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NEWTON'S QUANDARY ABOUT ACTION AT A DISTANCE*

1. Introduction

In a well known passage of his fifth letter to Samuel Clarke, written in 1716, Leibniz upbraids Newton for having revived scholastic occult qualities "under the specious name of forces". For unless Newton supposes God himself to effect the earth's movement toward the sun through empty space ("a miracle if ever there was any", Leibniz expostulates), he has resorted to attractions properly so called, that is to say, actions at a distance without any intervening means, which are nothing but "absurdities".[1] In a passage that today is even better known, Newton at least appears to share Leibniz's appraisal of unmediated distant action. Writing to Richard Bentley in the early 1690's, some five years after his *Principia* was first published, Newton declares,

> 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. And this is one reason why I desired you would not ascribe innate gravity to me. 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 through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it.[2]

* The author was a fellow of the European Institutes for Advanced Study (EURIAS) program within the academic year of 2011-2012.

Although some of these remarks appear to presage Leibniz's own words, there is no interpretive consensus about Newton's meaning. More generally, there is no consensus about the stance he took on the possibility of unmediated distant action, at this time or at any other, and accordingly about whether he was sincere when disavowing knowledge of gravity's cause, most famously in his General Scholium remarks, "I have not yet assigned a cause to gravity", and "I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses."[3]

Elsewhere, I have argued that Newton was sincere in denying knowledge of gravity's cause; while he entertained various hypotheses about gravity's cause—including the hypothesis of unmediated distant action—he never endorsed any of them. His lack of confidence in the hypothesis of unmediated distant action by matter is explained by an inclination toward such metaphysical principles as a principle of local causation. This interpretation is a conservative one, which resembles that of Ernan McMullin in some respects.[4] My basis for it includes negative evidence—what Newton's writings do not contain—as well as positive evidence. The positive evidence includes an overlooked but critical substitution that Newton makes to Bentley's words, in a paraphrase contained in the passage quoted above. Because Newton's method prohibits the use of metaphysical principles or other hypotheses when drawing conclusions in physics, I have also addressed the question of whether his inclination to such principles violates his method, arguing that it does not since by its nature, induction leaves room for such principles to play a certain motivational role, which is the only role that Newton allows them.

This paper extends those arguments. After sketching both the debate and the position I have previously taken in it, I extend my arguments by focusing upon the original version of the *Principia*'s third book published posthumously as *A Treatise of the System of the World*. That text has recently been interpreted as advancing what I shall call a 'scandalous hypothesis': the view that matter has robustly active powers of increasing the universe's scalar quantity of motion, and of doing so at a distance, without any spatially intervening medium.[5] Despite that interpretation's initial plausibility, it cannot be sustained. For as I shall show, it requires that Query 31's robust sense of activity be identical to the sense that matter possesses through its *vis inertiae* in Definition 3. Yet these turn out to be

very different sorts of activity, one drawn from the Cartesian tradition, the other from the Aristotelian.

To sketch what is to come, the next section provides an overview of debate about unmediated distant action, while sections 3 and 4 provide some negative and positive evidence, respectively, for a scandalous interpretation of Newton, reviewing some of my arguments given elsewhere. The remaining sections focus upon Newton's *System of the World*, and I rebut Schliesser's recent scandalous interpretation of that text.

2. The debate about unmediated distant action and gravity's cause

One way to frame the debate about what conclusion Newton may have reached about gravity's cause and the possibility of unmediated distant action is to begin with this question: Why does he disavow knowledge of gravity's cause? Four main responses to that question may be distinguished in the debate, and I set them out here, noting the difficulties I see with the first three positions and defending the fourth.[6]

According to one position in the debate, when Newton disavows knowledge of gravity's cause, he is not sincere, for he has privately reached the conclusion that Leibniz called "a miracle if ever there was any", namely, that God causes gravitational effects directly.[7] Although certain passages do suggest that Newton considered this view,[8] he does not seem to have embraced it. For he repeatedly treats the gravitational force as something that requires only divine concurrence, and that otherwise operates independently of God. In Query 31, for instance, gravity is one of God's tools. The active principles that Newton associates with gravity and also the speculative, short-range distance forces are "general laws of nature, by which the things themselves are formed", and, he writes, with respect to the speculative force of cohesion, it is "by the help of these principles" that God composes bodies.[9] Even more telling, at various points Newton infers the existence of a designer from the fact that the stars do not aggregate together or collapse into the sun.[10] If God were causing gravitational effects directly, there would not be any physical gravitational force to oppose, and preventing collapse would require only that he refrain from pushing the stars into the sun. By treating the force as something that God must oppose, Newton implies that it is distinct from God.

A second answer also takes Newton's protestations of ignorance to be insincere, but interprets him as accepting the direct variant of the hypothesis that matter has powers of unmediated distant action.[11] According to this view, observable bodies such as the sun and earth causally act upon one another from a distance and directly, without any intermediary such as the Query 21 aether. There are texts that do initially appear to support this interpretation, including some much-discussed remarks in Query 31 that speculatively attribute short-range distance forces to particles, and also a passage from the aforementioned text, *A Treatise of the System of the World*, which employs causal language in connection with the gravitational force. As I argue in a subsequent section, however, the *System of the World* does not in fact advance any causal hypothesis at all, nor does Newton attribute physical powers of attraction to particles in Query 31, despite initial appearances. In general, his proposals about attractive and repulsive distance forces are accompanied by caveats and qualifications. An unequivocal, confident attribution of powers to attract from a distance, such as we find with Bentley and Locke, is absent from Newton's writings, and in his manuscripts he instead seems perplexed by the nature and location of the active principles that he suggests are gravity's cause.

According to a third response, defended by John Henry,[12] Newton believes matter to possess powers of unmediated distant action, and yet speaks sincerely when disavowing knowledge of gravity's cause because he not certain which type of matter possesses those powers. Although he is confident that some sort of matter can act distantly, he is not sure whether those powers belong to ordinary, observable bodies, such that the celestial bodies can attract one another across separations of millions of miles, or only to the material particles of the *Opticks* aether, which repel one another at shorter ranges. Yet in Newton's struggles to understand the nature and location of the active principles that he associates with gravity, notably in the drafts related to Query 31, it is not the question of which sort of matter possesses active principles that confounds him, but rather the question of the relationship of active principles to matter *simpliciter*. "What that Principle is", he writes, and "how it stands related to matter is…difficult to explain."[13] An additional problem with this third response is that it may take the Query 21 hypothesis more seriously than Newton himself took it. I do not think the hypothesis was a mere ruse, in part because its reliance upon unmediated distant action among the aether particles meant that it could not be expected to silence critics sharing

Leibniz's concerns. But while I do think that Newton took the Query 21 hypothesis, and thus unmediated distant action, seriously enough to include it among his published speculations, I do not think he ever really endorsed it, for it is notoriously problematic. There is no reason to think that this rare and particulate aether is immaterial, and to suppose that Newton truly endorsed the Query 21 hypothesis for a material aether is to allow that he was willing to abandon either his second rule of reasoning or his conclusion that gravitation is universal. For the aether hypothesis holds that the planets are driven toward the sun by the aether's pressure, as its particles repel one another. Yet this provides no explanation for the gravitational attraction of any matter—whether observable bodies or aetheral particles—lying perpendicular to the density gradient rather than along it. And to require a distinct explanation for the gravitation of that matter is to violate Rule 2's tenet that "the causes assigned to natural effects of the same kind must be, so far as possible, the same".[14] Yet to avoid such a distinct explanation by supposing that the aether does not gravitate would be to abandon universal gravitation. In light of this, it is unlikely that Newton went beyond allowing the Query 21 hypothesis as a possibility.

