Eric Palmer, Allegheny College, epalmer@allegheny.edu

"Descartes on Nothing in Particular"
In R. Gennaro, C. Huenemann, eds. New Essays On the Rationalists.
Oxford University Press, 1999.

Descartes on nothing in particular

Eric Palmer, Allegheny College

Abstract

How coherent is Descartes' conception of vacuum in the *Principles*? Descartes' arguments attacking the possibility of vacuum are difficult to read and to understand because they reply to several distinct threads of discussion. I separate two strands that have received little careful attention: the scholastic topic of annihilation of space, particularly represented in Albert of Saxony, and the physical arguments concerning vacuum in Galileo that are also continued after the publication of the *Principles* in Pascal. The distinctness of the two sorts of opponent accounts for Descartes' odd habit of summarily declaring vacuum "contradictory" in some contexts, while providing extended conceptual and physical arguments meant to establish its "impossibility" in others. In several passages late in the *Principles*, Descartes also considers the physical ramifications of "empty space," including a discussion of the appearance of a star, were an empty space situated at the center of the celestial vortex. I argue that the discussion allows for a sensible conception of space with extension, but without matter, quite adequate to the physical discussions of vacuum among Descartes' contemporaries.

Introduction: The wine cask, and vacuum in the early *Principles*

How coherent, and how useful, is Descartes' conception of vacuum in the *Principles*? I will begin by backtracking: in the *World,* written most of a decade earlier, Descartes has much to say about macroscopic physical vacuum. He models the created universe as a finite container in which matter is situated, and his arguments are meant to

indicate that the container is full to its boundaries in a continuously connected medium, so that no vacuum is present, and light can travel as pressure in the medium (XI, 32, 86).[1] Though he suggests his argument is not conclusive, Descartes' well-known treatment of the wine cask is a noteworthy prop: wine will not flow from an unstopped hole in a full cask unless a vent is provided to allow air to take its place, since the universe is "as full as can be, and the part of the air whose place the wine would occupy if it were to flow out can find no other place to occupy in all the rest of the universe" (XI, 20).

As he does in the *World*, Descartes maintains in the second part of the *Principles* that "in every case of motion, there is a complete circle of bodies moving together," and he suggests that bodies that our senses cannot detect fill in the spaces as others separate. Descartes explains as much in his discussions of the empty jug (which is not empty, but full of air), and of rarefaction, which is taken to be the process of a body enlarging by incorporating other matter, much as a dry sponge grows as it incorporates liquid (II:33, 17, 6). He argues that vacuum is unnecessary for motion in a non-atomistic universe, and, as before, is a barrier to the passage of light (II:33, III:53 ff.). Physics in the two works is clearly similar, and so one would expect that Descartes would provide empirical argument for the nonexistence of vacuum in the *Principles* like those in the *World*. But such argument is not forthcoming in the *Principles*; and most notably, the wine cask is not evident. Why?

Part of the explanation for this change lies in a reconception of space that Descartes develops after the *World*. Space is no longer an absolutely full container, the bounds of which play their role in keeping wine within a cask: the argument in the *Principles* shifts to a fundamental reconception of matter as spatial, trumpeted in the claim, "There is no real difference between space and corporeal substance" (II:11).

> [I]f a stone is removed from the space or place where it is, we think that its extension has also been removed from that place, since we regard the extension as something particular and inseparable from the stone. But at the same time we think that the extension of the place where the stone used to be remains, and is the same as before, although the place is now occupied by wood or water or air or some other body, or is even supposed to be empty. (II:12)

---

[1]Quotations from Descartes' works are from the translation of Cottingham, Stoothoff & Murdoch *The Philosophical Writings of Descartes* (Cambridge, 1985-91), unless otherwise indicated. References of the form (XI, 32) refer to the volume and pagination of Adam & Tannery, references of the form (II:18) refer to *Principles* Part II, section 18. I include the latter convention because reference to Descartes' divisions will often be more illuminating than reference to pagination.

Though we may remove a stone, nonetheless, in so doing we do not remove the extension of the stone from its place. But Descartes also holds that there is no evidence of an absolute place distinguishable from bodies within which those bodies lie: bodies simply take the places of others also in motion within the universe (II:13). So there is no need to posit space as an entity distinct from bodies: extension is a property of bodies, "which is thought of as being the same, whether it is the extension of a stone or of wood, or of water or of air or of any other body - or even of a vacuum, if there is such a thing - provided only that it has the same size and shape..." (II:12).[2]

Descartes' identification of extension with bodies explains the absence of the wine cask argument from his discussion in the *Principles*: no such argument is available, because the universe is not a container, finite or infinite, that holds the wine in its place. What else follows from this metaphysics? Descartes comes quickly to one of the most puzzling sections of the *Principles*, his denial at II:16-18 of vacuum. One part of that discussion is the following, which I think may take the palm for the very least appreciated argument in the *Principles*.

> II:18. *How to correct our preconceived opinion regarding an absolute vacuum.* Almost all of us fell into this error in our early childhood. Seeing no necessary connection between a vessel and the body contained in it, we reckoned there was nothing to stop God, at least, removing the body which filled the vessel, and preventing any other body from taking its place. But to correct this error we should consider that, although there is no connection between a vessel and this or that particular body contained in it, there is a very strong and wholly necessary connection between the concave shape of the vessel and the extension, taken in its general sense, which must be contained in the concave shape. Indeed, it is no less contradictory for us to conceive of a mountain without a valley than it is for us to think of the concavity apart from the extension contained within it, or the extension apart from the substance which is extended; for, as I have often said, nothingness cannot possess any extension. [...]

In the final sentence, Descartes suggests that there is a metaphysical dependence of space, as the shape or volume of the vessel, upon extension; and of extension upon something called "extended substance." Since it is abundantly clear that Descartes has written this

---

[2]For further defense of the shift of position from the *World* to the *Principles*, see R. S. Woolhouse, *Descartes, Spinoza, Leibniz: The Concept of Substance in Seventeenth Century Metaphysics* (Routledge, 1993), 82. Some passages in the *World* suggest that a break from the container metaphysic is already in progress during the writing of the *World*: see, e.g., XI, 36.

passage as an argument against vacuum, it appears that the "extended substance" of concern would be what is not vacuum, i.e., bodies – and this conception, of course, coincides with his previous identification of body with extension. So Descartes has argued that, when we examine the matter carefully, we cannot clearly conceive of space without bodies, as a consequence of the sort of "wholly necessary connection" that also makes it clear to us that "nothingness cannot possess any extension." The idea of vacuum, then, would appear to be the product of inconsistent thought; and so, no vacuum could exist in nature.

