Newton's Metaphysics of Space: A *"Tertium Quid"* betwixt Substantivalism and Relationism, or Merely a "God of the (Rational Mechanical) Gaps"?

Edward Slowik
Winona State University

This paper investigates the question of, and the degree to which, Newton's theory of space constitutes a third-way between the traditional substantivalist and relationist ontologies, i.e., that Newton judged that space is neither a type of substance/entity nor purely a relation among such substances. A non-substantivalist reading of Newton has been famously defended by Howard Stein, among others; but, as will be demonstrated, these claims are problematic on various grounds, especially as regards Newton's alleged rejection of the traditional substance/accident dichotomy concerning space. Nevertheless, our analysis of the metaphysical foundations of Newton's spatial theory will strive to uncover its unique and innovative characteristics, most notably, the distinctive role that Newton's "immaterialist" spatial ontology plays in his dynamics.

In the contemporary literature on the philosophy of space, a general dissatisfaction with the limitations imposed by the standard substance/relation dichotomy has been the catalyst for numerous hypotheses that fa-

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vor a "third-way" *(tertium quid)* between the substantivalist and relationist ontologies; that is, an alternative account that does not conceive space as either a substance/entity (substantivalism) or a mere relation among substances/entities (relationism). Given this general search for additional options, it is not surprising, therefore, that the strict relevance of the substance/relation scheme has also been challenged with respect to many well-known historical theories of space—theories that, hitherto, have been safely assumed to uphold the dichotomy. Among the more notable re-evaluations in this vein is the work on Newton by Howard Stein (e.g., 1967, 2002) and Robert DiSalle (e.g., 2002, 2006), who contend that Newton's concept of "absolute" space should not be confused with a commitment to substantivalism. Yet, Stein (2002) puts forward a more contentious position, namely, that Newton's ontology of space does not in fact endorse substantivalism. One can possibly detect a similar, if somewhat more ambiguous, interpretation that downplays substantivalism in an important earlier work by J. E. McGuire (1978a), who argues that space for Newton is "the general condition required for the existence of any individual substance . . ." (1978a, p. 481).

This essay will examine the extent to which Newton's spatial ontology does not fit either a substantivalist or relationist classification, as claimed by Stein (2002) and others, and thus qualifies as an early example of a third-way theory of space. The analysis will proceed by contrasting Newton's various pronouncement on space with the spatial hypotheses of his predecessors and contemporaries, as well as by comparing the ontological and structural presuppositions of Newton's theory with contemporary third-way (i.e., non-substantival/non-relational) theories of space (and spacetime). While section 1 will introduce alternative ontological accounts of space, as well as the relevance of the substance/accident distinction for spatial theories, section 2 will be devoted to a critical examination of the non-substantivalist interpretation, especially the arguments offered in Stein (2002) that draw upon Newton's early unpublished tract, *De Gravitatione.* With the background provided in these three sections, the stage will be set, in section 4, for a more in-depth investigation of the role of the substance/accident distinction in Newton's spatial theory, although it will be prefaced by a short investigation of Newton's conception of the infinity of space. As will be demonstrated through an analysis of the relevant works, Newton subscribes to a limited or surrogate form of the substance/accident distinction, such that the existence of space is secured directly via God's omnipresence. This tacit appeal to the substance/accident dichotomy, along with the many neo-Platonic elements that constitute Newton's spatial ontology, will thus compromise a robust non-substantivalist interpretation, as well as a third-way classification. The

concluding section 4, nevertheless, will also suggest a way by which Newton's ontology of space, with its non-material extended God, may have actually assisted the emergence of a successful mechanics, albeit inadvertently.

1. Introducing Third-Way Theories of Space

1.1. Third-Way Theories and the Substance/Accident Dichotomy

While the details of the numerous non-substantivalist and non-relational theories of space (and time) do not allow an easy summary, there are a few general conditions that these third-way theories must meet:

(A) The rejection of substantivalism: space is not a special type of substance that provides the location and other spatial properties of entities (both material and immaterial). The term "substance" refers to an entity that can exist in the absence of any other substances/entities; in addition, substances have the potential to causally interact with other substances, although this potential may never be actualized.

(B) The rejection of any strict form of relationism: space is not merely the spatial relations among actually existing material entities/substances, and thus space, and motion (as change of spatial position over time), cannot also be reduced to these relations.

A host of diverse ontological schemes fulfill these requirements, of course, but the most popular is probably the class of "modal relationist" solutions, which construe space (and time) as a type of relation that transcends the actual relations among existing material entities; i.e., they incorporate *possible* relations among bodies within the account of space (e.g., Manders 1982). There have also been a handful of modern attempts to revitalize the "property" theory, such that space and/or the material properties whose determination refers to space (e.g., acceleration) are simply deemed to be further material properties (which are not reducible to the extant material relations; see, e.g., Teller 1987, 1991, Sklar 1974). Other influential third-way strategies involve conceiving space as a type of "structure" (e.g., Dorato 2000, Dieks 2001), or, as a sort of "definitional presupposition" for the construction of any physical theory.

A nice example of this latter approach can be found in a litany of works by both Stein and DiSalle, who maintain—as their own preferred view, respectively—that space does not fit the false dichotomy of substance or

strict relationism. In trying to steer a middle course between the usual spacetime dualism, DiSalle is led to comment:

> Properly understood, space is *defined* by its regulation of the motions of bodies, and so we cannot meaningfully speak of space in the absence of the bodies which measure it. Yet we can at the same time assert its essential independence of bodies precisely insofar as the behavior of and interactions among the latter are conditioned by the structure of space. (1994, p. 274)[1]

By claiming that space cannot be meaningfully discussed in the absence of body, although still somehow independent of body (since bodies are "conditioned" by space), a third-way ontological categorization best fits DiSalle's philosophy.[2]

If one were to venture to ascertain the root metaphysical doctrine that distinguishes the third-way interpretations of space from the entrenched substantivalist/relationist scheme, a good candidate would lie in the venerable substance/accident (or substance/property) dichotomy. The legacy of this Aristotelian-Scholastic principle, and its pervasive influence over the course of philosophical reflection on space, cannot be over-emphasized. The doctrine holds that all existents come in one of two exclusive types: either self-dependent substances, or the properties that can only exist "within" a substance.[3] Projecting the ontological question of space against this broader metaphysical backdrop, the substance/relation dichotomy follows almost inevitably—space is thus either a substance in its own right (substantivalism), or, as the "extension" *within* matter, it becomes an internal property of material substance alone (strict relationism). This latter theory must then confront the dilemma of empty or void space (vacuum), i.e., the spatial extension devoid of matter that lies between bodies. Strict

1. Unless otherwise noted, all italics in the quoted passages in this essay are from the original.

2. DiSalle also claims that the manner by which spacetime "forbids certain states of affairs and permits other . . . is more central to the metaphysical status of space and time than, say, the question of whether space is possible without bodies" (p. 274). This verdict may be correct if the main concern is with issues of objectivity and invariance, but if the topic is ontology, then the possible independent existence of space is of paramount importance. Overall, DiSalle's tendency to portray space (spacetime) as the "facts" associated with physical processes (which is a description of DiSalle's theory in Callender and Hoefer 2002, p. 178), or Stein's claim that spacetime structures are "an 'emanative effect' of the existence of anything" (Stein 1977, p. 397), renders ontological speculation rather difficult. This last quote, importantly, is both Stein's own conception of space as well as a direct reference to Newton's spatial hypotheses (see below).

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3. See, for example, Bolton (1998): "Accidents (or accidental forms) were often said to 'inhere in' individual substances but not strictly to constitute them" (p. 179).

relationism employs one of two strategies: (1) the relationist can "reduce" empty space to the status of a mere relation among actually existing material entities, thereby denying that empty space has any robust ontological significance;[4] or (2), simply dissolve the problem by dismissing the possibility of void space. In addition to rejecting substantivalism, third-way theories defy substance/accident strictures by violating the relationist options (1) and (2). Not only do many third-way hypotheses allow for the possibility of a vacuum, contra (2), but, by conceiving spatial relations as somehow transcending the actual relations among existing bodies (being either modal relations, structures, etc.), these hypotheses also pose a serious obstacle for any strict reductivist relationism committed to option (1). Put briefly, since these modal relations, or structures, etc., cannot be reduced to the actual spatial relations among material existents, nor are they independent of matter (i.e., they cannot exist in the absence of all material existents, via (A)), it is hard to reconcile these modal relations or structures with the traditional substance/accident system—as such, the *ontology* of third-way theories of space constitute a decisive break with traditional substance/property thinking.