The fourth answer to the question of why Newton lacks confidence in the hypothesis of unmediated distant action, instead considering himself ignorant of gravity's cause, is that he is inclined to think that matter is passive (in the sense of being incapable of initiating motions that would increase the universe's quantity of scalar motion) and that causation operates locally, which is to say by contact. In other words, an inclination to metaphysical principles prevents him from believing in unmediated action at a distance. Yet since that hypothesis seems the likeliest among secondary causes, Newton remains in a quandary about action at a distance, never embracing any explanation of gravity's cause. It is this fourth response that I defend. My conclusion is based upon both the negative evidence of what is absent in his writings as well as the positive evidence of what his writings do contain. In a brief reprise of arguments given elsewhere, sections 3 and 4 review, respectively, the negative and positive evidence.

3. Against the scandalous interpretation: negative evidence

Although Newton does not have the grounds to assert, as a demonstrated proposition, that spatially separated material bodies have the power to attract one another without any intervening medium, that hypothesis is the most probable one among secondary causes. And Newton does for the most part expect that gravity operates by secondary causes.[15] Since he proved in *Principia* Book 2 that the secondary cause cannot be a dense material medium, and since finding empirical support for an immaterial medium is a vexed problem,[16] the likeliest secondary cause on the table is a robust, active power of matter to accelerate other matter from a distance, without any spatially intervening medium. Newton does entertain the possibility of unmediated distant action, according to Query 21 of his *Opticks*. the planets are propelled inward toward the sun by the pressure of a very rare aether, whose density increases with distance from the sun, and whose pressure derives from the tremendous force with which the aethereal particles repel one another. Since these particles are almost certainly material, this aether operates by repulsive action at a distance by matter.

Yet neither Query 21's hypothesis about gravity, which poses the distantly-acting aether particles as a medium among observable bodies, nor a hypothesis attributing powers of distant action directly to observable bodies, wins Newton's confidence. The latter sort of hypothesis arguably has considerable appeal. It would serve as a causal explanation of gravity, and without the considerable problems facing the Query 21 hypothesis. Additionally, it offers the promise of resolving such long-standing problems as the mystery of cohesion, for which Newton speculatively introduces short-range distance forces in Query 31. We might therefore expect Newton's published speculations or else his private manuscripts to express confidence in the causal hypothesis of unmediated distant action. Even as Richard Bentley and John Locke come to accept unmediated distant action, and do so because of his gravitat ional theory, Newton remains uncommitted, denying knowledge of gravity's cause in his second letter to Bentley and much later in the General Scholium. Even his unpublished manuscripts do not contain any consistent, unqualified expectation that gravity is caused by a robustly active power possessed by matter for unmediated distant action.

Might the explanation be that he remains cautious when engaging in any speculations? Query 31 indicates that it is not. For some of his

spectulations there are advanced with considerable confidence. The most notable example, perhaps, is his attack upon Descartes' conservation principle, a principle holding the (scalar) quantity of motion in the universe to constant. "It is very certain that there is not always the same quantity of motion in the world," he writes in Query 31.[17] He then proceeds to argue with similar confidence for the existence of some motion-generating active principles. Clearly, then, Newton has confidence in some speculations; and so the speculative status of a hypothesis of unmediated distant action is not, then, sufficient to explain Newton's failure to endorse it clearly and unequivocally.

4. Against the scandalous interpretation: positive evidence

Two points are in order before reviewing some of the positive evidence, points which I have noted elsewhere but reiterate here. The first one concerns Newton's epistemic attitude. As I interpret the texts discussed below, Newton's remarks evince an inclination toward certain metaphysical principles—and I do mean inclination. I do not take him to be indefeasibly committed to those principles; speculations such as the Query 21 aether hypothesis indicate that he did consider abandoning those principles, and did consider the possibility that matter has the capacity for unmediated distant action.[18] The second point concerns the question of whether Newton's inclination toward metaphysical principles constitutes a violation of his own method. As I have argued elsewhere, it does not. For although his method prohibits metaphysical principles from grounding physical conclusions, the nature of induction is such that those principles may play a certain motivational role. There is no decisive point at which the failure to find a sought-after entity constitutes reason to conclude that it probably does not exist; and this means that a suspicion about unmediated distant action could motivate an ongoing search for gravity's cause without constituting a violation of his method.[19]

A focal text in the debate about Newton's stance toward unmediated distant action is his fourth letter to Richard Bentley (25 February, 1692/93), the following passage in particular, which begins with Newton's mention and approving paraphrase of Bentley's own words.

> The last clause…I like very well. Tis unconceivable that inanimate brute matter should (without ye mediation of something else wch is not material)

> operate upon & affect other matter without mutual contact; as it must if gravitation in the sense of Epicurus be essential and innate in it. And this is one reason why I desired you would not ascribe innate gravity to me. That gravity should be innate inherent & essential to matter so yt one body may act upon another at a distance through a vacuum without the mediation of any thing else by & through wch their action or force may be conveyed from one to another is to me so great an absurdity that I believe no man wh has in philosophical matters any competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent be material or immaterial is a question I have left to ye consideration of my readers.[20]

As I read this passage, Newton is making two objections.[21] He is not only objecting to the notion that gravity is essential to matter, but also to the notion that bodies are capable of unmediated distant action upon one another. If he meant to agree with Bentley's view—the view that God has superadded the capacity for such action to matter—we could expect him to refer to God clearly and directly, as Bentley does. Bentley uses the phrase "divine impression" to explain his view that God has superadded to matter the power for unmediated distant action. Yet when Newton paraphrases Bentley's words, he neither retains that phrase nor substitutes one of his own earlier, clear references to God. Instead, he substitutes this phrase, "ye mediation of something else wch is not material", which is imprecise in that its range of possible referents include not only God but also minds and, notably, perhaps an immaterial medium. Thus his substitution produces a statement with a very different meaning, one which, because it avoids any clear reference to God, seems to object to action at a distance. Newton's subsequent remarks are yet clearer. He writes, "That gravity should be innate inherent & essential to matter so yt one body may act upon another at a distance through a vacuum without the mediation of any thing else by & through wch their action or force may be conveyed from one to another is to me…an absurdity." As I have emphasized elsewhere, this remark could not easily be construed as referring to a divine sense of 'mediation', since it speaks of something that conveys the force or action from one body, at one region of space, to another body at another region of space. Newton is thus referring to something that is spatially intermediate between the bodies, which indicates an inclination toward the principle that causation is local.[22]

If we consider Query 31 and related draft passages, they too suggest an inclination to the aforementioned metaphysical principles.[23] The query's

opening sentence does seem to advance a causal hypothesis involving unmediated distant action, for there Newton asks whether the particles of bodies possess powers or forces by which they "act at a distance". Yet soon he qualifies that suggestion, first disclaiming any knowledge of how the forces operate, and then stating that the operation could involve impulse or something yet unknown. He also refrains from locating the active principles to which he attributes those speculative forces in matter. Whereas he clearly attributes the *vis inertiae* to the particles of matter—they "have" that passive principle—he adopts a locution that remains agnostic about location when discussing active principles; the particles of matter "are moved by" active principles. Some passages in related drafts show a similar uncertainty; instead of clearly asserting that matter possesses the power to act robustly, for instance, he instead writes, "Matter is a passive principle & cannot move itself."[24] All of this suggests that Newton's talk of distant action in Query 31 reflects the investigatory procedure he recommends in the *Principia*, in which the first questions to answer are whether the speculated forces actually exist and what their mathematical proportions are, with questions about physical causes being postponed until those first stages are accomplished.[25]

Yet in another text, Newton uses some causal language that has recentedly been interpreted as advancing a scandalous hypothesis. The next sections consider how that text should be interpreted.