It is evident that Descartes' argument is problematic, for it has supported diverging interpretations, most of which render the argument rather flat, nonetheless. Are we to take seriously the suggestion that ideas of empty space are a "prejudice," and nothing more; or has Descartes merely invoked his definition of matter as extended substance (II:4) to argue the point?[3] Perhaps Descartes has an argument in the relation of "necessary connection" among concavity, extension, and substance;[4] an argument which we might give serious attention, if we were to embrace Descartes' very parsimonious theory of corporeal substance, which attempts to account for all the properties of body strictly in terms of three-dimensional geometry and time (II:4). That conception is laden with problems for independent reasons,[5] however; and nonetheless, other possibilities need to be ruled out: for we, and apparently some of Descartes' contemporaries, do not find a contradiction, or even a difficulty, in carefully conceiving of vacuum or void as a space without material bodies within it.[6] John Buridan did well enough long before Descartes when he wrote of vacuum as "a space distinct from the magnitudes of natural bodies, which does not have to give way in order to receive natural bodies... a volume [*dimensio corpora*] equal in length, width, and depth to the natural body that would fill it up if one placed it in this void."[7] Furthermore, beyond mere conceivability, the metaphysical point, at least in its ordinary Seventeenth century formulation, appears to have also been settled through physics: we know that a vacuum is possible, since nothing stopped Torricelli from removing some of the mercury

---

[3]These are taken to be the matter of the argument as expressed in John Cottingham, *A Descartes Dictionary* (Blackwell, 1993),159-60.
[4]Frederic De Buzon and Vincent Carraud, *Descartes et les "Principia" II: Corps et Mouvement* (PUF, 1994), 27.
[5]See, among others, Margaret Dauler Wilson, *Descartes* (Routledge, 1978), 87; Daniel Garber, *Descartes' Metaphysical Physics* (Chicago, 1992), 179-80; Stephen Gaukroger, *Descartes: An Intellectual Biography* (Oxford, 1995), 240; and Jonathan Bennett, this volume.
[6]For one contemporary, see Charles Sorel, *Science Universelle, Tome 1* (Paris: Pierre Billaine, 1634), 38ff. For predecessors, see Garber, *Descartes' Metaphysical Physics*, p.128 and for current conceptions, see Bennett's discussion of "container space," this volume.
[7]Buridan, quoted in Pierre Duhem, *Medieval Cosmology*, Roger Ariew ed. and trans., (Chicago, 1985), 408.

from a glass tube without replacing it with air.[8] Unfortunately for Descartes, and so for us, it appears that Torricelli did so just one month before the *Principles* were finished their printing; and worse, Pascal's most important experiment and the growing body of experimental work on the vacuum were brought to Descartes' attention just after the later French edition of the *Principles* went to press.[9] Could II:18 be an argument seriously intended to serve against such conceptions of vacuum, even though it preceded Descartes' survey of those empirical arguments taken to be in their support?[10]

Descartes has much more to say about vacuum, and I will argue here that his conception in the *Principles* is more coherent and more sophisticated than most critics have allowed. Though discussions of Descartes' treatment of vacuum in the World and in work after the *Principles*, such as the letters to More, are well covered,[11] critics make less frequent note of Descartes' earlier letters, and very few mention his discussion of vacuum contained in later portions of the *Principles*. In the latter source, Descartes makes little ado about considering the physical ramifications of "empty space," including a discussion of what the appearance of a star would be, were an empty space to lie at the center of a celestial vortex; so indeed, some ideas about empty space don't strike Descartes as in the least contradictory.[12] Descartes also addresses the experimental point in his discussions with Pascal late in 1647, and instead of suggesting conceptual incoherence on his junior colleague's part (which would seem to be appropriate for a vacuist who expresses himself as Descartes does at II:18), Descartes sets up his own experiments, and may have suggested to

---

[8]For continuation of the metaphysical debate as a Twentieth century physical problem, e.g., concerning vacuum fluctuations, see Simon Saunders & Harvey Brown, eds. *The Philosophy of Vacuum* (Clarendon, 1991). Concerning Torricelli, see W. E. Knowles Middleton, *The History of the Barometer* (Johns Hopkins, 1964), Ch.2.

[9]Torricelli's experiments probably occurred in June 1644 (see Middleton, 22), and the *Principia* were printed by 10 July. Descartes to Princess Elizabeth, 6 June, 1647 (V, 60) mentions that the complete French *Principles* are already in press; Descartes' renewed engagement on the topic of the space above the mercury appears to have taken place in a meeting with Pascal in September of 1647, for Descartes writes to Mersenne in December that "I am surprised that you have kept this experiment secret for four years, as has the afore-mentioned M. Pascal..." Mersenne had experimented on the vacuum over 3 years before, and Pascal just one year before their meeting. For a detailed account of the history of Descartes' study of the experimental phenomenon, see Garber, *Descartes' Metaphysical Physics*, 136-43.

[10]Such a view of II:16-18 is expressed in Daniel Garber, "Descartes' Physics," in John Cottingham, ed., *The Cambridge Companion to Descartes* (Cambridge, 1992), 299-300, though with reference to Greek atomism, rather than to Descartes' contemporaries.

[11]See especially Garber, *Descartes' Metaphysical Physics*, Ch. 4-5.

[12]III:64. See discussion and defense, below.

Pascal "an experiment to see whether the mercury rises as high on the top of a mountain as at the foot."[13]

I would like to suggest that Descartes' arguments about vacuum in the *Principles* and other early writings have lately been misunderstood, and I hope to improve the general estimation of their coherence. They are difficult to read and to understand because the discussion of II:4-33, and further work in Principles III and IV, contain many distinct arguments presented as responses to at least three distinguishable threads of discussion concerning void that were current at the time of writing of the *Principles*. Though it has become difficult for us, at a historical distance, to distinguish the different lines of argument all put under the title "vacuum" by Descartes, to an audience familiar with the tradition of Albert of Saxony, and with Galileo's work, the different targets of many arguments should not have been difficult to sort out. Some of the arguments, such as II:18, may seem especially obtuse only because we cannot attend to their targets after having lost the historical thread. Several critics do acknowledge that Descartes' approach may be further illuminated by an investigation of Descartes' predecessors, and they make particular note of Edward Grant's helpful work on medieval conceptions of vacuum; but concerted efforts to explain the rationale of Descartes' approach and to explain his own conception of empty space have not been launched by these authors.[14] My main contribution, I expect, will be to separate two metaphysical strands that have received little careful attention, even though the first has received brief notice: the scholastic topic of annihilation of space, and Descartes' serious consideration of the possibility of physical vacuum in the third section of the *Principles*, and previously in correspondence with Mersenne concerning Galileo's discussion of vacuum. Exposing the former thread should reduce puzzlement surrounding II:18. The distinction between the two threads should clarify Descartes' odd habit of declaring vacuum "contradictory" in some contexts, "impossible" in others, and yet of arguing elsewhere at length to establish that none is present in our universe. Finally, in examining the latter thread, I will challenge the suggestion that Descartes ruled out vacuum conceptually or by definition, and that he did not countenance vacuum as a possibility within

---

[13]Descartes to Mersenne, 13 December 1647, contains the quotation and briefly mentions Descartes' experiments. Jacqueline Pascal reports on the meeting with Blaise Pascal, but does not clarify who proposed the experiment: see note p. 653 in Blaise Pascal, *Oeuvres Complètes*, Louis Lafuma ed. and notes (Éditions du Seuil, 1963).

[14]Desmond Clarke, *Descartes' Philosophy of Science* (Penn State, 1982), Garber, and Gaukroger refer readers to Edward Grant's *Sourcebook in Medieval Science* (Harvard, 1974), or to his detailed study, *Much Ado About Nothing* (Cambridge, 1981). Garber, *Descartes' Metaphysical Physics*, and Woolhouse, have presented the most serious efforts to clarify some aspects of Descartes' approach in discussion of Descartes' intersection with Pascal and with the 'container space' metaphysic respectively. Footnotes should indicate that I am indebted to these authors and to Bennett (this volume) in my discussion.

the metaphysics and physical science of the *Principles*. I will begin with an effort to clear up II:18 by discussing it in historical context, and in its context of argument, from II:5-19. A short foray into the historical background will be beneficial to start, however, since Descartes' argument is set against an Aristotelian tradition, and because his strategy of argument also shows specific parallels with that of Aristotle, whose approach may be easier to sort out.