1.2. Two Third-Way Interpretations of Newton's Spatial Ontology

Before proceeding, it is important to distinguish two general strategies in the assessment of Newton's concepts of absolute space. The first strategy is that, leaving aside the issue of Newton's metaphysics, absolute space is best regarded as a definition or structure required for the successful application of his physics, namely, for the three laws of motion and the theory of gravity (and including the mathematical apparatus associated these hypotheses). Consequently, Newton may have engaged in the ontological disputes over space that were common among seventeenth century natural philosophers, but the truly significant aspect of his overall approach is the realization that "a spatio-temporal concept belongs in physics just in case it is defined by physical laws that explain how it is to be applied, and how the associated quantity is to be measured" (DiSalle 2002, p. 51). We can label this strategy the "weak" third-way interpretation of Newton's spatial theory, for it would seem to permit additional evaluations of Newton's spatial concepts that focus on the ontological disputes common in the seventeenth century. This weak interpretation gains credibility, moreover, when viewed within the context of the first edition of the *Principia* (1687),

4. For example: the relation, "x is two feet taller than y", does not commit us to the existence of a property, "two feet taller than", since this relation can be fully captured by, and reduced to, the height—as an internal property—of x and y. This is not true of "real" bodily properties, such as "square", "solid", etc., which can not be completely reduced in this manner.

especially the Scholium on space and time, which contains little, if any, metaphysics (e.g., discussions of "God" or "substance"). However, the General Scholium of the second edition (1713), *The Opticks,* and other non-published writings (to be examined below), do discuss these ontological topics—hence it is difficult to gauge Newton's commitment to the weak third-way thesis.

While an in-depth examination of the definitional structures of the weak third-way strategy is outside the bounds of this essay, they can be briefly outlined: Newton held that all spatial positions in his infinite (Euclidean) space are "absolute", i.e., they do not change, but are fixed over time; and that time itself is "absolute", i.e., all of space endures over time in equal temporal increments. As revealed in the *De Gravitatione,* absolute space and time are invoked to counter Descartes, whose erratic concepts of place and duration (since they are defined relative to changing material existents) cannot serve as a basis for determining motions (see, Stein 1967, who was one of the first to correctly single out Descartes as the target of much of Newton's critique of space and time). Yet, as DiSalle notes, Newton's mechanics of bodily motion only requires absolute time and absolute acceleration (and, hence, rotation), and not absolute space (spatial position) and its correlate, absolute velocity.[5]

The "strong" third-way interpretation, as its name implies, advocates a much stronger position, specifically, that Newton's *ontology* of space does indeed constitute a third-way theory. Unlike the weak thesis, which is largely confined to the definitional role that Newton's spatial concepts play in his physics, the strong thesis aims to uncover evidence within Newton's metaphysical writings for a third-way ontological interpretation. In the most forthright example of a strong third-way reading of Newton, i.e., Stein (2002), the claim is made that "Newton's 'metaphysics of space' is . . . that space is (some kind of) effect of the existence of anything, and therefore of the first-existing thing [God]" (2002, p. 268). Basically, Stein interprets Newton's metaphysics as endorsing a third-way ontology of space, much like Stein's *own* metaphysical interpretation of space (spacetime)—in other words, if space is conceived as an "effect of the existence of anything", then a precise ontological analysis is quite difficult to obtain, especially a reading that sides with the traditional substantivalist assessment (see 1.1, and endnote 2). Given the far-reaching consequences of this strong third-way thesis for Newton scholarship, the

5. As DiSalle comments, a four-dimensional spacetime structure equipped with an affine connection would have sufficed for Newton's purposes (2002, p. 35). Rynasiewicz (1995) offers a sophisticated analysis of Newton's concepts of space, time and motion which would appear to be compatible with the weak third-way thesis.

greater part of this essay will thus be devoted to a critical investigation of the claims of its major proponents, in particular, the case made in Stein (2002).

2. The Strong Third-Way Interpretation

2.1. Making the Case: Space as a "Necessary Consequence or Result"

In perusing Newton's various pronouncements on space, the plausibility of a non-substantivalist, strong third-way interpretation is quite apparent. In the unpublished, pre-*Principia* treatise, *De Gravitatione,* Newton declares that space "has its own manner of existing which is proper to it and which fits neither substance nor accident [i.e., property]" (Newton 2004, p. 21). Space is not a substance since it cannot "act upon things, yet everyone tacitly understands this of substance" (p. 21), but neither is it an accident, "since we can clearly conceive extension existing without any subject, as when we imagine spaces outside the world or places empty of any body whatsoever, . . ." (p. 22). Nevertheless, Newton adds: "much less may [space] be said to be nothing, since it is something more than an accident, and approaches more nearly to the nature *(naturam)* of substance" (Newton 2004, p. 22)—a puzzling admission that will gain some degree of clarity when we examine the "determined quantities of extension" hypothesis in section 2.3. Newton's understanding of the substance/accident dichotomy would seem in accord with the characterization provided in section 1.1, moreover, as is evident in his ensuing discussion: because "we cannot believe that it [space] would perish with the body if God should annihilate a body, it follows that [extension] does not exist as an accident *inhering* in some subject" (p. 22, emphasis added). Rather, Newton repeatedly refers to space as an "affection" *(affectio)* or "attribute" *(attributa),* which may indicate an attempt to utilize neutral terms without substance/accident connotations. Having disposed of these standard ontological categories, Newton continues:

> Space is an affection of a being just as a being *(Spatium est entis quatenus ens affectio).* No being exists or can exist which is not related to space in some way. God is everywhere, created minds are somewhere, and body is in the space that it occupies; and whatever is neither everywhere nor anywhere does not exist. And hence it follows that space is an emanative effect *(effectus emanativus)* of the first existing being, for if any being whatsoever is posited, space is posited. (p. 25)

In an earlier passage, Newton similarly comments that space "is as it were an emanative effect of God and an affection of every kind of being" (p. 21).

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Based on this evidence, Stein concludes that "Newton does *not* derive his 'Idea' of space—its ontological status included—*from* his theology (as has often been claimed); for he tells us that if *anything* is posited, space is posited" (Stein 2002, p. 268). Since God is the first existing thing, "space (in some sense) 'results from' the existence of God" (p. 268), but this just constitutes a specific case of Newton's general hypothesis that "space (in some sense) 'results from' *the existence of anything*" (p. 268). In more detail, he concludes:

> But this sense of the word—simply *a necessary consequence,* with no connotation of "causal efficacy" or "action"—*exactly* fits the rest of what Newton says; indeed, this meaning might have been inferred directly from Newton's words: "[S]pace is an emanative effect of the first-existing being, for *if I posit any being whatever I posit space*": the second clause tells us precisely what the first clause *means.* (p. 269)

On Stein's interpretation, "space as an emanative effect" becomes "space as a necessary consequence or result of the existence of anything", which is the type of minimal or "deflated" ontological conception that the strong third-way theorist supports, since space is apparently being equated with a form of logical or conceptual fact, as opposed to a full-blown substance, property, etc. As will be argued below, and contrary to Stein's reading, there is only one being, God (or a World Soul), that can be the emanative cause of space. Finally, Stein even suggests a third-way structuralist rendering of a much-debated passage from the *De Gravitatione,* where Newton states that the "parts of space are individuated by their positions, so that if any two could change their positions, they would change their individuality at the same time and each would be converted numerically into the other" (Newton 2004, p. 25). With respect to this quotation, Stein reasons: "This can be taken, in rather modern terms, as saying that space is a *structure,* or 'relational system', which can be conceived of independently of anything else; its constituents are individuated just be *their relations to one another, as elements of this relational system*" (Stein 2002, p. 272).