5. Newton's description of gravity in the *System of the World*

In his remarks about forces that act between spatially separated bodies, Newton frequently includes caveats of the sort noted earlier, in connection with Query 31. This is certainly the case in the published *Principia*. It is therefore very interesting the the unpublished predecessor of the material published as the *Principia*'s third book, Newton discusses the gravitational force in a freer style. That original version—the aforementioned *A Treatise of the System of the World*, as it was published posthumously—was written in "popular form, so that it might be more widely read". Yet before publication, Newton thought better of making his ideas so accessible. He replaced it with a technical version, and he did not conceal his reason for doing so. He wished "to avoid lengthy disputations", by excluding those readers unable to "lay aside the preconceptions to which they have become accustomed".[26] And indeed, the *System of the World* contains

a description of gravity that might be construed as suggesting that matter has the capacity to act robustly and at a distance, without any intervening medium. Although he initially declares that he will consider the force only in a "mathematical way", avoiding all questions about its "nature or quality", [27] he seems to abandon that intention with an extended description of gravity that includes the following remarks.

> There is a double cause of action, to wit, the disposition of both bodies, as well as a double action in so far as the action is considered as upon two bodies. But as betwixt two bodies it is but one single one. 'Tis not one action by which the sun attracts Jupiter, and another by which Jupiter attracts the sun. But it is one action by which the sun and Jupiter mutually endeavor to approach each the other. By the action with which the sun attracts Jupiter, Jupiter and the sun endeavor to come nearer together, and by the action, with which Jupiter attracts the sun, likewise Jupiter and the sun endeavor to come nearer together. But the sun is not attracted towards Jupiter by a two-fold action, nor Jupiter by a two-fold action towards the sun: but 'tis one single intermediate action, by which both approach nearer together.[28]

After remarking upon that "double cause of action", Newton goes on to suggest that the single action of the force between two bodies arises "from the conspiring natures of both"[29] indeed, from "the universal nature of matter".[30] These remarks lack the caution that so frequently characterizes his tone, and they might even seem to lend themselves to a scandalous interpretation.

6. A scandalous interpretation of the *System of the World*

Two claims are required for the hypothesis that gravitation operates by robust and unmediated distant action. The first is the positive claim that matter possesses the power to attract other matter, such that new motion is generated. The second is the negative claim that no medium is required for that attraction to be initiated or conveyed. The remarks quoted in the previous section seem to suggest the positive claim that matter possesses a power of attraction, for Newton speaks of the "disposition" of the bodies as being "the double cause" of the action.

It must be noted that it would be a very different thing to say that matter's nature posseses the disposition to attract than to say it possess

the gravitational force itself. Newton consistently holds that gravity is not essential to matter.[31] But that consistent view would be compatible with a claim that matter possesses, by its essence or nature, the disposition to attract. This point is made clearly in Schliesser's explanation of the scandalous interpretation that he defends: "The cause of gravity is the disposition inherent in any individual body, but that the force of gravity *is* the actualization of that disposition."[32]

Although I will eventually consider Schliesser's interpretation more directly, at the moment I want to see what sort of case might be made for it by looking to some texts in which Newton discusses matter's nature or characteristic quality on the one hand, and gravity's cause on the other. Proceeding in this manner will better enable us to identify a requirement that the scandalous interpretation depends upon.

Since the passages considered above provide *prima facie* support for a scandalous interpretation, and since the *System of the World* was originally intended to be part of the *Principia*, perhaps further support for the interpretation can be found in the *Principia* itself. Although the *Principia* contains no definition of matter—Definition 1 specifying quantity of matter rather than defining matter itself—Definition 3 appears promising. Definition 3 sets out the 'inherent force' of matter, also called its *vis inertiae* ('force of inertia'), which underwrites matter's resistance. The *vis inertiae* is of particular interest because Newton takes this quality to be characteristic of and essential to matter.[33] So if Newton attributed a power of robust activity to matter in virtue of the *vis inertiae*, the attribution would help establish the positive claim needed for the interpretation under consideration. As Definition 3 makes clear, matter is capable of some sort of activity in virtue of its *vis inertiae*, or more accurately, its exerted *vis inertiae*.

> Inherent force may also be called by the very significant name of force of inertia. Moreover, a body exerts this force only during a change of its state, caused by another force impressed upon it, and this exercise of force is, depending on the viewpoint, both resistance and impetus: resistance insofar as the body, in order to maintain its state, strives against the impressed force, and impetus insofar as the same body, yielding only with difficulty to the force of a resisting obstacle, endeavors to change the state of that obstacle.[34]

Although in the absence of any impressed forces, a body's *vis inertiae* remains unexerted (the unexerted *vis inertiae* being the cause of the body's persistence of state[35]), in the presence of an impressed force the body exerts its *vis inertiae*. The exerted *vis inertiae*, Newton explains, may be seen either as resistance or as impetus, for these are only rationally distinct; differing only in how we view or conceive them, they are really identical to one another. As a number of commentators have noted, the exertion seems to amount to an impressed force.[36] In virtue of its exerted *vis inertiae*, then, a body is capable of acting to change the state of a body that impresses a force upon it by reciprocating with an impressed force; it is capable of delivering the reaction required by Law 3.

This characterisation of the exerted *vis inertiae* appears promising, then, but it could support the positive claim needed for the interpretation under consideration only given a certain requirement. The interpretation requires that the sense of activity that Newton attributes to matter in Definition 3 be identical to the robust sense of activity appearing in Query 31. This assumption is necessary to the scandalous interpretation for the following reason. It is only Query 31's sense of activity that Newton casts as robustly active, and as gravity's cause. Whereas Query 31's sense of activity increases the universe's scalar quantity of motion (as seen in more detail in the next section), the *Principia* does not explicitly suggest either that Descartes' conservation principle is false or that the universe must contain robustly active powers.[37] And it is only Query 31's sense of activity that Newton cites as gravity's cause: 'Seeing therefore the variety of motion which we find in the world is always decreasing, there is a necessity of conserving and recruiting it by active principles, *such as are the cause of gravity*'.[38] Meanwhile, it is only Definition 3's sense of activity that Newton clearly attributes to matter; at no point in Query 31 does he clearly locate 'active principles', the robust sense of activity, in matter.[39] Yet an identity between the two senses of activity could secure the positive claim. If Newton identified Definition 3's sense of activity, which belongs to the *vis inertiae* and thus to matter, with Query 31's sense of activity, which generates new motion, he would thereby attribute the robust power of generating new motion to the very nature of matter; and since in Query 31 he cites active principles as being gravity's cause, he would be grounding gravity's cause in the essence of matter.