Two arguments in Aristotle

That Descartes' discussion fits into a tradition is immediately apparent from a review of Aristotle's fourth book of the *Physics*, which provides argument with some similarities to Descartes' own. The treatment by Aristotle that, on the face of it, most closely parallels Descartes' discussion at II:18 runs as follows:

> The reason for thinking that between the limits of the container there is some kind of extension is that the distinct object contained often moves while the container stays still (think of pouring water out of a vessel), which makes it look as though there is something over and above the body which is being displaced. But this is wrong. What actually happens is that some other body – it could be anything, as long as it can be displaced and can fit the container – comes in to replace the original body. If place were some kind of extension which was capable of independent and permanent existence, there would be an infinite number of places in the same thing, because when water (or air) is being displaced, bit by bit, every bit behaves in the same way... Also, place will not in fact be a stable entity, and so one place will occupy another place, and there will be a plurality of coincident places.[15]

Aristotle argues in this passage that, because space is full of bodies, one body is replaced by another as the former is poured from a vessel. Descartes and Aristotle agree on this point as plenist physicists who hold that the physical universe is entirely filled with bodies. Descartes presents similar discussions of the flow of unperceived bodies into spaces vacated by others in his explanation of rarefaction (II:6) and his treatment of jugs, water, and air (II:16, 17). Aristotle's final two sentences in the passage above contain arguments in service of his claim that place is "the limit of the containing body" (212a4) rather than a thing itself: Aristotle is arguing for the claim that the place of an object, which he takes to be identical with the volume that it fills (216b12), is metaphysically dependent upon body, and is not itself a "stable entity. " Once again, this aspect of Aristotle's view coincides nicely with Descartes' physics in the *Principles* (cf., *Principles* II:10, 45). Points of divergence between the two authors can be found further on, however, in *Physics* IV:5, where Aristotle's

[15]Aristotle, *Physics*, trans. Robin Waterfield (Oxford, 1994), 87: *Physics* IV:4, 211b14-24.

concept of place is developed further, both as an explanation of gravitation through natural motion, and as a resource for absolute points of reference in space to which natural motions may be referred (211a21). Of course, Descartes' competing explanation of gravity (IV:20) and his relativistic conception of motion (II:28) conflict with those Aristotelian explanations quite directly.[16]

Descartes' argument at II:18 concerns void, however, and neither volume nor Aristotelian place. What Descartes may be attempting to defend, in Aristotle's words, is "that the only kind of extension there is is the extension of bodies, and that this cannot be separated from bodies or exist without them in actuality..." (Physics IV:6, 213a32; cf., Principles II:11, 46). The argument in Aristotle that most nearly approaches Descartes' treatment, then, is not the superficially similar discussion of the pitcher, but instead, the following:

> If you put a cube in water, an amount of water equal to the cube will be displaced. ...But this is impossible in a void, since a void is not a body. What must happen instead is that an already existing extension within the void, of equal dimension to the cube, must have penetrated the cube – as if the water or air were completely to permeate the wooden cube rather than being displaced by it. ...So what will be the difference between the body of the cube and the void and place which are equal to it? And if two things can behave like this, why cannot any number of things coincide? (216a27-b10)

Aristotle suggests that one might as well maintain that void is everywhere as that it is in a particular extended space where no body is, since it has similar properties – or similarly lacks properties – in either case. Clearly this alone wouldn't quite suffice as an argument to the conclusion "that the only kind of extension there is is the extension of bodies," and in fact, Aristotle is not arguing for that conclusion in this passage. Instead, he is only attempting to explain "what void is in its own right" (216a26), and his unsurprising suggestion is that if we consider it as distinct from all of place, extension and impenetrability, spatial void would not be distinguishable from (any other) nothing, or, as he may be taken to suggest in the final sentence, two or more voids in just the same spot! This discussion, then, is intended to point out a possible conceptual incoherence, and it would seems that Aristotle's argument against the existence of a physical vacuum must lie elsewhere; in fact, primarily in the passages of *Physics* IV:8 that precede this discussion. We will see shortly that Descartes is engaged in a similar effort of conceptual clarification at II:18.

---

[16]Descartes lays out his own more restricted conception of place at II:13-15.

A survey of those prior arguments reveals that Aristotle is concerned with showing the impossibility of the actual existence of void by reason of its incompatibility with the evidence presented by bodies in motion. Aristotle explains that his theory of motion implies that vacuum could not possibly have a place (214b17), nor coherently allow for the possibility of motion (214 b28-215a23).[17] Consequently, Aristotle's physics is plenist: matter must be everywhere that Aristotelian physics holds true, and so, wherever we find such a physics to hold, vacuum could not possibly be resident as well. Since Aristotle's discussion at 216a27ff. is explicitly couched in terms of plenist physics, we must consider that argument, which is only meant to clear up a conceptual confusion, to be one carried out under the plenist assumption, and not an attempt to establish the inconceivability of void *simpliciter*. Aristotle directly follows his discussion of the cube with the claim that the implication of the vacuist assumption, that two things may coincide, is an "absurd and impossible consequence." Again, I'd like to suggest that Aristotle does not argue here for the inconceivability of vacuum, but rather, he indicates the incompatibility, the "impossible consequence," of a vacuum existing in a physical world which includes the motions of objects that we perceive; a world that he has explained in terms of plenum and place, based upon independent justification. A separate void in an entirely empty universe has not been shown to be inconceivable; rather, in the world we experience, "It contributes nothing for there to be some other such extension, equal to the volume [of a material cube], but different from it." (216b19)[18]

What would the conceptions of vacuum that Descartes finds untenable be? For Aristotle, the coherent but physically incompatible position is presented in the void space of the atomists. Aristotle suggests that the impossible consequences engendered by conceiving of motion in a void show that the best arguments for vacuum, concerning motion, fail (216a21). Like Aristotle, Descartes will involve himself in two distinct tasks, of clearing conceptual confusion, and arguing that vacuum is ruled out empirically. Descartes will explicitly consider atomism in II:20ff.; so at II:18, it seems reasonable that his target could be the same opponent, or another, but Descartes leaves little trace to indicate just who his opponents are.[19] From the few clues that are present, however, and because the II:18 argument seems like a strong response to one position readily available for discussion at the time, I suggest that Descartes is arguing in passages from II:16-18 against a scholastic line

[17]These arguments are supplemented by arguments for the necessity of a motive medium 215a24-216a10.
[18]On the conceivability of vacuum in an Aristotelian physics, see Roger Bacon's position in Grant, *Much Ado About Nothing,* p. 106.
[19]Garber, "Descartes' Physics," 300, holds that Descartes positions himself against Greek atomist tenets at all of II:16-20. Garber correctly identifies the strategy of attack, which I will detail below, but overestimates the range of opponents addressed.

of thought that may be found in Albert of Saxony and is also represented in Descartes' time in the work of André d'Abillon. I will argue that Descartes attempts to clear up arguments such as Albert's in the passage at II:18, by arguing that Albert's position is a conceptual confusion, much as Aristotle approaches a different confusion at 216a27. Section II:20ff., by contrast, represents a shift of response, to a coherent conception of vacuum, found in Galilean atomists in particular, and discussion in Parts III and IV of the *Principles* covers yet another area of discussion of vacuum, this time a vacuum that Descartes suggests is physically possible, but then dismisses due to the weight of further empirical evidence. I will take up each of these claims in the three sections below.

