Newton and Kant on Absolute Space: From Theology to Transcendental Philosophy

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Abstract I argue that Einstein's creation of both special and general relativity instantiates Reichenbach's conception of the relativized a priori. I do this by showing how the original Kantian conception actually contributes to the development of Einstein's theories through the intervening philosophical and scientific work of Helmholtz, Mach, and Poincaré.

In my previous work on Newton and Kant I have primarily emphasized methodological issues: why Kant takes the Newtonian Laws of Motion (as well as certain related propositions of what he calls "pure natural science") as synthetic a priori constitutive principles rather than mere empirical laws, and how this point is intimately connected, in turn, with Kant's conception of absolute space as a regulative idea of reason – as the limit point of an empirical constructive procedure rather than a self-subsistent "container" existing prior to and independently of all perceptible matter. I have also argued that these methodological differences explain the circumstance that Kant, unlike Newton, asserts that gravitational attraction *must* be conceived as an "action at a distance through empty space," and even formulates a (rare) criticism of Newton for attempting to leave the question of the "true cause" of gravitational attraction entirely open. In this paper I emphasize the importance of metaphysical and theological issues – about God, his creation of the material world in space, and the consequences different views of such creation have for the metaphysical foundations of physics. I argue, in particular, that Kant's differences with Newton over these issues constitute an essential part of his radical transformation of the very meaning of metaphysics as practiced by his predecessors. I also suggest that the metaphysical and theological issues in question form an essential part of the intellectual context for the methodological issues I have emphasized previously – especially the issue of action at a distance.

It is now well known that the main target of Newton's rejection of "relationalism" in favor of an "absolutist" metaphysics of space was Descartes, and the *locus classicus* for Newton's own metaphysics of space is his unpublished

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De Gravitatione.[1] What was most important for Newton was decisively to reject Descartes's identification of matter with extension and to defend, accordingly, the concept of absolute (empty) space existing prior to and independently of matter. Yet Newton, like Descartes before him, also appropriated philosophical ideas from the neo-Platonic tradition,[2] which he incorporated into his own metaphysics. For Newton, the most salient source of such ideas was the Cambridge Platonism represented especially by Henry More, and Newton employs them in his doctrine that absolute space is neither a substance nor an accident, but what he calls "an emanative effect of God and an affection of every kind of being" (*De Grav*., p. 21).[3] In particular, absolute space or pure extension is even an affection of God himself, since God is omnipresent or everywhere. God can thereby create matter or body (as something quite distinct from pure extension) by endowing certain determined regions of space with the conditions of mobility, impenetrability, and obedience to the laws of motion. God can do this anywhere in space, in virtue of his omnipresence, by his immediate thought and will, just as our souls can move our bodies by our immediate thought and will. It is essentially this doctrine which surfaces in Newton's well-known published statements, in the General Scholium to the *Principia* and the Queries the *Optics*, that space is the "sensorium" of God.[4]

The sharp differences between Descartes's and Newton's metaphysics of space – their different conceptions of the relationships among space, God, and matter – are of fundamental importance. For Descartes, since space is simply identical with matter, God creates matter by creating space itself, and it is precisely this act of creation of space at successive moments of time that is responsible for the laws of motion. In particular, the conservation of what Descartes called the total "quantity of motion" results from the unity and simplicity of God, whereby God continually recreates the entire universe

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[1] This point was first made in Stein (1967), and we can now also cite Stein (2002) for an authoritative account of Newton's metaphysics. *De Gravitatione* first appeared, together with an English translation, in Hall and Hall (1962). An improved translation by Christian Johnson, made with the assistance of Andrew Janiak, and consulting an earlier unpublished translation by Stein, appears in Janiak (2004): my parenthetical page references to *De Grav*. – and to Newton's writings more generally – are to this edition.

[2] For Descartes's appropriation of neo-Platonic metaphysics, as mediated by Augustine, see Menn (1998).