2.2. Problem: Emanative Causation

Needless to say, the plausibility of Stein's strong third-way interpretation largely hinges on the question of Newton's intended usage of several key terms, many of which had a long pedigree in seventeenth century neo-Platonic thought, in particular, the various philosophies of space among the so-called Cambridge Platonists (or neo-Platonists).[6] An in-depth in-

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6. As Stein readily acknowledges (2002, p. 271), his analysis is contrary to the consensus, among Early Modern scholars, that Newton's spatial ontology retains significant neo-

vestigation of these issues, specifically, causal issues, is beyond the bounds of this essay, although many are discussed in Carriero 1990, and a more lengthy exploration can be found in Slowik 2007. Yet, a brief examination of some of these problems will be required in order to investigate the nature of the substance/accident dichotomy in Newton's spatial thought, as well as to assess the third-way thesis.

Besides the fact that Newton never refers to space as a *necessary* consequence,[7] the chief difficulty with Stein's case is his claim that "emanative effect" has "no connotation of 'causal efficacy' or 'action'" (p. 269). In McGuire's famous (1978a) article, a similar line is presented:

> The relation between the existence of a being and that of space is not causal, but one of ontic dependence. Newton is defining one condition which must be satisfied so that any being can be said to exist. In short, the phrase, 'when any being is posited, space is posited' denotes an ontic relation between the existence of any kind of being and the condition of its existence. (1978a, p. 480)

Nevertheless, as McGuire later conceded, there are historical precedents for a form of efficient causation that closely mimics his notion of "ontic dependence", adding that, "since the notion of an eternal and efficient cause does not involve any activity, production, or active efficacy between it and its effect, it is difficult to distinguish natural or ontic dependence in these contexts from the notion of causal dependence between eternal things" (1990, p. 105). In particular, the Cambridge neo-Platonist, Henry More (in his *The Immortality of the Soul,* 1659), had appealed to emanative causation in just this manner in explicating "Secondary Substance", which is spatially extended, immaterial, and coextensive with the extension of material substance. We have a "rationall apprehension of that part of a

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Platonic content, especially theological content: see the commentaries by Burtt (1952, p. 261), Jammer (1993, p. 110), Koyré (1965, p. 89), Funkenstein (1986, p. 96), to name only a few. On the estimation of Edward Grant: "if space is God's attribute, does that not imply it is somehow an accident or property of God?" (1981, p. 243).

7. In a later writing, however, Newton does refer to infinite space and time as "modes of existence in all beings, & unbounded *modes* & consequences of the existence of a substance that which is really necessary & substantially Omnipresent & Eternal" (Koyré and Cohen 1962, pp. 96–97). Yet, since "consequence" in this passage is used in conjunction with the ontological term, "modes", which denotes the specific way in which a being manifests a general property (e.g., "circular" is a mode of "shape"), this instance of "consequences" does not readily lend ready support to the ontologically thin, strong third-way reading. It should also be noted that "emanation" as used in the essay refers exclusively to the neo-Platonic, metaphysical variety, and not to any logical form (such that God's existence is logically equivalent to space's existence), although Stein obviously sides with the logical sense of that term.

Spirit which we call the *Secondary Substance*", reasons More, "whose Extension arising by graduall Emanation from the First and primest Essence [God] . . ." (1997b, p. 35). Furthermore, *"an Emanative Effect is coexistent with the very Substance of that which is said to be the Cause thereof",* and he explains that this "Cause" is "the adequate and immediate Cause", and that the "Effect" exists "so long as that Substance does exist" (1997b, p. 33). More importantly, "by an *Emanative Cause* is understood such a Cause as merely by Being, no other activity or causality interposed, produces an Effect" (1997b, p. 32). This last point is significant, since it helps to explain Newton's claim, in the *De Gravitatione,* that "extension is not created *(creatura)* but has existed eternally" (2004, p. 31)—as with More, eternal and infinite space is an emanative effect of an eternal an infinite being, unlike created being, which is finite both temporally and (presumably) spatially. In short, space can be a causal effect of God without being created by God. Hence, Stein's non-causal, ontologically sparse version of Newton's spatial theory fails to heed the subtle intricacies surrounding causation typical of seventeenth century neo-Platonic thought.

2.3. Problem: The "Determined Quantities of Extension" Hypothesis

A further obstacle for a strong third-way appraisal of Newton's spatial theory comes in the form of detailed example, or hypothetical scenario, that Newton develops in order to explicate his conception of body, but which also discloses crucial information concerning the role of God and space in his overall ontology. In short, Newton envisages a world whose spatial extension is furnished with bodily properties, such as impenetrability or color, by God's will alone, but without requiring an underlying corporeal substance to house these accidents: "If [God] should exercise this power, and cause some space projecting above the earth, like a mountain or any other body, to be impervious to bodies and thus stop or reflect light and all impinging things, it seems impossible that we should not consider this space really to be a body from the evidence of our senses . . ." (Newton 2004, pp. 27–28). On this hypothesis, Newton maintains that "we can define bodies as *determined quantities of extension which omnipresent God endows with certain conditions*" (p. 28; *corpora definire possemus esse* Extensionis quantitates determinatas quas Dius ubique præsens conditionibus quibusdam aificit); the "conditions" being, first, that these determined quantities are mobile, second, that they can bring about perceptions in minds, and three, that two or more cannot coincide. Provided these conditions and his overall scheme, which we will dub, the "Determined Quantities of Extension" hypothesis (hereafter, DQE), these bundles of quantities can replicate the phenomena of material bodies without recourse to Descartes' material substance, or the Scholastic notion of prime matter (2004,

pp. 27–31). Since these determined quantities are apparently sustained and moved through the exercise of the divine will alone, Newton offers numerous analogies on the relationship between the human mind and human body, on the one hand, and God's will and determined quantities, on the other, in order to explain his hypothesis:

> Since each man is conscious that he can move his body at will, . . . , the free power of moving bodies at will can by no means be denied God, whose faculty of thought is infinitely greater and more swift. And for the same reason it must be agreed that God, by the sole action of thinking and willing, can prevent a body from penetrating any space defined by certain limits. (p. 27)

Descriptions of this sort reveal the neo-Platonist undercurrent in Newton's spatial philosophy. That is, the numerous analogies that compare God's relationship to space by way of mental content, specifically, the mind's control of the body, is a key feature of neo-Platonist natural philosophy (i.e., the neo-Platonists regard inert matter as incapable of accounting for the full range of material phenomena, and thus they invoke immaterial agents; see, e.g., Garber et al., 1998). Therefore, the very exposition of the DQE hypothesis constitutes a serious obstacle for any strong third-way rendering of Newton's spatial hypotheses, since a theory that posits material bodies as bits of God's spatial extension is by its very nature thoroughly imbued in traditional ontological (and even theological) speculation.[8]

2.4. Problem: Ens Quatenus Ens

Given the preceding discussions, we are in a better position to grasp the meaning of Newton's claim that space is an attribute/affection of "a being

8. It should be noted that Newton qualifies his DQE hypothesis by stating that it is "uncertain", and that he is "reluctant to say positively what the nature of bodies is" (Newton 2004, p. 27). Yet, the DQE hypothesis is the only "model" put forth of his spatial ontology, and it comprises a significant portion of the *De Gravitatione.* Moreover, Newton frequently touts the superiority of the DQE hypothesis in comparison with both the Cartesian and Scholastic alternatives: e.g., "the usefulness of the idea of body that I have described [the DQE hypothesis] is brought out by the fact that it clearly involves the principal truths of metaphysics and thoroughly confirms and explains them" (p. 31). And, as a final summary on this hypothesis, he claims: "So much for the nature of bodies, which in explicating I judge that I have sufficiently proved that such a creation as I have expounded [the DQE hypothesis] is most clearly the work of God, and if this world were not constituted from that creation, at least another very like it could be constituted" (p. 33). Furthermore, all references to God's "extension" in this essay need qualification: it is unclear from the evidence of the texts if Newton did, or did not, accept "holenmerism", which is the view that God is complete in every part of extension, rather than claim that God is extended in the same manner as all other beings (but is simply not physically divisible).

just as a being" *(ens quatenus ens).* First of all, Newton's use of this hypothesis may have been based on a similar line of argument in More's *Enchiridion,* which employs a metaphysics of "being just as a being", and includes his spatial hypotheses: e.g., "the essence of *any being insofar as it is a being* is constituted of amplitude [extension] and differentia [form], which distinguishes amplitude from amplitude" (1995, p. 9; emphasis added).