Descartes' arguments: I: Against Vacuum without measure

Though far from contemporary with Descartes, Albert of Saxony (*ca.* 1316-1390) stands as a particularly appropriate figure to consider because his texts, in their many printed editions, were the principal source of knowledge of the scholastics' positions at least to the start of the Seventeenth century.[20] Though Albert largely follows John Buridan in his discussion of the void, his elaboration on the topic of annihilation of space shows significant changes and embellishments that are carried through and still taken as current thought in contemporary works that are similar in purpose to Descartes' *Principles*.[21] Descartes is not often one who identifies his opposition explicitly, however, and so Albert's text remains a useful focal point, as well as a particularly accessible one for us today.[22]

Albert begins his treatment of vacuum by arguing that, though vacuum can be defined as "'a place not filled by body,'" this does not imply that any vacuum exists. That is, Albert notes that being able to define the term does not show that the thing defined exists. But a vacuum could exist, Albert suggests; and he is careful to explain how one might come about, and what, then, it would be:

> a vacuum is possible by means of supernatural power. This is obvious, because God could annihilate everything that is within the sides [or concave surface parts] of the sky, after which the sky would be a vacuum...

To this point, Aristotle might have agreed with Albert, were he to have accepted Albert's premise concerning divine powers. Albert's continuation, however, shows a remarkable further development:

---

[20]Ernest Moodey, "Albert of Saxony," *Dictionary of Scientific Biography*, **I** 95.
[21]See especially the third book of André d'Abillon's *Nouveau Cours de Philosophie en François*: *La Physique des bons esprits, ou l'Idee et Abrege d'une Physique Familiere et Solide divisee en cinq livres* (Paris: S. Picquet, 1643), 278 ff.
[22]Albert of Saxony, *Questions on the Physics of Aristotle* Book IV, Question 8. Translated by Edward Grant in Grant, ed. *A Sourcebook in Medieval Science* (Harvard, 1974), 325-6.

> either the sides of the sky would be distant [that is, separated] or not. If they are not separated by a distance, they would be conjoined as two leaves of a book or an empty purse; but then it ought not to be conceded that the sky is a vacuum, because in the aforesaid case the sides of the sky would be immediate [that is, in contact]. If, however, it should be stated in this case that the sides of the sky are yet distant [or separated], there would then be some dimension between them by which they would be distant [or separated]; hence there would be no vacuum. To this one might respond that the sides [or concave surface parts] of the sky are not distant [or separated] by a straight line, although they may well be separated by a curved line. But if it is said that then the sides of the sky would be conjoined, I deny this, for the sky would remain spherical, just as now; and its sides would not be in direct contact, even if not separated by a [rectilinear] distance.

Albert's claim, then, is that we could measure distance *around the periphery* of such a true vacuum, but we could not measure distance *across* it: we could circumscribe the vacuum, but not measure it directly, as Descartes' contemporary André d'Abillon would suggest.[23] Though it could be a 'place', insofar as it would be the limit of the sphere of the moon as a containing body,[24] such a vacuum induced by God would not appropriately be called a space. I expect that Albert maintains that it could not be "a separate space in which there is no other body conjointly," because "a separate accident must not be assumed to exist without a subject." Albert's point, then, would be the plausible consequence of an Aristotelian metaphysics applied in a rather surprising situation: if God were to annihilate the region below the sphere of the moon, then no substance or *body* would be present; and so no bodily accident, such as length, could be present.[25]

---

[23]"les deux poles seroient distans, mais que entre eux deux, il ny auroit point de distance, car il ny auraoit rien entre les deux poles." D'Abillon, 304.

[24]Albert sketches this distinction in his treatment, which Toletus refers to as "external place:" see Woolhouse, 83.

[25]Albert of Saxony, 325; reaffirmed in arguments p.326. Note that this interpretation of Aristotelian metaphysics does not allow for the possibility of an accident occurring independently of substance, and would perhaps be unsurprising if it didn't also contradict one of the Condemnations of 1277 and Buridan's interpretation, which both maintain that God could create an accident without a subject (see Duhem, 410, and Grant, *Sourcebook*, 325 fn.7). Albert only allows this single way of conceiving of supernatural created vacuum, however, and explicitly denies Buridan's alternative conception, that there is a *dimensio corpora* that might remain in God's creation of vacuum. Duhem and Grant dismiss this difference, perhaps as a neglected possibility, but neither offers any substantial support for the dismissal. Albert is also followed in this explicit claim that where no substance is, no accident can be, by Descartes' contemporary Pierre Du Moulin; but only the natural and not the divine case is considered in *La Philosophie Mise en Francois et diuisee en trois parties, Sçauoir. Elements de la Logique. La Physique, ou Science Naturelle. L'Ethique, ou Science Morale* (Paris: Thomas Blaise, 1644), 18.

With Albert's argument, and the plausible justification in Aristotelian metaphysics in view, I hope that Descartes' discussion at II:18 appears more an argument, less a simple confusion. That argument, and the material leading up to it in II:16-17, stand as Descartes' effort to show the incoherence attendant upon attempts to consider what he calls vacuum in the "philosophical sense," "i.e., that in which there is nothing whatsoever:" a region that can be identified (e.g., circumscribed) yet is not measurable (II:16). Descartes' position appears to follow as a consequence of his own theory of extended substance, as Albert's did for Albert. Albert found there to be no bodily accidents without attendant substance, and Descartes' theory contains the principle that "There is no real difference between space and corporeal substance." (II:11) This appears to leave no room for vacuum in the sense that Albert suggests, for Descartes writes:

> For a body's being extended in length, breadth and depth in itself warrants the conclusion that it is a substance, since it is a complete contradiction that a particular extension should belong to nothing; and the same conclusion must be drawn with respect to a space that is supposed to be a vacuum, namely that since there is extension in it, there must necessarily be substance in it as well. (II:16)

Descartes continues in II:17 to consider why we might be deceived concerning our ordinary use of the term 'empty,' and in II:18 produces the argument with which we began. He finishes that discussion by effectively contradicting what Albert has supposed to hold true concerning a place in which substance is annihilated: "if God were to take away every single body contained in a vessel ... the sides of the vessel would, in that case, have to be in contact. For when there is nothing between two bodies they must necessarily touch each other." The argument might be considered a mere quibble if we allow that all Descartes has done is invoke his definition of matter as extended substance (II:4) to argue the point. Descartes follows his conclusion with further support, however:

> For when there is nothing between two bodies they must necessarily touch each other. And it is a manifest contradiction for them to be apart, or to have a distance between them, when the distance in question is nothing; for every distance is a mode of extension, and therefore cannot exist without an extended substance.

The final clause above might have been directed specifically at Albert or his followers, but the rest of Descartes' argument is more general. It might be well expressed using a subject that Albert has touched on, and that is especially dear to Descartes – geometry. Should the material inside the sphere of the moon be annihilated, then on Albert's account, basic geometric truths that Descartes would consider internal to the concept of a sphere would be violated, such as, that any great circle over the sphere would be equal to 2π times the radius of the sphere (VII, 225): for on Albert's account, that sphere really would not have a radius.

Who has it right in this regard: Albert or Descartes? My imagination cleaves to Descartes' line, but I only see an argument about imagination in Descartes' discussion, not even the geometric argument I have proposed. Furthermore, whether Descartes might allow that God would nonetheless be able to create such a vacuum despite our inability to conceive such a possibility cannot, I think, be easily settled, for it would take us deep into a different area of Descartes' thought, concerning the limits of God's power over contradictions and eternal truths.[26] Concerning Albert's proposal, the heart of the matter lies in a debate concerning the abilities of the God of the scholastics in relation to Aristotelian metaphysics, and in a disagreement with John Buridan, and I have nothing to add to those discussions.[27] Adjudicating such points is not my purpose here, sorting out a puzzling passage of Descartes' writing is, and the puzzle appears to be solved. Descartes' discussion in Part II of the *Principles* is not focused upon a treatment of the power of God, whereas Albert's is. Descartes is not concerned with whether God could perform such an annihilation; rather, Descartes' point is that the only sensible conception of such an event happening would include as a result the sides of the vessel lying against one another – a vessel no more – instead of the result that Albert envisions, which, I suppose, would allow what appears as a vessel from the outside, but one which nonetheless can contain nothing.[28] The two authors are at cross purposes, as one is focused on constructing a coherent theory of material substance, and the other is concerned with God's power; but at least Descartes' much maligned argument is an understandable one when directed to Albert, or d'Abillon, and is a response centered upon the point at issue for Descartes, the coherence of one's theory of material substance.