[3] Some of the most important writings of the Cambridge Platonists are collected in Patrides (1980). For discussion of the idea that space is an emanative effect of God see the exchange between J. E. McGuire and John Carriero in Bricker and Hughes (1990). See also the very careful discussion in Stein (2002, pp. 266–272). In the course of his discussion Stein is led to claim (p. 269) that "the grounds for thinking that Newton's theory of emanation is neo-Platonic, or 'Cambridge Platonic,' are very weak." Whatever one may think of Stein's particular reasons for this claim, it seems to me very hard to deny, in any case, that Newton is *appropriating* neo-Platonic (and, indeed, 'Cambridge Platonic') ideas for his own purposes here.

[4] In Query 31, for example, Newton describes God as (p. 138) "a powerful ever-living agent, who being in all places, is more able by his will to move the bodies within his boundless uniform sensorium, and thereby to form and reform the parts of the universe, than we are by our will to move the parts of our own bodies."

(the whole of pure extension, whose various parts may have different instantaneous tendencies to motion at any given time) at each instant while constantly expressing the very same divine essence. For Newton, by contrast, matter and space have radically different statuses vis-à-vis God's creation. Space is "an emanative effect of God and an affection of every kind of being," including God, while matter is the result of God's creative activity in space, wherein certain determined regions are then endowed with the conditions of mobility, impenetrability, and obedience to the laws of motion. By instituting the laws of motion, in particular, God thereby endows certain regions of space with Newtonian *mass* or quantity of matter (*vis inertiae*), and the presence of this quantity, specifically, clearly distinguishes matter from empty space. This not only leads, following earlier work of Wren, Wallis, and Huygens, to a much more adequate formulation of the laws of impact (whereas Descartes's inadequate formulation had no room for the quantity of mass, and thus no room for momentum or quantity of motion in the Newtonian sense), it eventually leads to the theory of universal gravitation of Book III of the *Principia.* And this theory, in turn, puts the notions of absolute space, time, and motion to real physical work in determining the center of mass of the solar system as the true "center of the world."

Nevertheless, despite these fundamental differences, both Descartes and Newton are using neo-Platonic ideas to support an essentially mathematical approach to physics over the older qualitative approach of Aristotelian physics. For Descartes, the world described by physics is, in its essence, the object of pure geometry. God, in creating this world, not only brings about (what Descartes takes to be) the (mathematical) laws of motion of the new physics, he also, in creating us as mind-body composites located within this world, guarantees that we can use our purely intellectual mathematical knowledge in successively correcting and refining our knowledge of the material world – as we apply pure mathematics, that is, to the initially misleading deliverances of our senses.[5] For Newton, although the world described by physics is not, in its essence, the object of pure geometry, space (which *is* the object of pure geometry) nonetheless constitutes the "frame of the world" – an emanative effect of the divine existence wherein God then creates matter by an immediate act of his will. The bare existence of space suffices for the existence of all the shapes and figures studied in pure geometry (*De Grav*., p. 22): "there are everywhere all kinds of figures, everywhere spheres, cubes, triangles, straight lines, everywhere circular, elliptical, parabolical, and all other kinds of figures, and those of all shapes and sizes, even though they are not disclosed to sight." And thus pure geometry is *ipso facto* applicable to all material bodies as well (pp. 22–23): "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." Therefore, in virtue of their (differently) neo-Platonic conceptions of a metaphysics of space, neither Descartes nor Newton has any room for a necessary gap (as there was in Plato's original "Platonism") between pure mathematics, on the one side, and the sensible and material world, on the other.

[5] This, in a nutshell, is how I read the argument for the existence of matter of the Sixth Meditation: see Friedman (1997, 2008).