Now, recalling Newton's famous quote, that "space is an emanative effect of the first existing being, for if any being whatsoever is posited, space is posited" (2004, p. 25), Stein maintains that "the second clause tells us precisely what the first clause *means*" (Stein 2002, p. 269). In addition to the problems raised earlier with respect to Stein's reading of "emanative effect" (section 2.2), this argument also relies on a dubious interpretation of "first existing being", a phrase that appears only once in the *De Gravitatione.* Stein's third-way version of Newton's hypothesis requires that "first existing being" be taken as referring to "any first existing being" (e.g., "if *anything* is posited, space is posited"; Stein 2002, p. 268); but, there are precedents in the earlier Cambridge neo-Platonist literature for employing phrases, like "first existing being", to refer to God alone. In the *Enchiridium Metaphysicum* (1679), More's characterization of infinite space draws upon Aristotle's arguments for the existence of an eternal, immovable "first" substance required to ground the world's lesser, finite, and mutable substances: "That which, however, is the first Being and *receives all others,* without doubt exists by itself, since nothing is prior to that which sustains itself" (p. 59; emphasis added).[9] "First Being" is only applicable to God or a world soul, consequently (although More's makes the novel point that many of the traits of "First Being" also apply to space). Hence, given the evidence provided above, the more plausible interpretation of

9. In describing the traits of infinite extension, More notes that "it is necessary that it be immobile. Which is celebrated as the most excellent attribute of First Being in Aristotle" (1995, p. 58). In the *Metaphysics* (Bk. XII, 1071^b1–1071^b10), Aristotle argues that "it is necessary that there should be an eternal unmovable substance. For substances are the first of existing things, and if they are all destructible, all things are destructible" (Aristotle 1984, pp. 1692–1693). See, also the discussion of More's notion of emanative causation in his earlier, *The Immortality of the Soul* (1659), section 2.2 above, which refers to God as "the First and primest Essence" (1997b, p. 35). As disclosed throughout this investigation, Newton likewise demands an infinite, immobile "first existing being" to ground the existence and extension of the lesser, mobile beings. The infinity of space is also necessitated on Newton's view: this will be further explored in section 3.2. On Newton's sources among the Cambridge neo-Platonists and others, see, Westfall 1962, and McGuire 1978a, which references works of More and Charleton. Newton's early notebook, *Quaestiones quaedum Philosophicae* (1661–1665, Cambridge University Library, Ms Add. 3996, folios 88–135), contains evidence that he had at least read both Charleton's *Physiologia* and More's *The Immortality of the Soul.*

the phrase "for if any being whatsoever is posited, space is posited" is that it is not intended to explicate the term "emanative effect"—rather, it is simply another instance of Newton's hypothesis that space is an attribute/affection of "a being just as a being". Stein's reading conflates the meaning and purpose of two distinct hypotheses, namely, emanative causation and *ens quatenus ens.* One can locate evidence for the separation of these hypotheses, furthermore, in Newton's first use of "emanative effect" in the *De Gravitatione,* where he claims that "[space] is as it were an emanative effect of God *and* an affection of every kind of being" (p. 21, emphasis added)—that is, this quotation does not run together space as an "emanative effect of the first existing being" and space as "an affection of every being" (= "if any being is posited, space is posited"), thus raising a serious difficulty for Stein's attempt to use the latter concept to *explain the meaning* of the former.

In order to determine its intended meaning, it would be helpful at this juncture to quote the broader context of Newton's controversial paragraph in full:

> Space is an affection of a being just as a being. No being exists or can exist which is not related to space in some way. God is everywhere, created minds are somewhere, and body is in the space that it occupies; and whatever is neither everywhere nor anywhere does not exist. And hence it follows that space is an emanative effect of the first existing being, for if any being whatsoever is posited, space is posited. And the same may be asserted of duration: for certainly both are affections or attributes of a being according to which the quantity of any thing's existence is individuated to the degree that the size of its presence and persistence is specified. So the quantity of the existence of God is eternal in relation to duration, and infinite in relation to the space in which he is present; and the quantity of the existence of a created thing is as great in relation to duration as the duration since the beginning of its existence, and in relation to the size of its presence, it is as great as the space in which it is present. (pp. 25–26)

Whereas the first sentence espouses the *ens quatenus ens* hypothesis, the second and third sentences posit an infinitely extended God, "God is everywhere", and postulate that created minds and bodies are located in, and occupy, this same space (and cannot be nowhere). Specifically, minds are "somewhere", and body "is in the space that it occupies", but, since God is "everywhere", these lesser beings must also partake of God's extension, a point presented quite explicitly later in the paragraph: "the quantity of the existence of God is . . . infinite in relation to *the space in which he is pres-*

ent". The fourth sentence makes reference to emanative causation ("space is an emanative effect . . ."), but this much-debated claim begins with the phrase, "And hence it follows that", an important qualification often ignored on the non-substantivalist reading of Newton. This phrase, which relates the content that follows to the previous three sentences, provides evidence for the following reconstruction of Newton's paragraph. In effect, Newton is arguing that, *since* God's extension is infinite, and *since* the other beings reside in this infinite space, "hence it follows that space is an emanative effect of the first existing being, for if any being whatsoever is posited, space is posited"—or, put differently, space must be the emanative effect of an unlimited, omnipresent being ("the first existing being") because all being is extended (via the *ens quatenus ens* hypothesis: "for if any being whatsoever is posited, space is posited"). That is, the remaining finite beings *require* an infinitely extended being to ground the existence of the infinite space in which they reside, which, as disclosed in the final two sentences, also applies to the existence of lesser beings in time. Newton's arguments in this paragraph thus can be seen as similar to More's line of reasoning in the *Enchiridion* (cited above), where an infinitely extended "first Being" secures the extension of all other being: "That which, however, is the first Being and *receives all others,* without doubt exists by itself, since nothing is prior to that which sustains itself" (1995, p. 59; emphasis added). As a result, the clause, "for if any being whatsoever is posited, space is posited", does not explain the meaning of "emanative effect"—rather, as an instance of the *ens quatenus ens* hypothesis, this clause provides Newton with the justification for positing space as an emanative effect of an infinite (or omnipresent) "first existing being". As a result, space is not a necessary consequence of the existence of any being, as Stein concludes—the entailment, in fact, goes the other way: the existence of any being necessarily presupposes space, and that precondition can only be established by God.

3. Newton's Spatial Theory and the Residue of The Substance/Accident Dichotomy

Thus far, we have examined Newton's theory of space largely from the perspective of a non-substantivalist, strong third-way standpoint, in particular, Stein's (2002) case. As revealed in section 2, the abundant neo-Platonic elements in Newton's spatial theory (emanative causation, the primacy of incorporeal being over corporeal being, etc.; see, Slowik 2007) raise insurmountable obstacles for any strong brand of non-substantivalist interpretation. This exploration of Newton's spatial ontology, moreover, provides the necessary background for a more detailed analysis of several questions first raised in section 1; namely, how the substance/accident di-

chotomy actually factors into Newton's theory, and, how Newton's specific application of this dichotomy affects the potential for a third-way classification of his overall theory of space.

3.1. Infinite Space

On the whole, the reasons for Newton's rejection of an accident metaphysics do not effect the larger issues involved with the more radical non-substantivalist interpretation of Newton's spatial theory: put briefly, whether space is God's accident or attribute does not change the fact that space is, so to speak, God's "predicate"—and there is nothing in the *De Gravitatione,* or in any of Newton's other works, for that matter, that would suggest that any lesser being can play the role of space's "subject" (including the hypothetical "world soul").[10] Furthermore, while Newton is critical of the idea that space "inheres" in God (see section 2.1), this more limited subject-predicate relationship between God and space remains an undeniably pervasive feature of Newton's natural philosophy. Given our inquiry, a question naturally arises at this point: Is this minimal relationship between God and space—namely, that space is God's attribute, without any sense of inherence—the only concession that Newton makes with respect to an accident/substance ontology? Additionally, what does the rejection of inherence imply for his overall spatial theory? Is the relationship between God and space more analogous to a non-spatial, logical or conceptual association, as opposed to the more spatially biased or suggestive notion of inherence?