It seems unlikely, then, that Descartes is attempting to argue incoherently against the conceivability of the sort of vacuum Buridan characterized as "a volume [*dimensio corpora*] equal in length, width, and depth to the natural body that would fill it up if one placed it in this void." That conception of space as a container, in which matter is to be placed, will demand a very different sort of treatment from Descartes, and indeed, Descartes marks the difference between opponents here by referring to only some of them as proponents of a "philosophical" conception of vacuum. Descartes' discussion of confused philosophical

---

[26]On that topic, see Descartes (VII, 145), and Descartes' letters to More, 5 February 1649, and to Arnauld, 29 July 1648. In these letters, Descartes states that he would not positively claim that God *can* do what Descartes cannot conceive clearly (V, 272), implying, I expect, that he would not claim that God cannot do it either; yet he also explains that "no barrel can be conceived to be so empty as to have inside it not extension, and therefore no body" (V, 224). See also De Buzon and Carraud, 27-9; Garber, *Descartes' Metaphysical Physics*, 151-2.

[27]For an account of the larger debate, see Duhem, 369-430.

[28]Cf., d'Abillon's characterization: "vn lieu, c'est a dire vne superficie concaue, dans laquelle il ny ait rien," which is entirely lacking in "espace, ou capacité" (297, 304).

conceptions of vacuum is contained in *Principles* II:16-18, and that discussion is nested within a larger discussion of a parallel philosophical conception of rarefaction that spans II:5-19. From II:20 forward, Descartes will argue in a different manner against what he takes to be a more sensible possibility, concerning a physical vacuum lying in the interstices between atomistic particles of matter. Descartes will consider larger macroscopic spaces in parts III and IV. These opponents I will dub 'physical vacuists,' and to them we now turn. Before considering Descartes' discussion at II:20, it will be worth jumping further ahead in the *Principles* to his discussion of macroscopic vacuum, where Descartes makes it especially clear that he countenances a number of conceptions of vacuum, and that vacuum construed as a region without extension is the only conception among them that he takes to be a confused.

II: On Space without plenum: Against Macroscopic void

The wine cask argument in Descartes' earlier work, the *World*, was intended to show that no macroscopic void, of the size of a drop of wine or larger, could exist in nature. Given Descartes' new metaphysical assumptions, however, space is not conceived as a container full of matter that holds the wine inside its cask. The wine cask argument against vacuum is unworkable, then, though we might still hope that Descartes will be able to explain the physical phenomenon by some other reasoning at some point. Not only is the argument unworkable: I believe that Descartes has reversed his views concerning the compatibility of macroscopic vacuum with the phenomenon of the wine suspended in the cask. Descartes no longer argues that physical phenomena are entirely incompatible with physical vacuum as reconceived according to his new account of space: instead, he is very clear about the possibility of vacuum existing, in his treatment of celestial mechanics in Part III (62-4), but he then rules out the possibility of it forming under any ordinary circumstances in his treatment of terrestrial gravity in Part IV (21-22). But what could vacuum be, on this reconception, and how to account for the wine cask?

On the *Principles* account, the physical universe is composed of three elements (III:52). In his efforts to elucidate his characterization of the second element that populates most of non-terrestrial space, Descartes writes:

> I shall examine [the effect of] these globules separately, without considering the matter of the first element any more than if all the spaces which that matter occupies were empty [*vacua essent*]; that is, if they were filled by a material which neither contributed anything to the motion of other bodies nor in any way impeded it. For in

> accordance with what has already been said, there obviously can be no other correct idea of empty space. (III:60; cf. IV:21)[29]

Though Descartes plainly commences his discussion of this fine matter as a conceptual simplification to account for the finer matter of the first element, that he finds such a simplification coherent already suggests his assent to the coherence of the idea of physical vacuum (cf. also II:12). Descartes goes on to develop the account by adding a discussion of a number of physical consequences that bring the concept of vacuum into its own. The vacuum, though it contains 'bodies', as Descartes suggests, appears to contain bodies with no discernible properties except extension: a continuous medium with no discernible particle size. Would this do well enough as a sensible Seventeenth century conception of macroscopic physical vacuum, worth the attention of Torricelli and Pascal?

The vacuum Descartes considers can easily be distinguished from particles of both the first and second elements. If such a vacuum were to surround the surface of the spinning earth, Descartes suggests, earthy bodies of the third element would fly *away* from the planet to fill the void (IV:21). That is the opposite of the activity of the third element in the presence of the second, for the vortex of particles of the second element that shrouds the earth drives earthy objects to the center of that vortex, and so, particles of the second element that are below earthy ones would flee the center of the earth's vortex. For like physical reasons, bodies of the first element would move similarly in the presence of bodies of the third. Only in the presence of vacuum, then, would the third element move away from the vortex's center. It would not do so in the presence of finer particles of any size, even those of the first element that are "divided into particles of indefinite smallness" (III:52).

There are other independent physical reasons for distinguishing vacuum from the first element. The first element "adapts its shapes to fill all the narrow parts" of space around larger particles (III:52), and for that reason, plays the role of the connecting medium that allows for light transmission. It must be unlike the vacuum, however, because of consequences concerning motion in the celestial vortex, and especially the motion that is light (III:64). Descartes suggests that, were a vacuum of the sort that he envisions present in a celestial vortex, bodies of the second element would fill it, and a space would shortly appear at the center of the vortex, as a consequence of the other bodies' tendency to move away from the center. A similar state of affairs would obtain between matter of the first and second elements, but Descartes closes by once again distinguishing between the first element and vacuum. Because bodies of the second element revolving in a vortex would strive away from the center, a universe with vacuum in place of the first element would be

---

[29]Quotations of *Principles* III and IV are from the translation of V. Miller and R. Miller (D. Reidel, 1984).

different from ours, but not by much: "if the body of the Sun were nothing other than an empty space, nevertheless, its light (which would admittedly not be as strong, but which would otherwise not differ from what it now is) would still be perceived by us." (III:64)

Descartes' view appears to allows for the following possible scenario. Imagine that God creates a vacuum of elements inside a pitcher on the earth's surface. This vacuum would not, of course, be appropriately characterized by the confused "philosophical" conception of vacuum dispensed with in the previous section: it would be body with no humanly detectable property excepting extension, and the sides of the pitcher would remain separate, and ready to contain material, such as air, that would soon fall into its open cavity. As material falls in, vacuum would re-appear in the place previously occupied by that material, were it not the case that other material is immediately present, and moving just as quickly to fill the prospective gap. Because all of the elements within a Cartesian vortex strive away from the center of rotation (III:60), this would suggest as a consequence that a new vacuum would make its appearance at the center of the Earth (as has been suggested two paragraphs above); but the celestial vortex also constricts the terrestrial one in its striving away from its own center, and so the entire dimension of the earth vortex would reduce by the volume of one pitcher. That constriction would be complemented by a similar adjustment in the ether that carries the earth vortex, and a vacuum would appear as quickly as one has disappeared, now at the center of the celestial vortex. The details of this scenario have been necessary to make the following point: The vacuum, it seems, would not be an entity that travels with a discernible path towards the center of the celestial vortex as would a body composed of, say, a distinct fourth element still finer than the first, that is chased away from its original place. Such a vacuum would have no intrinsic bulk, for as matter moves in (however fast) to fill the void in the pitcher, other matter would be in position to move just as quickly to fill any space as it became vacant, throughout the terrestrial and celestial vortices, excepting at the center of the latter, where a new vacuum would simply appear. What I will call 'Cartesian vacuum', then, does not occupy space as ordinary matter does: to the limits of human abilities to detect it, it is only space or extension, pure and simple, and in this most important respect it does not seem to diverge from what one would expect a physical vacuum to be.