The significance of this point becomes clearer if we contrast the conceptions of both Descartes and Newton with the quite distinct approach of Leibniz, who was explicitly opposed to both Descartes and Newton in correspondingly different ways. Leibniz began, in fact, by reacting to Descartes's failure adequately to formulate the basic laws of impact, which were supposed to govern, according to the then dominant paradigm of the mechanical natural philosophy, all phenomena in the material or corporeal world. Leibniz responded to this problem, in his "Brief Demonstration of a Notable Error of Descartes and Others Concerning a Natural Law" (1686), by emphasizing the importance of a new, essentially dynamical quantity, which he called *vis viva* or living force (in modern terms, mass multiplied by the square of the velocity), where the basic law of motion is now formulated as the conservation of the total quantity of *vis viva*. Beginning with his *Discourse on Metaphysics* (written in the same year), Leibniz also strongly emphasized that living force is not purely geometrical or mechanical, so that, in particular, this quantity (unlike Descartes's purely mechanical "quantity of motion") reintroduces an element of Aristotelian teleology into the mechanical philosophy. For *vis viva*, on Leibniz's view, is the counterpart of the Aristotelian notion of *entelechy*: namely, that internal (non-spatial) principle by which an ultimate simple substance or monad determines (by a kind of "appetition") the entire future development of its own internal state. Moreover, in accordance with this same renewed emphasis on Aristotelian teleology, Leibniz then articulated a doctrine of divine creation in terms of God's choice of the best among all merely logically possible worlds. The distinction between what is logically possible and what is actual – between all merely thinkable worlds available to the divine intellect and the best and most perfect of these worlds as determined by the divine will – thereby corresponds to the distinction between principles of pure mathematics (including geometry) and principles of natural science or physics (the laws of motion). In particular, the laws of motion, unlike the principles of pure mathematics, precisely express the divine wisdom in actualizing or creating the best and most perfect of all possible worlds.

Leibniz thereby breaks decisively with Descartes's metaphysics of space, for the actual world of material substances results from a special act of the divine will which introduces additional non-spatial, and essentially teleological elements into the mechanical laws of motion. Indeed, Leibniz's break with Descartes on this issue is deeper still, for, on Leibniz's view, the entire mechanical physical world (including the space in which bodies move) is a secondary appearance or phenomenon (a "well-founded phenomenon" like the rainbow) of an underlying metaphysical reality of mind-like simple substances or monads – substances which, at this level, are not spatial at all, but rather have only purely internal properties and no external relations. This point, in turn, is closely connected with a fundamental disagreement with Descartes about the nature of the intellect: whereas Descartes entirely rejects traditional Aristotelian logic and takes purely intellectual knowledge to be exemplified by the procedure of his new analytic geometry instead, Leibniz self-consciously returns to the idea that purely intellectual knowledge is essentially logical. And, although Leibniz appears to have envisioned some sort of extension of Aristotelian logic capable of embracing the new algebraic methods of his calculus, there is no

doubt that the traditional subject-predicate structure of this logic pervades his monadic metaphysics: it is precisely because ultimate metaphysical reality is essentially intellectual in the logical sense that the entire mechanical world, including space, is a merely secondary reality or phenomenon. Thus, although Leibniz, like everyone else in the period, holds that there are exact mathematical laws governing the sensible and material world, he reintroduces a new kind of necessary gap between reality as known by the intellect and this sensible world.

For Newton, by contrast, space – the very space in which bodies exist and move – is metaphysically fundamental, for, as we have seen, it is "an affection of every kind of being," including God himself. Indeed, Newton puts the point even more strongly several pages later (*De Grav*., p. 25): "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." In particular, God, through his omnipresence, creates matter in space by endowing certain determined regions with mass (*vis inertiae*), and God thereby institutes the (Newtonian) Laws of Motion by singling out momentum (mass multiplied by velocity) as the fundamental dynamical quantity governing all changes of motion of matter. For Newton, moreover, impressed force (*vis impressa*) is a further dynamical quantity involved in such changes – where this refers to any action on the body in question by which a change of momentum is produced. Impressed force, in the Newtonian sense, is an external action on a body by something else, not an internal principle of change like Leibnizean *vis viva*, and, what is more, the changes it effects are not intrinsically limited to the condition of contact. On the contrary, the principal instantiation of this concept, in the *Principia*, is precisely the force of universal gravitation, whereby one body exchanges momentum with another body immediately and at a distance; and it is the theory of universal gravitation, as we have said, which then puts the notions of absolute space, time, and motion to real physical work in determining the true "center of the world."

