectilinear motion] is found in bodies in each instant which can be picked out while they are in motion, but not all that is required to produce circular motion” (ibid.). In terms of a modern mathematical understanding of motion, this is nonsense: there is no sense in which the first derivative of a body’s position is ‘comprehended in an instant’, but the second derivative is not. But in terms of a theory of inclination or impetus, Descartes’s assertion makes excellent sense: at each instant what God creates in a body is a bare inclination to move with a certain speed in a certain direction, not rectilinearly or circularly or in any other determinate way; but at each instant God renews in this body an

inclination to move with the same speed and in the same direction, and so he produces a uniform rectilinear motion.

So far, we have avoided the greatest and most obvious problem for Descartes's theory of the causes of motion: on Descartes's account, God produces only rational motion, which is uniform rectilinear motion. But God is the only source of motion, excepting the case of finite minds: how then is it that motions other than uniform rectilinear motion are in fact observed, both in the heavens and on the earth?

The way Descartes deals with the difficulty reveals perhaps his most profound divergence from the old Platonic–Aristotelian tradition. The older philosophers held that circular motion was the only rational motion and that this motion was perfectly realized in the heavens: since the phenomenal motions of the heavenly bodies are not perfectly circular, they encouraged the construction of astronomical hypotheses to resolve the phenomenal motions into perfect circles. But since rational motion does not appear to be fully realized beneath the moon, they concluded that sublunar bodies were not fully rational, that their natures prevented them from fully receiving the divine impulse toward order; thus while sublunar bodies obey an approximate rationality, we cannot construct an exact science of their motions, and there is no point in trying. Descartes refuses to accept this solution: for him bodies are purely intelligible in their essence, and he will not consign any portion of the physical world to the realm of mere semi-intelligible phenomena. The world is highly complex, but it must be, in principle, fully intelligible. Thus for Descartes the problem of sublunar physics is the same as the problem of celestial physics: to explain how simple laws or inclinations to rational motion, compounded with one another in complex configurations, yield the apparently disorderly phenomena which we observe.

Now we have already quoted Descartes as saying, in very traditional language, that “the various dispositions of matter” can distort the impulse to motion into crooked and irregular paths, just as our will can distort the divine impulse towards the good. But by Descartes's own view the analogy cannot be perfect: minds have the power to resist the divine determination, and bodies do not. The dispositions of matter can render motion crooked and irregular only by complicating it, by bringing two impulses to motion together in the same part of matter, forcing them to be resolved into a single resultant motion which will no longer be uniform.

This happens when bodies collide, as a plenum of bodies in rectilinear motion inevitably must, unless the whole universe is moving with a single rigid motion. For the Aristotelians, this had been an argument that the primary motion must be circular, since no rectilinear motion could continue indefinitely. Descartes agrees that actual motion must go in circles, but he insists that all motion is intrinsically rectilinear and that a moving body tends to continue in a straight line unless some other body prevents it. Thus circular motion, even in the heavens, cannot simply be posited: it must be explained as the result of collisions of bodies moving in straight lines.

Descartes insists that collisions are not violations of the law of conservation of motion; they are just circumstances dictating that this law must be observed in a complicated way. Motion, or rather the impulse to motion continually proceeding from God, remains constant: but this constant power “now applies itself to some and now to other parts of matter” (Descartes 1964, vol. V, p. 405), so that in a collision one body can transfer some of its motive force to another. Descartes attempts to calculate how much motion bodies will lose and gain in collisions, and so discover universal rules of impact. Descartes’s way of calculating the quantity of motion is crude and unargued, and all his subsequent conclusions are wrong. He is struggling, with inadequate data and inadequate conceptual equipment, to explain how a simple constant force, governed by a universal law of conservation, can produce phenomena of indefinite complexity, so that “even this continual mutation in creatures is an argument of the immutability of God” (art. 42). If Descartes had little success in explaining phenomena through simple laws, he at least succeeded in laying down a challenge for other physicists.