The claim that Newton employs a single sense of activity both in Definition 3 and in Query 31 has been suggested recently by Eric Schliesser, 2011, who defends a version of the scandalous interpretation

developed in this section. Focusing his attention first upon the *System of the World*, Schliesser argues that Newton understood gravity as a relation arising from the dispositions in material bodies. Of particular interest here is the robustly active nature of the dispositions giving rise to the gravitational force. As Schliesser understands Newton, bodies have both passive and active dispositions, the former being codified in the second law of motion and the latter in the third law; and the active disposition including a disposition to produce the gravitational force.

> The action is i) twofold as it is *upon* two bodies, and ii) single as *between* two bodies. A way to capture this is to say that a body has two dispositions: a 'passive' disposition to respond to impressed forces is codified in the second law of motion, whereas an 'active' disposition to produce gravitational force is treated as a distinct interaction codified in the third law of motion.[40]

Continuing, Schliesser emphasises that in his view, Newton thinks matter can be 'viewed' as either active or passive, which is to say that activity and passivity are only rationally, that is, conceptually distinct: "I should emphasize that in my position Newton neither asserts that matter is altogether active nor passive. It depends on the way we are conceiving things."[41]

That Schliesser takes Newton to consider matter to have powers of activity and passivity that are only rationally distinct, and really identical, should not mislead us into thinking that he has a thin sense of activity in mind here. Query 31's sense of activity is robust, as Schliesser acknowledges by quoting the passage in which Newton cites active principles as the cause of gravity and fermentation.[42] Then in an explanatory footnote, Schliesser seems to suggest that he considers the sense of activity operating in Query 31 to be identical to that appearing in Newton's definition of the *vis inertiae*, that is, the 'force of inertia' or 'inherent force' of Definition 3:

> While this may sound strange, it is by no means unique in Newton. See, for example, Newton's treatment of the 'inherent force' of inertia. Newton claims that this force can sometimes be viewed 'passively': 'Inherent force of matter is the power of resisting'; but sometimes it is more 'active': 'a body exerts this force…during a change of its state, caused by another force impressed upon it' (quoted from the third definition).[43]

Broadening his focus beyond the *System of the World*, he then reinterprets Newton's fourth letter to Bentley in a way that permits the unmediated distant action interpretation of Newton to extend at least into the post-*Principia* period. Newton is not objecting to unmediated distant action per se, but to the Epicurean version of it, Schliesser argues, which as he construes it contains not only the claim that gravity is essential to matter, but also the internally inconsistent position that passive matter can act.

> [What Newton rejects is] the 'absurd' *Epicurean* position in which *passive* matter can *act* at a distance…. But it does not follow from this….that Newton rules out action at a distance *tout court*. For, Newton's position in the [fourth] Letter to Bentley permits us to understand that in the right circumstances matter can be viewed as 'active'.[44]

Once again, the 'right circumstances', Schliesser suggests, are those described in Query 31, an essay that introduces a clearly robust sense of activity, being associated with Newton's (speculative) assault on Descartes' conservation of motion principle.

Might I have misunderstood Schliesser? Perhaps he does not mean to say that a single sense of activity is operating in both Definition 3 and in Query 31, but rather means to say that Definition 3 provides an example in which Newton takes *some* sort of activity to be only rationally distinct from passivity; but that that is a thin sort of activity, one different from Query 31's robust activity. If so, that would not advance Schliesser's argument for the claim that Newton is endorsing unmediated distant action. For again, since Newton clearly attributes only Definition 3's sense of activity to matter, and clearly cites only Query 31's sense as gravity's cause, the interpretation at issue requires that they be identical. The main order of business, then, is to determine whether the senses of activity appearing in Definition 3 and in Query 31 are one and the same.

7. Against the scandalous interpretation of the *System of the World*: two senses of activity and an alternative interpretation

It is clear that Newton attributes a certain sense of activity to matter, for as we saw in connection with the discussion of Definition 3, a body's *vis inertiae*, when exerted, endeavors to change the state of that body impressing a force upon it. It is also clear that the sense of activity

possessed by the 'active principles' of Query 31 are robustly active, and that Newton cites them, albeit speculatively, as gravity's cause. But is the robust sense of activity appearing in Query 31 really identical to the sense that Newton attributes to matter in Definition 3? A consideration of Newton's reasoning in Query 31 will provide the answer.

As we saw in some brief passages quoted earlier, Newton attacks Descartes' conservation principle in Query 31; and whatever his position may have been earlier, it is evident that in Query 31 he is thinking in terms of a very robust sort of activity. Let us now consider his reasoning. As is well known, Newton is profoundly struck by processes that appear to destroy and to generate motion. In Query 31, he speculatively but strenuously contests two related Cartesian claims: (a) a body can lose motion only by transferring that motion to other bodies; and (b) the universe's total scalar quantity of motion remains constant (the Cartesian conservation principle). In contesting them, he first invokes a thought experiment involving a system of two globes connected by a rod, which rotates as its centre of gravity moves in a right line.

> For from the various composition of two motions, it is very certain that there is not always the same quantity of motion in the world. For if two globes joined by a slender rod revolve about their common centre of gravity in an uniform motion, while that centre moves on uniformly in a right line drawn in the plane of their circular motion, the sum of the motions of the two globes, as often as the globes are in the right line described by their common centre of gravity, will be bigger than the sum of their motions, when they are in a line perpendicular to that right line. By this instance it appears that motion may be got or lost.[45]

As Newton analyses the case, both of Descartes' claims are disproved. Contra (b), the quantity of motion in the universe does not remain constant, since contra (a), each globe loses motion at various points in the rotation, but does so without communicating that motion to another body. It is notable that Newton takes this position, because he is not driven to it. Neither is he precluded from it, of course; his analysis of the case is consistent with his own conservation principle, Corollary 3 to Law 3, which states, 'The quantity of motion, which is determined by adding the motions made in one direction and subtracting the motions made in the opposite direction, is not changed by the action of bodies on one another.'[46] His own conservation principle is not violated because

the losses and gains of motions in this case do not result from any action between the bodies, resulting instead from the 'composition of two motions'. But again, he is not driven to conclude from this case that motion may be gained and lost, for unlike Descartes, he has the vector concept. If he were inclined to believe that the scalar quantity of motion remained constant rather than varying, he could consider the vector sum to be the relevant one for the case, which gives equal results for both orientations.[47] Instead, he takes the numerical sum. That he does so is evident, because taking the numerical sum is the only way to obtain his conclusion that the sum of the motions differs for the two orientations.[48]

The same preference for the conclusion that motions are genuinely lost and then generated anew is evident in his discussion of collision cases. Unlike the two-globe case, in which he sees an internal means by which losses of motion are compensated by gains, natural processes such as friction and the 'weakness of elasticity in solids'[49] in collisions actually destroy motion, Newton suggests. In support of his speculation that 'motion is always on the decay',[50] he points to cases of bodies that do not rebound from one another in collision, because they are 'either absolutely hard, or so soft as to be void of elasticity', such that 'impenetrability makes them only stop'.[51] While the pre- and post-collision momenta are equal—in accordance, again, with Newton's own principle that the vector quantity of motion is conserved—the world is nonetheless very different after the collision than it was before. Newton's propensity to believe in a robust sort of activity is underscored by the fact that there are ways of avoiding the conclusion that motion can be genuinely lost, and that he does not avail himself of them. Just as one might avoid that conclusion in the two-globe case by taking the vector rather than the numerical sum to be relevant, one might avoid the conclusion for friction and collision cases. Instead of concluding that motion is genuinely destroyed, Newton could have supposed that motion lost at the macro level is simply transferred to the micro level, as heat.[52] This supposition, which favors the Cartesian conservation principle, had precedents, for instance in Boyle. Newton's sympathies lie elsewhere, however. In thinking reminiscent of Aristotle, and having vitalist roots in his alchemical and chemical experiments and readings,[53] Newton speculatively concludes that such losses create an explanatory demand for some replenishing, generative source of new motion—some 'active principles', as he calls them. The actions of these active principles collectively function to keep the quantity of motion more

or less stable, but individually, they alter that quantity, increasing it to make up for the losses caused by processes such as friction.