An answer to these questions is potentially contained within Newton's endorsement of the infinity of space. In the *De Gravitatione,* he proclaims: "Space is extended infinitely in all directions. For we cannot imagine any limit anywhere without at the same time imagining that there is space beyond it" (2004, p. 23). He subsequently concedes that we cannot imagine the infinity of extension, yet "we can understand it" (p. 23), as he demonstrates by means of a rough geometric proof involving the intersection point of two lines that slowly approach a parallel configuration: "therefore there is always such an actual point where the produced [lines] would meet, although it may be imagined to fall outside the limits of the physical universe", or, as he also puts it, "the line traced by all these points will be real, though it extends beyond all distance" (p. 23). In contrast to Des-

10. Concerning that decidedly neo-Platonic concept of a "world soul", Newton comments that "the world should not be called the creature of that soul but of God alone, who creates it by constituting the soul of such a nature that the world necessarily emanates [from it]" (p. 31). Throughout the *De Gravitatione,* Newton follows standard neo-Platonic doctrine by locating incorporeal beings (spirits, souls) at the top of the hierarchy, with the lower, corporeal world regarded as emanations from these incorporeal beings.

cartes, who asserts that space can only be understood to be "indefinitely" extended (which is a negative conception that lacks the positive connotations attached to "infinity"),[11] Newton claims that we do have a positive idea of infinite extension. Despite human limitations, "God at least understands that there are no limits, not merely indefinitely but certainly and positively, and because although we negatively imagine [extension] to transcend all limits, yet we positively and most certainly understand that it does so" (pp. 24–25). In the *De Gravitatione,* Newton conceives space as actually possessing the geometric figures, relationships, etc., that material bodies only manifest in space: "For the delineation of any material figure is not a new production of that figure with respect to space, but only a corporeal representation of it, so that what was formerly insensible in space now appears before the senses" (pp. 22–23). Accordingly, if we can grasp the infinity of space through geometric reasoning, and geometric relationships or properties actually exist in space, then it would seem to follow that the actual infinity of space is derived from our understanding of the infinity of Euclidean geometry (see, McGuire 1983, pp. 179–188, which reaches similar conclusions). Consequently, Newton's *ens quatenus ens* hypothesis, examined in section 2.4, gains an important qualification in the light of this discovery; namely, if anything is posited, *infinite* space is posited (more on this below).

3.2. Substances/Accidents and Third-Way Theories: An Assessment

Newton's reification of an infinite Euclidean space has interesting, if subtle, implications for the substance/accident distinction. While rejecting the notion of inherence, Newton's "space is an attribute of *ens quatenus ens*" hypothesis nonetheless entails that the domain of space is closely tied or restricted to God's domain; in other words, space is infinite *because* God is infinite, an hypothesis that is stated quite clearly in several later works, such as in the 1713 *Principia:* "He endures forever, and is everywhere present; and by existing always and everywhere, he constitutes duration and space" (2004, p. 91). In the earlier *De Gravitatione,* this "congruence", as we may call it, between the ontological domains of both God and space is presented in more detail. He claims that "[space and time] are affections or attributes of a being according to which the quantity of any thing's existence is individuated to the degree that the size of its presence and persistence is specified", whereupon he concludes, "so the quantity of the existence of God is eternal in relation to duration, and infinite in relation to

11. Descartes defines as "indefinite" anything whose limits cannot "be discovered by us", whereas something is "infinite" if we understand that it has no limits at all; Descartes reserves this latter designation for God alone. (Descartes 1976, AT VIII 15)

the space in which he is present; and the quantity of the existence of a created thing is as great in relation to duration as the duration since the beginning of its existence, and in relation to the size of its presence, it is as great as the space in which it is present" (pp. 25–26). He also adds that "space is eternal in duration and immutable in nature because it is the emanative effect of an eternal and immutable being" (p. 26). Furthermore, God's infinite "quantity of existence" with respect to the attribute space is a "substantial", or actual, presence, and not merely a figurative or "virtual" presence. In a passage from the 1713 *Principia,* which possibly alludes to God's active role in gravity, he contends that "He is omnipresent not only *virtually* but also *substantially;* for action requires substance" (p. 91). Therefore, notwithstanding his repudiation of the substance/accident dichotomy, Newton presupposes a metaphysics of space that closely mimics the dichotomy, save for the notion of inherence. Newton's spatial theory requires a substantial or actual entity to ground the existence of space, and the domain or extent of the former determines the domain of the latter: specifically, space can only be infinite if the entity that provides the foundation for space is infinite (i.e., omnipresent), and, as revealed above, the infinity of space is tantamount to a certain (a priori?) truth on Newton's scheme.

This interpretation of Newton's spatial theory is partially confirmed in a manuscript from the early 1690s, dubbed "Tempus et Locus" by McGuire, where Newton denies the possibility "that a dwarf-god should fill only a tiny part of infinite space with this visible world created by him" (1978b, p. 123). In other words, if space is infinite—as he presumably believes is necessarily the case—then God must be infinite. Furthermore, nowhere does Newton suggest that any lesser being, besides God or possibly a world soul, can ground the existence of infinite space. A finite or infinitely extended material body is not capable of "emanating" infinite space since Newton judges the traits of body to be radically divergent from the characteristics of space: "extension is eternal, infinite, uncreated, uniform throughout, not in the least mobile, nor capable of inducing changes of motion in bodies or change of thought in the mind; whereas body is opposite in every respect" (p. 33). This same point is likewise in evidence in Newton's final use of the phrase "emanative effect", as just quoted above: "space is eternal in duration and immutable in nature because it is the emanative effect of an eternal and immutable being" (p. 26; i.e., the immutable nature of space must come from a similarly immutable being). Finally, given Newton's contention that space is infinite, perhaps necessarily infinite, it seems implausible to suppose that Newton would allow a finite being to "emanate" a finite space (on Stein's rendition of "emanative effect"). In summary, given Newton's contention that space is

an affection/attribute "of a being according to which the quantity of any thing's existence is individuated to the degree that the size of its presence . . . is specified" (p. 25), it would seem to follow that a being's spatial attribute must match (or, be congruent with) its "quantity of existence" and the "size of its presence", with these latter terms presumably indicative of more general ontological issues pertaining to a being's very existence.

Newton's tacit utilization of a sort of surrogate substance/accident concept may not at first appear to be a setback for a non-substantivalist interpretation of his spatial theory; yet, if the non-substantivalist's interpretation strives to portray Newton's theory as comparable to third-way approaches to the ontology of space, as discussed in section 1, then Newton's latent form of substance/accident thought does indeed constitute a serious problem. Third-way theories of space, as previously argued, depart significantly from the dichotomy by admitting modal or possible relations, or structures, that transcend the actual relations among the world's actual inhabitants. For example, third-way theories are thus consistent with a hypothetical Stoic universe wherein the structure of space is infinite Euclidean despite a finite ("island") material distribution: A third-way theory can meaningfully entertain, for example, whether space possesses a flat (infinite, unbounded) Euclidean structure, or a spherical (finite, unbounded) non-Euclidean structure, since the foundation of all spatial relations, whether finite or infinite, actual or possible, can be obtained through the existence of a finite number of objects/entities, perhaps only one. Third-way theories do not confine the domain of all spatial relations so as to exactly match the domain of *actually* existing entities—the mere *possibility* of a matter-filled universe (plenum) is enough to classify the space as infinite Euclidean or spherical non-Euclidean for a third-way theorist (since the infinity of bodies in the former case is quite distinguishable from the finite composition of the latter). Substantivalists and strict relationists may spurn these third-way ontologies, of course, since they accept the substance/accident dichotomy; but, as revealed in our investigation, Newton would likely concur in their disparagement of these alternative theories, for he advocates a surrogate form of that dichotomy. Like the substantivalists and strict relationists, Newton's spatial theory necessitates a congruence between the domain of actual existing entities, either corporeal or incorporeal, and the domain of the "attribute" space. In the larger scheme of the ontological classification of spatial theories, consequently, Newton's rebuff of the notion of inherence does not appreciably effect the classification of his own theory, which runs counter to third-way conceptions.[12]

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12. There are a class of third-way theories that do not significantly part from the

4. Conclusion: An Important Consequence of Newton's Spatial Ontology

To recap: our investigation has criticized the more ontologically daring non-substantivalist, strong third-way conception of Newton's theory (while not criticizing the more traditional, epistemological appreciation of the definitions of absolute space as embodied in the weak third-way reading; see section 1). This raises an intriguing question: Did Newton's science benefit in any way from his incorporeal-based, or spirit-infused, spatial ontology, as opposed to his conception of absolute space? As a conclusion to our investigation, therefore, it will be useful to briefly survey a particularly beneficial consequence of Newton's spatial ontology, while leaving aside the purely methodological values of his definitional constructions. Oddly enough, this positive feature is formed by the conjunction of Newton's concept of gravity and the dissolution of the incorporeal/corporeal substance distinction.