Descartes' discussion of dim stars late in the *Principles* suggests that he did indeed mean to allow for the possibility of such a scenario despite that this appears to conflict with one important tenet of his system. The tenet is plenist physics, the view that the universe is full of bodies and that all motion is merely circulation of bodies, with no gaps among them of the sort that I have characterized as Cartesian vacuum. Even after the shift to the new conception of space in the *Principles*, the tenet plays its role in many important explanations

of phenomena, such as gravity and the transmission of light. The conflict is only apparent, however, because Descartes' physics does not require such plenism, even though he is under the impression that no vacuum exists (II:33). Though vacuum is not an impossibility, Descartes still has the plenum for most practical purposes anyway, because vacuum is so readily removed from our ordinary local physical environment. Practically, the physical universe in which we move is full: whatever vacuum may arise at the birth of the universe, or due to divine action, quickly becomes isolated at the center of a hollow vortex that continues to press its inner boundaries outwards by virtue of the naturalness of rectilinear motion (II:39, III:58). The sun might change some characteristics, such as luminosity, but nothing else would be new under the sun, unless one were able by some means to oppose the pressure of the celestial vortex and recall vacuum from the center of the vortex: a topic that will be at issue in Descartes' discussion with Pascal in the next section. I will argue in the next section that Descartes has good reasons for defending this conception against Pascal, even in the face of the experiments Descartes came to confront after the *Principles*; for Descartes can allow that such a vacuum might exist at the center of a star, and nonetheless plausibly defend the claim that what Pascal discovered through his experimental manipulations was material of the second element, and not such (non-bulky) vacuum.

The problem of the wine cask with which we began has, of course, been solved along the way: whether or not there is a physical plenum, the pressure imposed by the celestial vortex upon the earth's atmosphere accounts for the wine's inability to flow. The wine cask argument, then, is displaced from Descartes' universe, not to re-appear in the *Principles*. Container space vanishes also, but a sensible conception of vacuum remains, and vacua might have existed at the centers of Cartesian stars, though Descartes claims that they do not. He has not provided a clear argument to suggest that vacua do not reside there in our universe, however, for though stars with such holes at their centers might be dimmer than filled stars, Descartes has provided no argument to suggest that some (or all) the stars we observe are not just such dim stars!

III: On Rarefaction and against Galilean interstitial void

To this point, I have argued that Descartes considers two very different sorts of vacuist position, and replies to them in two very different sorts of ways. Descartes responds with conceptual analysis to those 'philosophical' vacuists who argue that vacuum is truly nothing. To those who argue that space may contain extension devoid of any other properties of matter, Descartes proposes a physical argument concerning the physical consequences of such void space in a fluid medium of the elements. In this section I will introduce a final area of concern in the *Principles*, Descartes' focus on void and rarefaction.

The discussion of rarefaction overlaps the other two treatments in that Descartes presents *both* conceptual clarification and physical argument, and I will suggest that the two sorts of arguments are again directed at different opponents. Clarification is once more used to respond to opponents – such as Albert, once again – who argue that matter itself may expand and contract. Descartes takes the other tack in his discussion of atomism and void from II:21ff.: a new set of physical arguments are necessary to respond to different opponents, his atomist contemporaries. Descartes' purpose is to show the irreconcilability of atomism with plenism, and in his letters to Mersenne, though not in the systematic exposition of the *Principles,* Descartes also responds to independent arguments from Galileo intended to deny plenism and support the hypothesis of a vacuum between atoms: an interstitial, microscopic void. I will consider these arguments in turn.

Descartes' first attack in the *Principles* upon interstitial void concerns topics introduced by Aristotle (213b14), such as the apparent increase in size of an object without apparent increase in quantity of matter; as wine, for example, behaves during fermentation. Aristotle's position is that expansion and diminution of matter itself does occur, and that consequently, such an example of rarefaction would not support claims concerning the existence of an interstitial void between particles (214a26ff.). That matter may itself expand can be found in Albert as well,[30] and it should be no surprise that this constitutes what Descartes considers a conceptually confused philosophical position concerning the nature of matter. Descartes holds that rarefaction of such an object occurs much as rarefaction of a dry sponge does when it is placed in water, absorbing other particles from its environment: "its pores are open wider, so that it spreads over a greater space" (II:6). A quantity of matter cannot itself expand because matter can be clearly conceived of in terms of its extension only: more extension just is more matter (II:9). Descartes' argument on this topic concludes at II:19, so it is clear that the clarification concerning the terms 'place' and 'space', and the examination of faulty conceptions of vacuum that we have considered above are intended to clarify misconceptions concerning the rarefaction of wine as well as the space in the pitcher it occupies: Descartes effectively completes at II:19 a discussion he has begun at II:5, where he marks his concern with "preconceived opinions concerning [both] rarefaction and empty space." I will not, however, consider this argument further here: Descartes' argument is certainly flagged at II:9 as an effort to clarify conceptual confusion; how much clarification

[30]Albert of Saxony, Questions on the Physics of Aristotle, Book IV, Question 12. Translated by Edward Grant in Grant, ed. *A Sourcebook in Medieval Science* (Harvard, 1974), 339.

results from Descartes' argument I will leave to others to consider,[31] so that I may keep this paper focused on Descartes' account of vacuum.

From II:20 forward, however, Descartes is not concerned with the preconceived opinions of the "philosophical" vacuist and matter theorist. His target, after making a conceptual point at II:20, is of a different sort: the atomist who allows for the possibility of interstitial micro-vacuum between individual atoms in a solid or fluid body. Though, as I've suggested in the previous section and will support further below, Descartes could find such a conception of vacuum "intelligible," he nonetheless also holds that there is no such vacuum, because "every place is full of bodies" (II:33). Descartes' treatment of atomism culminates in a response at II:33-5, in a thought experiment intended to demonstrate that motion is possible without recourse to vacuum for the plenist, whereas it would require vacuum of the atomist. In the argument, Descartes asks the reader to consider a collection of bodies flowing through a closed circuit of motion in a fixed volume, and then to consider the consequences of including a continuously narrowing funnel within that circuit. The narrowing, he suggests, demands that the flowing material must be effectively continuous, or composed of assorted sizes that diminish *ad infinitum* if the whole is to remain of constant volume, for, as the passage narrows by infinitesimal degrees, the particles must re-assort themselves in indefinitely many combinations of breadth to accommodate that narrowing. Under the assumption that the universe is in fact full, and so all bodies move in closed circles of constant net volume, Descartes suggests that such motion is possible only if there is no smallest particle – i.e., no atom – for no vacuum can be created to allow the change in volume that would be required for atoms to assort themselves in order to pass through such a passage. If there were a smallest actual particle, then, we might expect that any such movement would be halted wherever it were to occur throughout the universe, as particles would jam at whatever continuously constricting spaces they were to encounter.