Newton leaves no doubt in Query 31, then, about the robust, motion-generating nature of his active principles. But he also leaves no doubt there about the nature and limitations of the *vis inertiae*'s capacities. Far from identifying the robust sense of activity with that of the *vis inertiae*, he explicitly contrasts active principles against matter's *vis inertiae* and against the three laws of motion resulting from it—all of which he now labels 'passive'.

> The *vis inertiae* is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, and resist as much as they are resisted. By this principle alone there never could have been any motion in the world. Some other principle was necessary for putting bodies into motion; and now [that] they are in motion, some other principle is necessary for conserving the motion.[54]

By contrasting the 'passive' *vis inertiae*, and the laws of motion resulting from it, against principles which are 'active' in the sense that they generate new motion, Newton clearly indicates what it means to be passive: to be unable to increase the universe's scalar quantity of motion. Matter's essential quality, the *vis inertiae*, is passive in that it can only redirect or redistribute existing motion, and never generate new motion. This point is reinforced in a draft related to the published Query, in which Newton writes that bodies 'are passive', and 'without some other principle than the *vis inertiae* there could be no motion in the world.'[55]

Since the *vis inertiae* has the capacity only to redirect or redistribute existing motion, it can be construed as a kind of activity only in a thin sense. Indeed, it is a sense of activity that is only rationally distinct from, but really identical to, passivity.[56] Since this thin sense of activity is associated with Descartes' conservation principle, we may say that it belongs to the Cartesian tradition; if the universe contains only this thin sense of activity, Descartes' conservation principle will be true. The robust sense of activity, meanwhile, is most assuredly not just another way of conceiving passivity. If the universe contains this robust sort of activity, Descartes' conservation principle will be false. We may say that robust activity belongs to the Aristotelian tradition because it evokes Aristotle's belief that absent some generative source, all motion would eventually cease and the universe would reach stasis.

The suggestion that robust powers of activity belong to the *vis inertiae* and thus to matter's very nature receives no support, then, from the late text we have been considering, Query 31. The *vis inertiae* is capable only of the thin, Cartesian sense of activity; and yet as we saw earlier, it is the robust, Aristotelian sense of activity that Newton cites as gravity's cause.[57]

So things stand in Query 31, but Newton wrote that essay long after first formulating Definition 3 for the *Principia* (and that may be said even if we take into account its earlier versions, Query 23 of the 1706 *Optice*, in particular). When he first defined the *vis inertiae* for the *Principia*, did he have only the thin, Cartesian sense of activity in mind, or might he at that time have associated robust activity with the *vis inertiae*, as needed for the scandalous interpretation? Newton's remarks in Definition 3 indicate that in one important respect, he is thinking in terms of the Cartesian tradition. Recall that in explaining the exerted *vis inertiae*, Newton stated that it may be considered as either resistance or impetus, since there is no real distinction between them, only a rational distinction, that is, a difference in viewpoint. Consider two colliding bodies, A and B. Body A's exerted *vis inertiae* may be considered either in terms of its effect upon body A itself or in terms of its effect upon body B. Considered in terms of its effect upon A itself, it is resistance, which is to say a striving to preserve its state such that it will not, say, be accelerated to infinite speed when it encounters B's impressed force. Considered in terms of its effect upon body B, however, body A's exerted *vis inertiae* is impetus, which is to say an endeavor to change B's state.

While this seems plausible for the case of colliding bodies, it seems plausible for only that case; and that suggests that Newton developed his ideas about the exerted *vis inertiae* with contact action in mind. If we consider the case of an attractive force acting between spatially distant bodies, it is difficult to sustain the notion that a body's resistance to an impressed force is only rationally distinct from, and really identical to, its endeavor to change the state of another body. When attracted by the sun, Jupiter exerts resistance, and therefore will not accelerate to infinite speed. Yet Jupiter's resistance, its failure to accelerate to infinite speed, cannot easily be seen as really identical to its endeavor to change the sun's state by exerting an attraction upon it. Jupiter's resistance to being accelerated and the attraction it exerts upon the sun instead seem really distinct.[58] This suggests that the sense of activity appearing in Definition 3 was developed with contact action in mind, and it accordingly seems

associated with the Cartesian tradition, in which motion can be only transferred among colliding bodies, never destroyed or generated anew.

The suggestion that Newton associated the robust sense of activity with the *vis inertiae* gains no support, then, from the *Principia*'s definition of it. The scandalous interpretation thus fails for the *Principia* as for Query 31, because the requirement needed to sustain it fails.

Yet what of the *System of the World*, the text whose description of gravity most strongly seemed to support the scandalous interpretation's positive claim? Here I briefly summarize the interpretation I have defended elsewhere.[59] Throughout that text, Newton remains focused upon establishing that gravitation is universal, and that the force's structure is a single, mutual endeavor. The language that employs causal terms indeed appears, at first glance, to present a causal hypothesis. Yet if we follow Newton's reasoning carefully, his aim turns out to be something quite different. He aims to show that although we might conceive the attraction between two bodies as if it consisted in two, unidirectional forces, that is only a mathematical convenience, not a representation of the force's actual structure. The structure of the physical force itself is singular; it does not consist in multiple endeavors, but is one, mutual endeavor. It might be mathematically convenient to consider either of two gravitating bodies as if it were only a body that is attracted; this is his point when he speaks of the "double action" upon two bodies. Similarly, however, we could think of either of two gravitating bodies as if it were only a body that attracts; and *that* is his point when he speaks of the "double cause" of the action. For when he speaks of the "double cause", he is still explaining how we might consider the force; and those ways of considering the force, however useful for mathematical purposes, are to be contrasted against the structure of the physical force itself. Contrary to initial appearances, then, Newton's use of the word 'cause' actually belongs to a description of mathematical ways of considering things, and the remark does not advance the positive claim needed for the scandalous interpretation.

8. Against the scandalous interpretation of the *System of the World*: the question about a medium

The last question to consider is whether the *System of the World* advances the scandalous interpretation's negative claim, the claim that no medium is required for producing or conveying the gravitational force. If it

could be shown that Newton endorses the negative claim in the *System of the World*, perhaps the scandalous interpretation could be established after all. For though Newton does not directly consider or endorse the positive thesis in the *System of the World*, neither does he directly deny it. What better reason to think that he accepted the positive claim than to find in the *System of the World* evidence that he endorsed the negative claim? After all, the most obvious reason for arguing that no medium is required for producing or conveying the gravitational force is that one believes matter capable of acting robustly and distantly. We therefore might take any indication that Newton's *System of the World* endorses the negative claim as reason to believe that he endorsed the positive claim too—and so accepted a scandalous interpretation.