Now, in setting out Descartes’s thought on the causes of motion, and on the role of God in establishing the law of conservation, it would have been possible to start at the end, with Descartes’s law of the conservation of the total quantity of motion in the universe. But this would give a distorted picture of the way Descartes thinks about conservation. Descartes’s fundamental idea, shared with Aristotelians and Platonists, is that God communicates his constancy to the world by continually reproducing a constant impulse to motion in a given body. Because Descartes makes this conservation universal, not restricting it to bodies with apparently uniform motion, he is forced to invoke the transference of motion in collisions in order to save the phenomena.

In the process, Descartes speaks of an amount or quantity of motion, and formulates what looks like a modern conservation law, with a specified "conserved quantity". But this is just an accidental by-product of Descartes's great innovation, which is to extend to all the parts of a uniform space the divine conservation of motion formerly restricted to the heavenly bodies.

My report on Descartes generally supports Duhem's thesis of continuity between medieval and early modern discussions of the causes of motion. At a sufficiently abstract level, Descartes's theory of the causes of motion is very close to the older theory represented by Avicenna; the great difference, of course, is Descartes's conception of body as extension, which abolishes the finite universe and the privileged status of the heavens. The study of Descartes, again, confirms Duhem's view of the importance of medieval discussions of impetus: but we must consider impetus theory in a broad way, not as a particular explanation of the motion of projectiles, but as the Platonist (or Platonizing Aristotelian) discussion of the relation between separate and immanent forms as causes of motion. The doctrine of a natural permanence of impetus, which Duhem claimed to find and Maier claimed not to find in various fourteenth-century figures, proves not to be important for Descartes: conservation of motion is consistent with the doctrine that all motion always proceeds from a mover, as long as that mover is God.

Perhaps our most surprising result is the continued vitality, for Descartes, of the Aristotelian and Platonist doctrine of separate incorporeal movers. In a way this would have pleased Duhem, for Descartes is certainly dismissing any angelic movers, and letting the will of God take over their functions. But Duhem suggests that "the instant when the stars stopped being perceived as moved by divine beings" marked the divide between ancient and modern science (Duhem 1913, p. ix). This division does not work, at least not for the one peculiar strand of early modern science which is Cartesian physics. The less naturalistic the Aristotelian account of celestial motion became, the closer it came to Descartes. Descartes could not have used an account of bodies as naturally disposed to motion by their own substantial form; he could and did use an account of bodies as moved by a separate divine Reason. Precisely because the separate movers were outside the natural order, they could survive the destruction of the old world picture, and play a constructive role in one variety of the new physics.

NOTES

* I would like to thank Daniel Garber, Alison Laywine, and Ian Mueller for their comments. Since I have not seen a text of Professor Westman's remarks, either before or after he delivered them, I cannot respond to his criticisms.

¹ Duhem (1913). My summary of Duhem's work corresponds closely to his own review of (what he saw as) his chief results in his preface to this volume.

² Here I am summarizing Maier's main points in criticism of Duhem in her article 'The Significance of the Theory of Impetus for Scholastic Natural Philosophy', collected (in English translation) in Maier (1982), pp. 77–102.

³ By an 'Aristotelian' I mean here any writer who accepts Aristotle as an authority in philosophy, and who therefore prefers not to disagree with Aristotle when he can avoid it; some Aristotelians will be more ready than others to disagree with Aristotle on special occasions, or to interpret Aristotle's text in implausible ways to harmonize him with other authorities. How far Aristotle himself was an Aristotelian depends on how far he tried to remain consistent with himself, an issue I will not address here. A 'Platonist', similarly, is a writer who accepts Plato as an authority. Thus the Athenian and Alexandrian philosophers of the fifth and sixth centuries A.D. are (to varying degrees) both Aristotelians and Platonists at once. The histories of Aristotelianism and Platonism are closely interwoven, and it is a serious mistake to look only at Aristotelians (or, worse, only at 'pure' Aristotelians) in studying the medieval background to early modern science.

⁴ I will frequently keep *nous* in the original, and use it as a technical term within an English context. It is translated into Arabic as '*aql*', which often becomes *intellectus* in Latin, but in the context of celestial physics becomes instead *intelligentia*. In citing Arabic texts, I will retranslate the Arabic '*aql*' back into the Greek *nous*. For what follows, I will be chiefly interested in the paradigmatic case of the outermost heaven; I will not explore the problem of the plurality of unmoved movers and their relation to the first mover.