The atomist, therefore, cannot allow the scenario that Descartes envisions without appeal to vacuum. Why not, then, appeal to vacuum, especially since Descartes suggests further on that vacuum is actually possible? Descartes claims to have found earlier that the universe is full of bodies, but in the Latin text he does not claim to have provided a demonstration; and indeed, the previous argument hardly suffices to seal the case against the atomist. If he had shown previously that vacuum is impossible, the demonstration at II:33 would also be quite redundant. Descartes claims to have shown the impossibility of the vacuum of atomists later, at IV:202, but that passage follows the discussion of macroscopic vacuum in III and IV also, after which he might more justly (though nonetheless

[31]See Bennett, this volume, and see Woolhouse's discussion of the views of some of Descartes' opponents in detail, 84-6.

erroneously), conclude that he has constructed a demonstration. So the question remains: why not allow for the creation of such an interstitial vacuum, that is drawn from the center of a vacuous star, perhaps?

I can find no compelling evidence in the *Principles* to complete this argument, though some support may be found in other writings. Descartes finds a contemporary opponent for this portion of the *Principles* in Galileo, in the *Two New Sciences*. Descartes certainly read Galileo's book, which he discusses in great detail with Mersenne in about a dozen letters over the course of a year, beginning in October of 1638.[32] It will be worth a careful excursion into Galileo's text and Descartes' comments to determine how Descartes extended himself to reply to this sort of vacuist position, in order to show that he did not find vacuum in this case to be an incoherent concept, as he does for philosophical vacuum at II:18.

In one of the passages Descartes focuses upon, Galileo notes that two marble plates, if well-polished, will slide smoothly alongside one another, but will momentarily resist lateral separation, even when great force is applied. Galileo applies this observation to philosophical effect by using it to call Aristotelian arguments concerning motion in a vacuum into question:

> Seeing the lower slab follow the upper when this is lifted with swift motion assures us that motion in the void would not be instantaneous despite the opinion of many philosophers, and perhaps of Aristotle himself. For if it were, the two surfaces would be separated without any resistance whatever, the same instant of time sufficing for their separation and for the running together of the surrounding air to fill the void that might [otherwise] remain between them. Thus, from the following of the upper slab by the lower, it is deduced that motion in a void would not be instantaneous.

Though this reply has significant affinities with the position Descartes develops in the *Principles*, at the next link in his chain of reasoning, Galileo does not move as Descartes would; for on the basis of the phenomenon, he concludes that a vacuum exists:

> It is then further deduced that some void indeed does remain between the surfaces, at least for a very brief time; that is, for as long as the time consumed by the ambient air in running to fill this void. For if no void existed there, neither would there be

[32]See most of the correspondence between Descartes and Mersenne to 25 December 1639, at which point the discussion of vacuum and pumps shifts to water lifting devices based on other principles.

> any need on the part of the ambient air of running together, or of any other motion.[33]

Here Galileo proposes the existence of a small microlayer vacuum, providing an ingenious analysis of a phenomenon that stands as a plausible counterexample to Descartes' anti-vacuist position in II:33-5. The separation of the plates, which approximates a separation of two planes, would require an infinite velocity of in-rushing air if the separation were to occur without pause.[34] The air particles, we might also note as a consequence of Descartes' analysis above, would have to begin their infinite rush at the first infinitesimal separation of the plates, to ensure that no vacuum existed in nature. But that a resistance to separation arises, and a pause is required before the marbles are separated, suggests to Galileo that a genuine vacuum is demonstrated by this phenomenon: one that exists at least for the space of time it takes for the in-rushing air, whether it is atomistic or infinitesimal in size, to flow between the plates and meet at their centers.

Galileo proceeds further with his analysis of the example, and brings the discussion around to a theory of interstitial vacuum as he generalizes his conclusion concerning the marble surfaces in a hypothesis concerning the general characteristic of cohesion among the parts of solid and fluid bodies. Perhaps, he suggests, the vacuum force that holds the two marble plates together is the same force as the interstitial force that holds molecule to molecule in a body, each attracted to the other by a mutual resistance to a vacuum between each pair of particles. After proposing an experiment to measure the attractive power of vacuum, Galileo proceeds to a discussion of pumping devices, and notes the observation related to him by an expert that no suction pump will lift water in a column to a height greater than "18 Braccia." He concludes:

> although I understood that a rope, a wooden staff, or an iron rod can be lengthened until its own weight breaks it when attached from above, it never occurred to me that the same thing will happen, and much more easily, with a rope or rod of water. And that which is drawn up in a pump is nothing else than a cylinder of water which, having its attachment above and being lengthened more and more, finally arrives at that boundary beyond which it breaks, just as if it were a rope. (64)

Galileo suggests, then, that vacuum provides a force of cohesion within solid and fluid bodies. His approach provides a surprising twist on Aristotelian metaphysics, for he

---

[33]Galileo Galilee, *Opere* VII 60. Translated by Stillman Drake in Galileo, *Two New Sciences* (Wisconsin, 1974), 20.

[34]The physical problem of the separation of planes, and a response similar to Descartes' (see below) can also be found in an abstract treatment in Francisco Suarez, *Disputationes Metaphysicae* 19.1.7. See F. Suarez, *On Efficient Causality: Metaphysical Disputations 17, 18 and 19*. Alfred J. Freddoso, trans. (Yale, 1994).

allows that nature abhors a vacuum not absolutely, but only to a limited degree: to a measure of force that correlates with a column the height of 18 Braccia in the case of water, to a greater measure in the case of iron, *etc*. Galileo completes his account of interstitial vacua with another hypothesis concerning the supposed effects of fire for breaking the vacuum that holds gold in its rigid shape:

> Sometimes, in considering how heat goes snaking among the minimum particles of this or that metal, so firmly joined together, and finally separates and disunites them; and how then, the heat departing, they return to reunite with the same tenacity as before, without the quantity of gold being diminished... I have thought that this may come about because of very subtle fire-particles. ...these might, by filling the minimum voids distributed between these minimum particles [of metal], free them from that force with which those voids attract one [particle] against another, forbidding their separation. And being thus able to move freely, their mass would become fluid, and remain so until the fire-particles between them depart. But when these go, leaving the pristine voids, the usual attraction returns, and consequently the attachment of the parts. (66-7)

Galileo's hypotheses concerning the phenomena of the marble plates, interstitial vacua and the action of fire, then, stand as a body of theory clearly opposed to Descartes' plenist physics. Do Descartes' replies to Galileo suggest that he did find such a conception of vacuum intelligible, even if false? Yes, but with some confusion that will require spelling out.

Descartes' easy dismissal of the problem of infinite speed of travel is that, try as one might to separate the marbles in a perpendicular line, one will nonetheless invariably pull them at some angle, separating one side first; and so one will not face the problem of infinite velocity in that case. He admits, however, that if one were able to separate them so, one would indeed create a vacuum for an instant: so Descartes once again hints at the coherence of the possibility of vacuum in this case.[35]

Concerning Galileo's discussion of the adhesion of the plates, Descartes writes: "What he ascribes to vacuum should only be ascribed to the weight of the air. If it were abhorrence of a vacuum that prevented two bodies from separating, there would certainly be no force capable of separating them."[36] What Descartes is after in the second of these sentences is not clear to me, and he does not elaborate. Perhaps he suggests that the phrase, 'nature abhors a vacuum,' if it is to have any explanatory value, expresses an absolute law of nature that would prohibit the creation of a vacuum. Why that must be so is not evident,

---

[35]Descartes to Mersenne, 9 January 1639 (II, 482). But see footnote 5 notes below for a qualification of this claim.