I see two possible grounds on which one might think that Newton accepts the negative claim. First, most obviously and convincingly, we will think he endorsed the negative claim if we find that he directly addresses the question of whether the medium exists and concludes that it does not. Does Newton's *System of the World* deny that a medium exists? It does not. He never addresses the question in that text, so the first way of attributing the negative claim to him fails. So let us consider the second way. We might think that Newton endorsed the negative claim if we find that he is fully silent on the question of a medium; a deafening silence on such a momentous question would perhaps indicate a tacit belief that no medium exists. Schliesser argues that Newton advances the negative claim in this manner, denying the existence of a medium tacitly, through silence. Schliesser writes,

> In the *Treatise*, Newton is entirely silent on…the invisible medium, if any, to explain in what way momentum could be exchanged between two bodies. *Given that he uses the language of 'action' and is completely silent on the possibility of a medium of transmission, the natural reading of this passage is I) Newton's endorsement of action at a distance* with II) the start of an explanation of the cause of gravity in terms of some of the qualities of matter.[60]

Yet it turns out that Newton is not fully silent. In concluding his discussion of aggregate bodies, he states that the parts of the other planets mutually attract, just as the parts of the Earth do, causing all of these bodies to have spherical shapes. Their parts cohere, he continues, '*and are not dispersed through the Ether*'.[61] Instead of maintaining silence on the question of a

medium, which might have suggested belief in the negative claim, Newton treats the ether as something whose existence may be casually assumed. The reason, evidently, is that a medium is simply not relevant to the questions he is addressing. Thus Newton gives no indication in the *System of the World* of accepting either the positive or the negative claim, nor indeed of giving the causal question about gravity any consideration at all.

9. Conclusion

I do not take Newton to assert any metaphysical principles, such as the principle that causation is local, nor do I interpret him as being defeasibly committed to any such principles in private. As I have emphasized at various points, he does sometimes consider the possibility that matter has the capacity for unmediated distant action. I do, however, interpret him as being inclined to the principles that causation is local, and matter incapable of the robust sort of activity that generates new motion, in the sense of increasing the universe's scalar quantity of motion. This most certainly does not commit me to the view that Newton attributed gravitational effects to God. I have explicitly rejected that conclusion in other writings. It would be a mistake to suppose that the only interpretive positions available are occasionalism, on the one hand, and unmediated distant action on the other. Such a supposition overlooks the claim that Newton was genuinely uncertain about gravity's cause, and that while he speculated about a number of possibilities, he never really endorsed any of them. The question about gravity's cause remained open, for him. That is not the question that captured his attention in the *System of the World*, however. As many commentators have remarked, Newton was able to set certain questions aside while pursuing others with zeal. That ability is seen, as I have argued, in the *System of the World*, which focuses not upon the causal question but upon gravity's scope and structure.

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NOTES

1 Leibniz, 5.113; 5.118; in Ariew.

2 Newton's fourth letter to Bentley, Feb. 25, 1692/3, in *Philosophical Writings*, 102-103.

3 *Principia*, 943.

4 See *Newton on Matter and Activity*, chapters 2 and 4, especially p. 84.

5 The term 'scandalous interpretation', though a bit flippant, provides a label for any interpretation that takes him to attribute both of the following capacities to matter: the capacity to act robustly, such that the universe's scalar quantity of motion is increased; and the capacity to act distantly, such that spatially separated bodies can interact causally without any spatially intervening medium. Although Newton does tend to associate the bearer of robustly active principles (whatever that may be) with the cause of forces acting between spatially separated bodies, there is no necessary connection between a capacity for robust action on the one hand and a capacity for unmediated distant action on the other.

6 This section reviews the explanation given in §5 of Kochiras, 2011.

7 Among commentators holding some variant of this view, Richard S. Westfall interprets Newton as attributing a broad range of phenomena, including gravitational effects, to God, and as doing so consistently. (See Westfall, 1971, *Force in Newton's Physics*, pp. 396-400.) J.E. McGuire sees the period during which Newton accepted primary causation as limited, arguing that although Newton attributed phenomena involving distance forces to God during the post-*Principia* period, he sought secondary causes following but after the 1706 *Optice*. (See McGuire, 1968, "Force, Active Principles, and Newton's Invisible Realm", pp. 207-208.) Joan Hawes takes Newton to attribute gravitational effects consistently to God, but argues that he allowed unmediated distant action for electrical effects. (See Hawes, "Newton's Revival of the Aether Hypothesis and the Explanation of Gravitational Attraction", p. 205.)

8 See in particular ULC Ad. 3965.6 f.269, discussed by Westfall in *Force*, pp. 397-98 and by McGuire in "Force, Active Principles, and Newton's Invisible Realm", p. 196; and ULC, *Add MS* 396.6, f. 266v, in Westfall, *Never at Rest*, p. 509.

9 Query 31, *Opticks*, 401.

10 «What hinders the fix'd Stars from falling upon one another?....Does it not appear from phenomena that there is a Being incorporeal, intelligent[?]» (Query 28, *Opticks*, 369.) See §3 of Kochiras, 2009 for a somewhat more detailed discussion of this and other passages.

11 Although I mention the scandalous hypothesis here in connection with an interpretation that takes Newton's disavowals of gravity's cause to be insincere, this is simply a possible interpretation. Eric Schliesser has argued

that Newton accepts the scandalous hypothesis, however his interpretation does not quite represent the possibility I mention here, because he takes Newton's General Scholium remarks to be sincere. Although Schliesser's attribution of the scandalous hypothesis focuses mainly upon Newton's *System of the World*, he tries to extend it to later texts, including Newton's correspondence with Bentley in the 1690's and also the 1713 General Scholium. In doing so, he argues that it is not gravity's *cause* that Newton is uncertain of, in the General Scholium, but rather the *reason* for gravity's particular properties. See Schliesser, 2011, 'Without God: Gravity as a relational quality of matter in Newton's *Treatise*'. See also my assessment in §6.1 of Kochiras, 2011, "Gravity's Cause and Substance Counting: Contextualizing the Problems",

12 See Henry, «Pray do not ascribe that notion to me: God and Newton's gravity», p. 133 in Force (ed.)

13 Newton, Cambridge University Library, Additional Ms. 3970.3, ff. 618v; *Draft Versions of 'The Queries'*, The Newton Project. Newton does cross this sentence out, however he does so without attempting to explicate the relationship between active principles and matter, which suggests continued uncertainty. (Further, he crosses out other thoughts from the drafts that he clearly did not disown, for instance the claim that the laws associated with our power of moving our bodies remain unknown to us; see Cambridge University Library, Additional Ms. 3970.3, ff. 618v; *Draft Versions of 'The Queries'*, The Newton Project.)

14 *Principia*, p. 795.