⁵ See Duhem (1913), p. ix. He adds there that the moment when Buridan made this proposal marked the line "separating the reign of ancient science from the reign of modern science".

⁶ I will necessarily be brief and will discuss only selected thinkers and texts. I give some interpretations which are controversial, particularly of the *Philebus* and *Timaeus* (where I generally agree with Hackforth and with the consensus of the ancient Platonists), and of Aristotle *De Anima* III, 5 (where I agree with Alexander of Aphrodisias). I cannot defend these interpretations adequately here; this is inevitable, in a study not primarily devoted to Plato and Aristotle. I will develop these interpretations at length in other works.

⁷ See Hackforth (1945) and Hackforth, 'Plato's Theism', collected in Allen (1965).

⁸ Compare Plato: "*nous* is either the same as truth, or it is of all things the most like to it and the truest" (*Philebus* 65D).

⁹ Simplicius *In Aristotelis Physicorum Libros Quattuor Posteriores Commentaria*, in (1882), vol. 10, p. 1219, quotes Alexander as saying this in his (now lost) commentary on *De Caelo* Book II. Simplicius remarks there that Alexander is interpreting Aristotle "harmoniously to his own opinion about the soul", namely that soul is inseparable from the body (and thus mortal), as a nature would be; it is clear that this implication for the

soul is why all the Platonizing commentators object to Alexander's doctrine of the causes of celestial motion. They routinely refer to the doctrine of the soul's mortality as "his [Alexander's] own opinion", and accuse him of forcing Aristotle to agree with him; in fact their charge suits themselves better than Alexander. Their arguments (besides the doctrine of immortality) for denying that Aristotle could count the soul as a nature come from Aristotle's description of the soul as the entelechy of a certain kind of natural body: soul is therefore something superadded to a body which already possesses a nature.

¹⁰ Simplicius *In Aristotelis De Caelo Commentaria*, in (1882), vol. 7, p. 382; Simplicius is commenting on *De Caelo* II, 1, which he is harmonizing with *Timaeus* 34A and other Platonic texts. The 'divine man' is not (as the editor wrongly says) Plato, but Plotinus; the reference is to the opening sentences of Plotinus II.2, 'On the Motion of the Heaven', which in turn are explicating *Timaeus* 34A.

¹¹ While I do not mean to devalue the role of John Philoponus in the history of impetus theory, I do think it is important to bring out the role of Avicenna, who is much more squarely in the mainstream of the history of philosophy and science. Duhem, pp. VI–VII, says that the late Greek and Arab philosophers do not even mention impetus theory, and he implies that this is because they despised its (supposed) Christian origins. While everyone now knows that Duhem was wrong about this, I think it is important to bring out just how universally Platonists and Platonizing Aristotelians accepted some version of impetus theory.

¹² This chapter, from which the subsequent quotations are drawn, is Book IX, Chapter 2 of the *Metaphysics* of the *Shifa'*. I translate from Ibn Sina 1960, in which the chapter is pp. 381–93.

¹³ Buridan proposes this *imaginatio*, explicitly qualifying it as such, at Buridan (1942), pp. 180–81, and in other works. Throughout this work (e.g., at p. 132), and in other works, Buridan continues to uphold and presuppose the theory of moving *intelligentiae*.

¹⁴ For a discussion of Descartes's use of the older tradition, see my unpublished dissertation, Menn 1989. I am better able there than here to defend some controversial interpretations.

¹⁵ The *Principles of Philosophy* is found in Descartes (1964), vol. IX, pt. 1. I will refer to the different sections of Part Two of the *Principles* simply by their article numbers.

¹⁶ The French translator also uses "les memes loix" for the "eadem ratione" of art. 36.

¹⁷ Thus Descartes says at Descartes (1964), vol. I, p. 152: "he [God] is the author of the essence as well as of the existence of creatures; but his essence is nothing other than these eternal truths"; and there are quite a few parallels. It is *not* possible to read Descartes as explaining essence in terms of eternal truths; in context, the explanation is clearly the other way around.

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