Most of the ontological achievements cited by commentators, not surprisingly, concern his empirical approach to the concepts most closely associated with the laws of motion and the theory of gravity, such as his treatment of force; but, once again, these virtues appear to be more methodological than ontological, since the "inner" nature of the causes of material phenomena are largely glossed over for a technically brilliant mathematical treatment of their observable effects (as Leibniz and his fellow Rationalists often complained). Consequently, if we turn to the elements in his theory that represent its true ontological underpinnings, i.e., his theology, then any questions about the benefits of his ontology become questions about the advantages of his conception of God; and, as detailed above, Newton's God is conceived after the manner of a spatially diffused incorporeal being, such that God is substantially present throughout an

substance/accident dichotomy, however, such as the sophisticated relationist interpretation of spacetime in the works of, say, Dorato (2000) or Dieks (2001). By conceiving the metric field of General Relativity in the manner of a physical field, it thus follows trivially that the domain of spacetime, i.e., metric field, is congruent with the domain of physical fields (and thus the substance/accident distinction can be claimed to have been upheld via their congruent domains). Stein (2002, p. 286) also mentions the possibility that Newtonian gravity can be conceived as a field, as did Koyré (1957, p. 214), since gravity's effects permeate all of space. Thus, Newton's theory might obtain a third-way classification by a similar congruence of God (or gravity) and space. Unfortunately, if Newton's theory acquires a third-way designation by this means, then the plethora of earlier theories that also posit a God-infused space, from Plotinus to More, would also obtain this same third-way label, as would any theory that links the domain of material phenomena with the domain of spatial extension (like Descartes')—and this, of course, would trivialize the third-way classification since nearly all spatial hypotheses would now count as third-way. In short, the theories of Dorato, Dieks, et al. are merely consistent with the substance/accident distinction, but it is not a necessary requirement of their theories.

infinite Euclidean space. Most natural philosophers would likely regard this notion of God as both crude and superfluous, perhaps a throwback to a more primitive manner of conceiving God.

Ironically, Newton's theology exhibits some significant advantages when viewed within the context of the "mechanical" philosophy, especially when Newton's approach is contrasted with the theology of his Rationalist competitors, such as Descartes or Leibniz, who also advocated mechanistic explanations. Whereas Descartes' God, for example, does not selectively intervene in the operation and governance of the world's various physical events (since the perfection of the original creation eliminates the need for the future mending of any specific system), it is well-known that Newton did entertain the possibility of an "immaterial agent" in gravity, if not God's direct participation.[13] What ensues from these diver-

13. Roughly, the mechanical view attempts to explain physical phenomena by exclusive appeal to deterministic laws that govern the motion and impact of material bodies, such that non-material forces or influences are prohibited. Since Newton's underlying ontology is essentially immaterial, the popularity of the mechanical philosophy in his own day thereby posed a persistent challenge to his neo-Platonism. Yet, Newton was instinctively inclined towards mechanical (or, at least, anti-action-at-a-distance) explanations throughout his own work in physics, as is evident from his attempts to locate a mechanism to account for gravity: e.g., his speculative aether (see, Newton 1978, p. 181). In the Correspondence with Bentley (11 February, 1692/3), he argues: "It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact, as it must be, if gravitation in the sense of Epicurus, be essential and inherent in it. . . . That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum without the mediation of anything else, by and which through their action and force may be conveyed from one to another, is to me . . . an absurdity, . . . Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers" (2004, pp. 102–103). As argued in Henry (1994), Newton's reference to a possible "immaterial agent" need not be God or any spiritual being acting directly on bodies, but could be simply an unknown non-mechanical process (akin to alchemy?) that God has superadded to matter. McGuire (1968) discloses Newton's dissatisfaction with the specific type of spiritual forces/agents used by More to explain natural phenomena, although the evidence dates from 1714/1715, which is long after the *De Gravitatione:* "The notion of an unreflecting intermediary which blindly performed Divine edicts, struck Newton as not only an ontological extravagance, but as scientifically impotent . . ." (p. 212). Yet, as McGuire also points out, "Newton did not accept the strict dualism which stated that a thing must be either material or immaterial. . . . The vivifying effects of chemical spirits merged imperceptibly in Newton's world, through a chain of gradations into the spiritual realm" (p. 213); and, "[Newton's forces] . . . seem to occupy a twilight zone between the corporal and the incorporeal" (p. 212). Needless to say, this tendency to "blur" the distinction between the corporeal and incorporeal (as we have dubbed it) is clearly evident in the *De Gravitatione,* and is indicative of Newton's imbibed neo-Platonism.

gent attempts to provide a sort of theological foundation for physics are quite intriguing. Given Descartes' non-participatory role for God (leaving aside the general issue of occasionalism, of course), any difficulties in reconciling his fundamental physical laws and hypotheses with empirical evidence must be forestalled by employing further mechanical hypotheses, usually at the unobservable level of minute particle interactions. For instance, the abundant evidence that apparently disconfirms Descartes' conservation law for the quantity of motion is explained away by invoking a set of ideal conditions that, allegedly, are often unmet at the level of macroscopic bodies (see, Slowik 1996). Descartes' laws and conservation principle are God-ordained, needless to say, but the working-out of the details, especially as regards accommodating empirical evidence, can only be achieved by positing more and more mechanical hypotheses. The result, of course, is a baroque system of physical mechanisms and hypotheses that often appear ad hoc, if not outright implausible and mutually inconsistent.

Newton's physics, on the contrary, is free of these complications since his concept of an omnipresent "immaterial agent" can apply, quite literally, any local forces or causes mandated by his physical system. Gravity, in particular, requires the repeated application of an (instantaneously acting) force to, say, keep the planets within their orbital paths, yet no material mechanism, such as his proposed aether, was detected in the vast emptiness of space, nor were any such mechanisms seemingly constructible. Newton solves this problem by appealing to an omnipresent immaterial "mechanism" (which may be God or an unknown non-mechanical process superadded to matter) that can supply the needed local action directly, and thereby preserve a general commitment to the mechanical philosophy's ban on action-at-a-distance causes/forces as regards matter's essence (see endnote 13). Given God's non-participatory role in physics, the Cartesians required a host of unobservable particles and mechanisms to explicate gravity, and thus they inevitably complicated their physical theory by invoking an ever more complex lower level of further mechanical hypotheses. Newton's active God, in contrast, could either supply the needed immaterial agent or serve the role of these elaborate mechanisms straightforwardly—and this, in hindsight, had the beneficial side-effect of allowing Newton to concentrate his full attention to the observable level of bodily behavior without worrying about the metaphysics of their underlying causes (see, Westfall 1971, pp. 398–399, who makes a similar point). Specifically, since the processes involved in a local *immaterial* cause are unknown, but not its effects, Newton could devote his full attention to harmonizing his mathematical apparatus with the local force *effects* of

gravity. By deploying their ever more successful mathematical techniques to, say, account for the recalcitrant orbits of various planets, Newton and his predecessors would ultimately acquire a series of remarkable achievements in reconciling the empirical evidence with the basic tenets of Newtonian natural philosophy; a success, moreover, that would assist the Newtonians in the long-run by securing a significant empirical foundation and argument for the reality of such unknown, "occult" *causes.* This is not to suggest that Newton's mathematics does not provide information or knowledge, possibly inductively, on the causes of material phenomena; rather, the simple point is that Newton's approach need not explicate these causes prior to the application of mathematics (see, Ducheyne 2005, on the role of mathematics vis-à-vis causal knowledge). Newton's Cartesian and Leibnizian detractors, on the other hand, insisted that a corporeal mechanical explanation for the cause of gravity be obtained *first;* for, as Descartes had earlier commented in connection to Galileo's mathematical treatment of physical phenomena (1638 Mersenne): "without having considered the first causes of nature, [Galileo] has merely looked for the explanations of a few particular effects, and he has thereby built without foundations" (Descartes 1976, AT II 380). The search for foundations is indeed an important aspect of physics, but, with the full benefit of hindsight, a systematic mathematical construction that incorporates and accounts for the observable effects of gravity was what was desperately needed at this point in the historical development of the discipline.