15 See §3 of Kochiras, 2009. John Henry seriously misrepresents me on this point, first attempting to amalgamate my view with that of Andrew Janiak and then attributing p to me, even though I explicitly asserted $\sim p$ in the paper that he cites. On pp. 17-18 of his 2011 paper, Henry writes, "Although they are careful to avoid saying so, it seems hard to resist the conclusion that Janiak and Kochiras are offering us a picture of a Newton who believes in occasionalism." This misrepresentation of my view is in fact easy to resist, since in the 2009 paper that Henry cites, I devoted an entire section of that paper to arguing *against* an occasionalist interpretation of Newton. My abstract states, "The causal problem remains vexing, for *he neither invokes primary causation*, nor accepts action at a distance by locating active powers in matter" (Kochiras, 2009, p. 267, emphasis added); and I end §3 with the following words: "Even during the 1690s, then (the period to which McGuire's chronology dates Newton's strongest attraction to the primary causation hypothesis), *Newton takes the gravitational force to operate independently of God*. In other words, *he expects the gravitational force to operate by secondary causes*." (Kochiras, 2009, p. 272, emphasis added). In misrepresenting my view as he does, Henry seems to allow for only two interpretive positions, namely, occasionalism and unmediated distant action;

yet the claim that Newton is genuinely uncertain about gravity's cause is a third interpretive position, and that is the one I hold.

16 See §6 of Kochiras, 2009.

17 Query 31, *Opticks*, 397.

18 I explain my view at length in §4 of Kochiras, 2011, correcting various misrepresentations of it; see also Kochiras, 2009, p. 275, including note 64, and p. 278.

19 See the end of §4, Kochiras, 2011.

20 Newton to Bentley, 25 February, 1692/3 (Letter 4), p. 253-254 in *The Correspondence of Isaac Newton,* Vol. III.

21 For my extended analysis of the letter, see §6.3 of Kochiras, 2011.

22 See Kochiras, 2009, p. 275; Kochiras 2011, pp. 180-181.

23 My extended analysis appears in Kochiras, 2011, §6.4.

24 ULC, Add. 3970, fol. 619r], in McGuire, "Force, Active Principles, and Newton's Invisible Realm", p. 171; c. 1705, according to McGuire's dating.

25 The general recommendation appears in *Principia,* Scholium to Book I, Section 11; p. 588. Newton seems to have the same recommendation in mind in a draft of the *Conclusio* (initially intended to be published with the *Principia*'s first edition, but ultimately remaining unpublished), because there too he focuses upon the goal of proving "that forces of this kind do exist", and though he calls them "attractive and repulsive", he qualifies this by noting that he means the term 'attraction' to refer to any forces "by which bodies are impelled towards each other, come together and cohere, whatever the causes be." See *Unpublished Scientific Papers of Isaac Newton*, p. 345.

26 *Principia*, 793. Newton states his reason at the outset of the published third book.

27 *System of the World,* p. 5.

28 *A Treatise of the System of the World,* anonymous translation, believed to be by Andrew Motte; first published: 1728; this edition, with an introduction with by I. Bernard Cohen (Dawsons of Pall Mall, London 1969), pp. 38-39.

29 *System of the World,* 40.

30 *System of the World,* 44-45.

31 The best known statements to this effect include Newton's concluding remarks to Rule 3, (*Principia,* 795-96), and his second letter to Bentley (*Philosophical Writings,* 100).

32 Schliesser, 2011, p. 80.

33 In his explanatory remarks following Rule 3 (the rules being added for the *Principia*'s second edition), Newton cites the *vis inertiae* as the quality that is inherent and essential to matter. He does so by way of contrasting it to gravity, which, as noted, he consistently maintains is not essential to matter.

34 *Principia*, 404-405.

[35] For an alternative view, see Collingwood ([1938] 1991), 'On the So-called Idea of Causation'; Hulswit (2007), 'A Short History of Causation', §3.2.2.

[36] In connection with this point, see Howard Stein ('Newton's Metaphysics', 284), and Alan Gabbey ('Force and Inertia in the Seventeenth Century: Descartes and Newton', in *Descartes: Philosophy, Mathematics, and Physics*, ed. S. Gaukroger; Sussex: Harvester Press, 1980, p. 275.)

[37] If Newton thinks that the world contains such a robust sense of activity, he gives no direct indication of that in the *Principia*. However, some commentators (notably McMullin, 1978, pp. 53-55) hold that the robust sense of activity also appears in the *Principia*, though indirectly, via Newton's suggestion that comet vapors replenish the fluids needed for life on Earth. Yet to my mind, it is not certain that Newton's suggestion that fluids need to be replenished implies the claim that he speculatively advances in Query 31, namely, that without some generative source of new motions, motion in the universe would eventually cease. While it is likely that Newton is thinking along the same lines as he does later, in Query 31, it also seems possible that he is not; for the claim that without comet vapors, fluids would be depleted and life thereby extinguished does not by itself imply that without comet vapors, the universe would not retain a constant scalar quantity of motion.

For representative remarks about comet vapors, see *Principia*, Book III, Proposition 41, p. 926 (emphasis added):

> 'Just as the seas are absolutely necessary for the constitution of this earth, so that vapors may be abundantly enough aroused from them by the heat of the sun, which vapors either—being gathered into clouds—fall in rains and irrigate and nourish the whole earth for the propagation of vegetables, or—being condensed in the cold peaks of mountains (as some philosophize with good reason)—run down into springs and rivers; so for the conservation of the seas and fluids on the planets, comets seem to be required, so that from the condensation of their exhalations and vapors, there can be a continual supply and renewal of whatever liquid is consumed by vegetation and putrefaction and converted into dry earth. For all vegetables grow entirely from fluids and afterward, in great part, change into dry earth by putrefaction, and slime is continually deposited from putrefied liquids. Hence the bulk of dry earth is increased from day to day, *and fluids—if they did not have an outside source of increase—would have to decrease continually and finally to fail.* Further, I suspect that that spirit which is the smallest but most subtle and most excellent part of our air, and which is required for the life of all things, comes chiefly from comets.'

For a classic discussion of the role of comets in Newton's thinking, see David Kubrin (1967).

[38] Query 31, *Opticks*, p. 399.

39 In Query 31, Newton follows his suggestion that the particles of bodies have "certain Powers, Virtues, or Forces, by which they act at a distance" which the caveat that the question of how those attractions are performed is a question "I do not here consider." (Query 31, *Opticks*, 375-76). Later, he refrains from locating active principles in matter, as noted in an earlier section.

40 Schliesser, 2011, p. 85.

41 Schliesser, 2011, 90.

42 See Schliesser, 90, citing *Opticks,* 400-401.

43 Schliesser, 2011, p. 97, n. 30.

44 Schliesser, 2011, p. 90. See also pp. 91-92: "It would, of course, be a contradiction in terms for 'passive' matter to be an 'agent'; but Newton never claims in his own voice that matter must always be passive."

45 *Opticks,* pp. 397- 399.

46 Corollary 3 to Law 3, *Principia*, 420.

47 That he takes the numerical sum, and concludes that by the composition of motions, motion can be 'got is lost', is especially striking in light of the following. It opens him to the same charge he leveled at Descartes, as a reason for rejecting his doctrine of relative motion: 'It follows from the Cartesian doctrine that motion can be generated where there is no force acting.' Yet with Query 31's two-globe case, Newton seems to abjure that criticism; since the result of a changing quantity of motion is generated by the composition of motions, Newton implies that motion can be generated without force. See *De gravitatione*: 'It follows from the Cartesian doctrine that motion can be generated where there is no force acting. For example, if God should suddenly cause the spinning of our vortex to stop, without applying any force to the earth which could stop it at the same time, Descartes would say that the earth is moving in a philosophical sense—on account of its translation from the vicinity of the contiguous fluid—whereas before he said it was at rest, in the same philosophical sense....It also follows from the same doctrine that God himself could not generate motion in some bodies even though he impelled them with the greatest force. For example, if God impelled the starry heaven together with all the most remote part of creation with any very great force so as to cause it to revolve around the earth (suppose with a diurnal motion): yet by this, according to Descartes, the earth alone and not the sky would be truly said to move (Part III, article 38), as if it would be the same whether, with a tremendous force, he would cause the skies to turn from east to west, or with a small force turn the earth in the opposite direction. But who will suppose that the parts of the earth endeavor to recede from its center on account only of a force impressed upon the heavens?' (*Philosophical Writings*, 18.)