[36]Descartes to Mersenne, 11 October 1638 (II, 382); see also a near reprise of this comment in Descartes to Mersenne 15 November 1638 (II, 440).

however, for other empirical phenomena, such as the particular constant rate of acceleration of gravity measured by Galileo, seem no less remarkable than a particular force of cohesive attraction. Descartes could also have been prompted by the historical connotations of the phrase to turn briefly to a mention of vacuum in the 'philosophical' sense, as presented in Albert's treatment. If so, his reply is a bit cryptic as a reply to Galileo. Indeed, if the interpretation of the discussion of vacuum in the *Principles* that I have sketched is appropriate, and appropriate to his thinking at that time, he himself ought to have found it valueless.[37]

I would prefer to draw your attention to Descartes' first phrase, concerning the weight of the air as the cause of the adhesion of the plates. Descartes continues on in the letter to present a similar explanation of Galileo's water column in the pump and its incapacity to climb higher than 18 yards. If the impediment is not attributable to mechanical shortcomings of the pump, he goes on to suggest, then it could be attributed "to the weight of the water, which counterbalances that of the air."[38] This account is the sort of explanation that Pascal would provide for the suspension of the mercury in the barometer ten years later in his *Récit de la Grande Expérience de l'Équilibre des Liqueurs*: of "an equilibrium of the weights of air and mercury."[39] Pascal, however, would go on to explain the equilibrium with reference to vacuum: the mercury would fall out of the tube into a mercury bath to a level that would support a similarly heavy column of atmosphere, and the space above the mercury in the closed tube would be a vacuum. How would Descartes explain the suspension of the mercury?

Descartes' plenist physics clearly would prohibit any explanation referring to vacuum; yet his approach to the water column problem could easily suggest a measure of the weight of the air. Descartes had no faith in the integrity of water pumps for such measurement, however, and it appears from Descartes' communication that Mersenne, in a letter now lost, had proposed an experiment to measure the weight of the air by measuring the force required to separate marbles laterally. This led Descartes to comment that one probably could not practically ensure that the marbles would be appropriately smooth, nor that they would separate laterally instead of obliquely, even though the experiment, if

---

[37]Descartes' discussion would find a better target, once again, in André d'Abillon, who argues for a position very like Albert's, that void cannot be produced by less than supernatural means of annihilation of substance. He continues on to the odd suggestion that the problem natural beings would face, were they to try to produce a void, is that they would not be able to muster *enough force* to separate bodies. See d'Abillon, 298.
[38]Descartes to Mersenne, 11 October 1638 (AT II 382), my translation. The CSMK translation cuts this passage mid-sentence, and consequently leaves out this final hypothesis.
[39]Pascal, 221.

successful, would create a void between the marbles. Such an admission would appear to run against Descartes' plenism,[40] but as Descartes proceeds in a brief space to discuss "subtle matter" in his letter, I expect that he would go on to suggest that matter of the second or first element would rush in to cancel out the formation of void through pores in the marbles (II, 481-483). Thus, in raising the marble disc, one would be lifting the entirety of the column of the atmosphere above the disc, and forcing subtle matter from above the air to descend through the air, so that some subtle matter in the loop of bodies would fill the space vacated by the marble. As the space opens enough to allow the passage of air, the subtle matter then returns to its previous place, and the force necessary to separate the marbles is relieved. Thus, what we might have expected to be a measure of the force of interstitial vacuum on Galilean principles, or of the weight of the atmosphere in a framework that countenances void, is smoothly converted to a measure of the weight of the atmosphere under pressure from the celestial vortex in a plenist Cartesian physics.[41]

After Descartes and Mersenne had discussed and then dismissed experiments to measure the weight of the air using marble discs, Pascal argued for a reliable and convincing method for measuring the weight of the air with the mercury column, and presented an especially important argument in October of 1648, in the *Récit de la Grande Expérience* as a result of the Puy de Dôme experiment, in which his cousin showed that mercury will fall further at the top of a mountain than at its foot. The experiment suggested to Pascal and others that differences in the weight of air above the two columns was the cause of the observed difference. In discussions that arose in the wake of Pascal's *Expériences Nouvelles Touchant le Vide* of the previous year, many others became involved in the debate concerning the nature of the material, or the lack of material, at the top of the tube. In this period, Descartes proposed several experiments to Mersenne concerning barometric pressure and tests of the composition of the transparent space. He also asked others about Pascal's progress in the light of his suggestions, and he watched his own column.[42] Upon hearing the results of Pascal's experiment, and finding that it was not contrary to his expectations and confirmed his hypothesis concerning subtle matter, Descartes awaited further challenges from Pascal: challenges that he presumably did not come across before

---

[40]Victor Cousin's edition of Descartes' works presents a variant text, mentioning a vacuum "of air," not suggesting absolute vacuum. See Cousin, IX 71-2.

[41] Descartes suggests a similar explanation of a related phenomenon as early as 1631, though, of course, he countenances a different metaphysics of space at the time. Descartes to [Reneri], 2 June 1631 (I, 206-7).

[42]Descartes to Mersenne, 13 December 1647 and several letters between the two for several months after contain various reports of findings on the barometer; Descartes to Carcavi, 11 June 1649 (V, 366) poses the question of whether Pascal had completed the experiment suggested by Descartes in 1647.

his death. Descartes must have felt vindicated, for the Puy du Dôme experiment disagreed with the Galilean theoretical stance that Pascal held at the time of their last communication, and Descartes may have been unaware that Pascal had changed his theory since that time.[43] The experiment also supported his physics in one independent respect that ran contrary to both of Pascal's vacuist positions: Descartes, I expect, could see clearly through the substance at the top of the glass tube, and since light required a medium, on Descartes' account, there was reason to believe that something more than Cartesian vacuum remained there.

Conclusion

Descartes, like Aristotle, presents two sorts of response in his treatment of vacuum, against two types of position: conceptual analysis of what he takes to be nonsense, and metaphysical explanation and physical argument against what he takes to be competing physical theory. The nonsense position that Aristotle dispensed with quickly was a view that was properly reducible to the position that vacuum is truly nothing, once abstracted from all of place, extension and impenetrability. Similarly, the nonsense positions that Descartes dispensed with from II:5-19 were the views that vacuum has no extension, and that the extension of a given quantity of substance is alterable. The authors approach another set of opponents – in Aristotle's case, atomists – very differently, however. Much of Aristotle's argument attacks the possibility of motion in a void. We do observe motion, so void is ruled out: such an attack is intended to exclude physical possibility. Descartes goes further than Aristotle, in that he takes several opportunities to detail sensible conceptions of both macroscopic and interstitial vacuum as extended space lacking in any other properties of matter; most notably, bulkiness. Late in the *Principles*, Descartes allows that this conception of vacuum would be compatible with his physics, but for the brightness of the sun, and so, he returns to an empirical argument, a strategy that closely parallels Aristotle's. Descartes' conception is also suitable for formulating a response to atomists such as Galileo, and for his later discussions of macroscopic vacuum with Mersenne and others, in material written after the French *Principles*. In each of these attempts to rule out the possibility of vacuum he was not entirely successful, but a reasonably coherent and sophisticated body of argument on vacuum can be ascribed to Descartes.[44]

---

[43]On the later history, and especially Descartes' in his own position, see Garber, *Descartes' Metaphysical Physics*,138-43.

[44]Many thanks to the editors of this volume, and to Jonathan Bennett and the National Endowment for the Humanities Summer Seminar Program, which provided the opportunity for me to commence work on this subject. Thanks also to Jonathan Bennett, George Gale, Charles Huenemann and Matthew Stuart, who provided helpful comments, and to the

Allegheny College faculty development committee, which funded primary research presented in this paper.