Furthermore, Newton's metaphysics possesses a decided advantage over the earlier neo-Platonist theories, such as More's, that also posit an incorporeal basis for gravity. This advantage likely resides in Newton's reluctance to classify spatial extension as "incorporeal", a description that More and the other Cambridge neo-Platonists unproblematically endorse (see endnote 14). The rationale for Newton's reluctance to employ the "incorporeal" designation probably derives from his concerns regarding the concept of substance, specifically, the division between corporeal and incorporeal substance. As hinted at in section 2, the *De Gravitatione* denies the Cartesian distinction between material and immaterial substance. Newton argues that "if extension is eminently contained in God, or the highest thinking being, certainly the idea of extension will be contained within the idea of thinking, and hence the [Cartesian's complete] distinction between these ideas will not be such that both may fit the same created substance, that is, but that a body may think, and a thinking being be extended" (p. 31). As regards the Scholastic bare substance/substantial form dichotomy, Newton proposes that, by rejecting the corporeal/incorporeal dichotomy among substances, the distinction among corporeal and incorporeal attributes is also undermined:

> If we adopt the common idea (or rather lack of it) of body, according to which there resides in bodies some unintelligible reality that they call substance, in which all the qualities of the bodies are inherent, this (apart from its unintelligibility) is exposed to the same problems as the Cartesian view. Since it cannot be understood, it is impossible that its distinction from the substance of the mind should be understood. For the distinction drawn from substantial form or the attributes of substance is not enough: if bare substances do not have an essential difference, *the same substantial forms or attributes can fit both,* and render them by turns, if not at one and the same time, mind and body. (pp. 31–32; emphasis added)

Accordingly, since extension is an attribute of both mind and body for Newton, there is no longer any need for More's classification of spatial extension as incorporeal. On Newton's estimation, space is simply God's attribute, an attribute that generically applies to all types of being, including both the corporeal and incorporeal, since all being emanates from God. Finally, despite his judgment that God is more akin to a mind-like, incorporeal substance, Newton's aversion to the very idea of substance is so great that he even considers the possibility that God's attributes can be conceived without a corresponding notion of God's substance: "if we should have an idea of that attribute or power by which God, through the action of his will alone, can create beings, we should readily conceive of that attribute as subsisting by itself without any substantial subject and [thus as] involving the rest of his attributes" (and spatial extension, of course, is one of God's attributes; p. 33).

Given Newton's largely dismissive attitude towards the metaphysics of substance, along with its corresponding sharp distinction between corporeal and incorporeal substances, there is, accordingly, some room in his natural philosophy for the judicious use of incorporeal local causes to explain material phenomena (especially when there are no apparent local corporeal sources to explain these effects). Since there is no difference *in substance* between the corporeal and the incorporeal, the conjunction of an incorporeal cause and a corporeal effect does not constitute as great an ontological hurdle for Newton as it would for those who do invoke a corporeal/incorporeal dichotomy among substances. The immaterial cause of gravity was likewise defended by More; but, unlike Newton, More accepted a distinction between corporeal and incorporeal substance, and thus the alleged causal interaction among these substances would seem to comprise a much bigger problem for More than for Newton.[14]

14. More argues for the incorporeal nature of gravity in the *Enchiridium,* chap. XI (see, Gabbey 1990). More's belief that space is incorporeal stems from his idea that the dimen-

Newton's concept of God, therefore, is much like the Creationist's "God of the gaps". The Creationist attempts to reconcile theology with cosmology by confining God's creative act to an ever more shrinking domain of physical events that either remain unexplained or offer some opening for theological speculation (such as in the modern debate over the cause of the Big Bang). Newton hopes to placate the anxieties of the mechanical philosophers in an analogous fashion, i.e., by positing an immaterial source for the observable gravitational effects that are encompassed within his "rational mechanics" (from the preface to the *Principia:* "*rational mechanics* will be the science, expressed in exact propositions and demonstrations, of the motions that result from any forces whatever and of the forces that are required for any motions whatever", 2004, p. 41). Consequently, Newton's "God of the (rational mechanical) gaps", as we may dub it, can be viewed as complementing, or a component of, his famous "I feign no hypothesis" response to the cause of gravity in the *Principia's* 1713 General Scholium (2004, p. 92). In short, immaterial causes are unknown, therefore, until experimental and observational evidence is brought forward (if indeed it is possible), we can feign no hypotheses on their mode of operation. To summarize, Newton's spatial ontology displays, arguably, two noteworthy traits: first, it fortuitously channeled the mechanist's interests away from the unobservable causes of gravity and towards their observable effects, and, second, it rendered an immaterial basis for gravity more plausible by denying a sharp corporeal/incorporeal substance dichotomy. It is principally in these two respects that Newton's spirit-infused ontology of space boasts a significant advantage over his

sions of space, like spirit, "penetrate" the dimensions of corporeal substance (More 1995, pp. 123–124; and, see, Charleton 1654, p. 68). In addition, while More retains a distinction between corporeal and incorporeal substances, he strives, also like Newton, to minimize the distinction between the two: In the *Enchiridium,* More argues that *"matter is not from itself, since it is not necessary and, therefore, that there is some immaterial principle from which it exists"* (1995, C.IX, Sec.10, p. 76). This suggests that Newton may have derived his tendency to downplay the differences among substances from More's similar approach, although the dependence of the corporeal on the incorporeal is a common neo-Platonist conception (and Newton clearly makes a more determined effort to blur the difference between the incorporeal/corporeal than does More). Given that More (and Charleton) incorporate two types of extension, i.e., an incorporeal extension that penetrates corporeal extension, in their respective natural philosophies, it follows that Newton's DQE hypothesis is more parsimonious since it employs only one, namely, the divine attribute of extension. Although beyond the bounds of this essay, also relevant to the discussion in this section is the question of Newton's theological voluntarism (roughly, the role of God's will over material affairs, as opposed to his intellect). As argued in Harrison 2002, however, there is a general uncertainty about the content of this thesis, and who held it, among seventeenth century natural philosophers, including Newton.

competitors, and not in any alleged benefits that accrue from his rearrangement of familiar neo-Platonic spatial concepts—alas, many contemporary "enthusiasts" of Newton's spatial theory will likely deem this a rather dubious compliment.

References

Ariew, R. and A. Gabbey. 1998. "The Scholastic Background." Pp. 425–453 in *The Cambridge History of Seventeenth Century Philosophy, Vol. 1.* Edited by D. Garber and M. Ayers. Cambridge: Cambridge University Press.

Bolton, M. 1998. "Universals, Essences, and Abstract Entities." Pp. 178–211 in *The Cambridge History of Seventeenth Century Philosophy, Vol. 1.* Edited by D. Garber and M. Ayers. Cambridge: Cambridge University Press.

Boylan, M. 1980. "Henry More's Space and the Spirit of Nature." *Journal of the History of Philosophy,* 18, 395–405.

Burtt, E. A. 1952. *The Metaphysical Foundations of Modern Science.* Atlantic Highlands: Humanities Press.

Callender, C. and Hoefer, C. 2002. "Philosophy of Space-Time Physics." Pp. 173–199 in *The Blackwell Guide to the Philosophy of Science,.* Edited by P. Machamer and M. Silberstein. Oxford: Blackwell Publishers.

Carriero, J. 1990. "Newton on Space and Time: Comments on J. E. McGuire." Pp. 109–134 in *Philosophical Perspectives on Newtonian Science.* Edited by P. Bricker and R. I. G. Hughes. Cambridge, MA: MIT Press.