48 My thanks again to Lon Becker for this point.

49 398,*Opticks*

50 398, *Opticks*

51 'But by reason of the Tenacity of Fluids, and Attrition of their Parts, and the Weakness of Elasticity in Solids, Motion is much more apt to be lost than got, and is always on the Decay. For bodies which are either absolutely hard, or so soft as to be void of elasticity, will not rebound from one another. Impenetrability makes them only stop. If two equal bodies meet directly in a vacuum, they will by the laws of motion stop where they meet and lose all their motion, and remain in rest, unless they be elastic and receive some new motion from their spring....This may be tried, by letting two equal pendulums fall against one another from equal heights...if of elastic bodies, they will lose all but what they recover from their elasticity. If it be said that they can lose no motion but what they communicate to other bodies, the consequence is that in a vacuum they lose no motion, but when they meet they must go on and penetrate one another's dimensions....'(Query 31, 398 *Opticks*)

52 As for heat, he associates it with forces that appear to act at a distance, and concomitantly with active principles.

53 The vitalist strain of Newton's thought is strongly evident in the closing line of the following manuscript, a drafft for Query 23(31) of the 1706 *Optice*, dated by McGuire as c. 1705:

> By their vis inertiae they continue in their state of moving or resting & receive motion proportional to ye force impressing it & resist as much as they are resisted; but they cannot move themselves; & without some other principle than the vis inertiae there could be no motion in the world. (And what that Principle is & by (means of) laws it acts on matter is a mystery or how it stands related to matter is difficult to explain). And if there be another Principle of motion there must be other laws of motion depending on that Principle. And the first thing to be done in Philosophy is to find out all the general laws of motion (so far as they can be discovered) on wch the frame of nature depends. (For the powers of nature are not in vain [two words are illegible]. And in this search metaphysical arguments are very slippery. A man must argue from phenomena). We find in o^{r}selves a power of moving our bodies by o^{r} thoughts (but the laws of this power we do not know) & see y^{e} same power in other living creatures but how this is done & by what laws we do not know. And by this instance & that of gravity it appears that there are other laws of motion (unknown to us) than those wch arise from Vis inertiae (unknown to us) wch is enough to justify & encourage o^{r} search after them. We cannot say that all nature is not alive. (ULC, Add. 3970, fol. 620r; see McGuire, (1968), pp. 170-171.)

54 Query 31, *Opticks*, 397-399.

55 ULC, Add. 3970, fol. 620r, quoted by McGuire (1968), pp. 170-171.

[56] On this point, see McMullin:

"In his account of *vis inertiae*, Newton appears to attribute to the 'impulse' elicited by way of opposition to impressed force a surprisingly active role in affecting the state of motion of the agent body. Yet *vis inertiae* could not be the ultimate source of material agency. There is a world of difference between 'action' and 'reaction', between the attraction the sun, for example, exerts upon the earth (when considered *as* attraction, i.e., as rooted in some 'active principle' initiating motion) and the reaction of the earth upon the sun (considered *as* reaction, i.e., as rooted in the *vis inertiae* of the earth):

> The *vis inertiae* is a passive principle by which bodies...resist as much as they are resisted. By this principle alone there never could have been any motion in the world. Some other principle was necessary for putting bodies into motion, and now that they are in motion, some other principle is necessary for conserving the motion.[Query 31]

Otherwise, all motion would rapidly come to an end, he notes, for it is 'always on the decay' in inelastic or only partially elastic impacts, in motion through viscous media, and so forth." (McMullin, 1978, p. 45; and quoting Newton, Query 31 (23))

[57] In a passage quoted earlier, Newton mentions 'gravity's cause' as one instance of an active principle. In the following passage, however, where he speaks of 'active principles, such as is that of gravity', it is not fully clear whether he means to identify gravity's cause, or gravity itself as an active principle:

> ....It seems to me farther, that these particles have not only a *vis inertiae*, accompanied with such passive laws of motion as naturally result from that force, but also that they are moved by certain active principles, such as is that of gravity, and that which causes fermentation, and the cohesion of bodies. These principles I consider, not as occult qualities, supposed to result from the specific form of things, but as general laws of nature, by which the things themselves are formed; their truth appearing to us by phenomena, though their causes be not yet discovered.....(Query 31, *Opticks*, 401.)

Given the highly speculative nature of active principles, perhaps the rather obscure locution reflects Newton's own uncertainty about whether the active principle is the force or its cause. (If Newton means gravity's cause, rather than gravity itself, as the active principle, that would support the "two-tiered" ontology that McMullin considers and rejects, on which active principles cause forces and forces cause motions. On this point, see McMullin, 1978, p. 82. McGuire takes the opposite view; 1968, p. 172.)

[58] See McMullin's discussion of this point, 1978, p. 45.

[59] Kochiras, "Causal Language and the Structure of Force in Newton's *System of the World*" (manuscript, n.d.)

60 Schliesser, 2011, p. 86; emphasis added. Surprisingly, though Schliesser clearly suggests here that Newton denies the existence of a medium and endorses distant action, he also allows at one point in the same paper that Newton allows the possibility of a medium. Specifically, he indicates that there are reasons for remaining agnostic about 'how this view should be fully squared with other, potentially competing proposals that Newton entertained on such matters (for example, the role and nature of God or *a very subtle ether in supplying the mechanism for attraction*)'(p. 82, emphasis added). And in detailing the advantageous features of his view, he indicates that his view is 'theologically neutral', in that 'Newton leaves room for a possible role for God (for example, *as the medium*, or as cause of the world.'(p. 88, emphasis added.) Perhaps Schliesser's position is that (a) Newton did advance a hypothesis of unmediated distant action in the *System of the World*, but (b) he at other points considered other hypotheses, such as a subtle ether. For to concede that Newton allowed the possibility of an ether in the *System of the World* would amount to conceding that he is not there advancing the negative claim that gravitational effects do not depend upon any medium; and that concession would undermine Schliesser's conclusion that Newton is endorsing unmediated distant action in *A Treatise of the System of the World*.

61 Newton's more extended remarks read as follows: 'As the parts of the Earth attract one another, so do those of all the planets. If Jupiter and its satellites were brought together, and formed into one globe; without doubt, they would continue mutually to attract one another as before. And on the other hand, if the body of Jupiter was broke into more globes, to be sure, these would no less attract one another than they do the satellites now. From these attractions it is that the bodies of the Earth, and all the planets affect a spherical figure, and that their parts cohere, *and are not dispersed through the Ether*. But we have before proved that these forces arise from the universal nature of matter, and that therefore the force of any whole globe is made up of the several forces of all its parts. And from thence it follows, that the force of every particle decreases in the duplicate proportion of the distance from that particle…' (*System of the World*, pp. 44-45; emphasis added)

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