Charleton, W. 1654. *Physiologia Epicuro-Gassendo-Charletoniana.* London.

Copenhaver, B. 1980. "Jewish Theologies of Space in the Scientific Revolution: Henry More, Joseph Raphson, Isaac Newton and their Predecessors." *Annals of Science,* 37, 489–548.

Descartes, R. 1976. *Oeuvres de Descartes.* Edited by C. Adams and P. Tannery. Paris: J. Vrin.

Descartes, R. 1991. *Principles of Philosophy.* Translated by V. R. Miller and R. P. Miller. Dordrecht: Kluwer Academic Publishers.

Dieks, D. 2001. "Space and Time in Particle and Field Physics." *Studies in History and Philosophy of Modern Physics,* 32, 217–241.

DiSalle, R. 1994. "On Dynamics, Indiscernibility, and Spacetime Ontology." *British Journal for the Philosophy of Science,* 45, 265–287.

DiSalle, R. 2002. "Newton's Philosophical Analysis of Space and Time." Pp. 33–56 in *The Cambridge Companion to Newton.* Edited by I. B. Cohen and G. E. Smith. Cambridge: Cambridge University Press.

DiSalle, R. 2006. *Understanding Space-Time.* Cambridge: Cambridge University Press.

Dorato, M. 2000. "Substantivalism, Relationism, and Structural Spacetime Realism." *Foundations of Physics,* 30, 1605–1628.

Ducheyne, S. 2005. "Newton's Training in the Aristotelian Textbook Tradition: From Effects to Causes." *History of Science,* 43, 217–237.

Funkenstein, A. 1986. *Theology and the Scientific Imagination from the Middle Ages to the Seventeenth Century.* Princeton: Princeton University Press.

Gabbey, A. 1990. "Henry More and the Limits of Mechanism." Pp. 19–35 in *Henry More.* Edited by S. Hutton. Dordrecht: Kluwer.

Garber, D., Henry, J., Joy, L., and Gabbey, A. 1998. "New Doctrines of Body and its Powers, Place, and Space." Pp. 553–623 in *The Cambridge History of Seventeenth Century Philosophy, Vol. 1.* Edited by D. Garber and M. Ayers. Cambridge: Cambridge University Press.

Grant, E. 1981. *Much Ado About Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution.* Cambridge: Cambridge University Press.

Harrison, P. 2002. "Voluntarism and Early Modern Science." *History of Science,* 40, 1–27.

Henry, J. 1994. "'Pray do not Ascribe that Notion to me': God and Newton's Gravity." Pp. 123–147 in *The Books of Nature and Scripture.* Edited by J. Force and R. Popkin. Dordrecht: Kluwer.

Jammer, M. 1993. *Concepts of Space.* 3rd ed. New York: Dover.

Koyré, A. 1957. *From the Closed World to the Infinite Universe.* Baltimore: Johns Hopkins University Press.

Koyré, A. 1965. *Newtonian Studies.* Cambridge, MA: Harvard University Press.

Koyré, A. and Cohen, I. B. 1962. "Newton and the Leibniz-Clarke Correspondence." *Archives internationales d'histoire des sciences,* 15, 63–126.

Manders, K. 1982. "On the Spacetime Ontology of Physical Theories." *Philosophy of Science,* 49, 575–590.

McGuire, J. E. 1968. "Force, Active Principles, and Newton's Invisible Realm." *Ambix,* 15, 154–208; reprinted pp. 190–239 in *Tradition and Innovation: Newton's Metaphysics of Nature.* Dordrecht: Kluwer, 1995.

McGuire, J. E. 1978a. "Existence, Actuality and Necessity: Newton on Space and Time." *Annals of Science,* 35, 463–508; reprinted pp. 1–51 in *Tradition and Innovation: Newton's Metaphysics of Nature.* Dordrecht: Kluwer, 1995.

McGuire, J. E. 1978b. "Newton on Place, Time, and God: An Unpublished Source." *British Journal for the History of Science,* 11, 114–129.

McGuire, J. E. 1983. "Space, Geometrical Objects and Infinity: Newton and Descartes on Extension." In *Nature Mathematized.* Edited by W. R. Shea. Dordrecht: D. Reidel; reprinted pp. 151–189 in *Tradition and Innovation: Newton's Metaphysics of Nature.* Dordrecht: Kluwer, 1995.

McGuire, J. E. 1990. "Predicates of Pure Existence: Newton on God's Space and Time." Pp. 91–108 in *Philosophical Perspectives on Newtonian Science.* Edited by P. Bricker and R. I. G. Hughes. Cambridge, MA: MIT Press.

More, H. 1925. *Philosophical Writings of Henry More.* Edited by F. I. MacKinnon. New York: AMS Press.

More, H. 1995. *Henry More's Manual of Metaphysics: A Translation of the* Enchiridium Metaphysicum *(1679),* Parts I and II. Translated by A. Jacob. Hildesheim: Olms.

More, H. 1997 [1655]. *An Antidote Against Atheism.* 2nd edition. Bristol: Thommes Press.

Newton, I. 1962. *De gravitatione et aequipondio fluidorum.* Pp. 89–164 in *Unpublished Scientific Papers of Isaac Newton.* Translated and edited by A. R. Hall and M. B. Hall. Cambridge: Cambridge University Press.

Newton, I. 1978. *Papers and Letters on Natural Philosophy.* 2nd ed. Edited by I. B. Cohen. Cambridge, Mass.: Harvard University Press.

Newton, I. 1983. *Certain Philosophical Questions: Newton's Trinity Notebook.* Edited by J. E. McGuire and M. Tamny. Cambridge: Cambridge University Press.

Newton, I. 1999. *The "Principia": Mathematical Principles of Natural Philosophy, a New Translation.* Translated by I. B. Cohen and A. Whitman, with J. Budenz. Berkeley: University of California Press.

Newton, I. 2004. *Philosophical Writings.* Translated and edited by A. Janiak and C. Johnson. Cambridge: Cambridge University Press.

Palter, R. 1987. "Saving Newton's Text: Documents, Readers, and the Ways of the World." *Studies in History and Philosophy of Science,* 17, 385–439.

Rynasiewicz, R. 1995. "By Their properties, Causes, and Effects: Newton's Scholium on Time, Space, Place, and Motion." *Studies in History and Philosophy of Science* 25, Part I, 133–153; 26, Part II, 295–321.

Sklar, L. 1974. *Space, Time, and Spacetime.* Berkeley: University of California Press.

Slowik, E. 1996. "Perfect Solidity: Natural Laws and the Problem of Matter in Descartes' Universe." *History of Philosophy Quarterly,* vol. 13, 1996, 187–204.

Snobelen, S. 2001. "'God of gods, and Lord of lords': The Theology of Isaac Newton's General Scholium to the *Principia.*" *Osiris,* 16, 169–208.

Stein, H. 1967. "Newtonian Space-Time." *Texas Quarterly,* 10, 174–200.

Stein, H. 1977. "On Space-Time and Ontology: Extract from a Letter to Adolf Grünbaum." Pp. 374–403 in *Foundations of Space-Time Theories.* Minnesota Studies in the Philosophy of Science, vol. 8. Edited by

J. Earman, C. Glymour, and J. Stachel. Minneapolis: University of Minnesota Press.

Stein, H. 2002. "Newton's Metaphysics." Pp. 256–307 in *The Cambridge Companion to Newton.* Edited by I. B. Cohen and G. E. Smith. Cambridge: Cambridge University Press.

Teller, P. 1987. "Space-Time as Physical Quantity." Pp. 425–448 in *Kelvin's Baltimore Lectures and Modern Theoretical Physics.* Edited by P. Achinstein and R. Kargon. Cambridge, MA: MIT Press, 425–448.

Teller, P. 1991. "Substance, Relations, and Arguments about the Nature of Space-Time." *Philosophical Review,* C, 362–397.

Westfall, R. S. 1962. "The Foundation of Newton's Philosophy of Nature." *British Journal of History of Science,* 1, 171–182.

Westfall, R. S. 1971. *Force in Newton's Physics.* London: MacDonald.