It is by no means surprising, therefore, that Newton also rejects the traditional Aristotelian notion of substance, and replaces it, in effect, with space itself – or, more precisely, with space plus God (*De Grav*., p. 29): "For the existence of these beings [bodies] it is not necessary that we suppose some unintelligible substance to exist in which as subject there may be an inherent substantial form; extension and an act of the divine will are enough. Extension takes the place of the substantial subject in which the form of the body is conserved by the divine will; and that product of the divine will is the form or formal reason of the body denoting every dimension of space in which the body is to be produced." For Leibniz, by contrast, space, as we have seen, is a mere "well-founded phenomenon," and pure intellectual knowledge is explicitly modelled on Aristotelian subject-predicate logic: (a modified version of) the Aristotelian concept of substance *must* be metaphysically fundamental.

Newton's struggles with the problem of action at a distance result in significant complications here. Although later Newtonians (including Kant) were happy to conceive gravitation as an immediate action of one body on another body across empty space, Newton himself was seriously troubled. He appeared deliberately to leave it open in the first (1787) edition of the *Principia* that gravity may ultimately be explained by mechanical impact; and he also speculated in the *Optics* about

an interplanetary aetherial medium as the cause of gravity.[6] Moreover, Newton famously declared that the idea of action at a distance is an "absurdity" in his well-known letter to Bentley of February 5, 1693 (pp. 102–103):

> 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 that no man who has in philosophical matters a 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, I have left to the consideration of my readers.

And what is most striking, from our present point of view, is the suggestion that the true cause of gravity may be an *immaterial* agent – perhaps even God himself.

It is natural, in the first place, that the mediating agent between distantly gravitating bodies be immaterial, for it is essential to Newton's argument for universal gravitation in Book III of the *Principia* that such mutually attracting bodies – Jupiter and Saturn, for example – directly and immediately exchange momentum with one another, entirely independently of any other matter that may be located in between. Whatever is playing this mediating role must therefore experience negligible exchanges of momentum with the two attracting bodies themselves, and the most natural way to achieve this, in general, is to conceive the mediating agent as massless or immaterial. Moreover, in the second place, since God exists or is omnipresent everywhere in space, and he thereby creates matter and its fundamental laws by an immediate act of the divine will, it is natural to suppose that the ubiquitous immaterial agent ultimately responsible for gravitational attraction is either God himself or an ubiquitous immaterial spirit directly resulting from God's own ubiquity.[7] Finally, in the third place, God is described in the

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[6] Thus, for example, in the Scholium to section 11 of Book I of the *Principia*, after discussing the three-body problem at some length, Newton says (p. 86, my emphasis): "I use the word 'attraction' here in a general sense for any endeavor whatever of bodies to approach one another, whether that endeavor occurs as a result of the action of the bodies either drawn toward one another or acting on one another by means of spirits emitted or whether it arises from the action of the aether or air or of any medium whatsoever – whether corporeal or incorporeal – *in any way* impelling toward one another the bodies floating therein." However, as explained in note 17 below (which also discusses the aetherial medium proposed in the *Optics*), Newton definitely appears to exclude mechanical impact from the possible candidates in the second (1713) edition of the *Principia*.

[7] In Query 31 to the *Optics* (unlike *De Grav.*), Newton suggests that God's act of creating matter in space is responsible not only for impenetrability and mass (in accordance with the three "passive" laws of motion), but also for specific forces or "active principles," including gravity (pp. 136–137): "[I]t seems probable to me, that God in the beginning formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them;… 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 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 forms 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." Compare also the passage quoted in note 4 above, which can easily be taken to suggest that God himself "moves" the bodies interacting in accordance with universal gravitation.

General Scholium added to the second edition of the *Principia* in 1713 as an omnipresent acting substance (p. 91): "God is one and the same God always and everywhere. He is omnipresent not only *virtually* but also *substantially*; for action requires substance."[8] Therefore, Newton does not so much entirely reject the traditional notions of substance and active agency, but reinterprets them in light of his metaphysics of space. He continues to conceive of efficient causality as the (local) action of one substance on another, and God, in particular, is the ultimate substantial agent underlying all causal action in the material world. His true opposition to Descartes concerns the notion of specifically *material* substance, and he uses his neo-Platonic (Cambridge Platonic) metaphysics of space to craft a further argument against Descartes's metaphysics from the (apparent) phenomena of gravitational attraction at a distance.

The importance of Newton's metaphysics of space in underwriting his principled rejection of the mechanical philosophy has not, I believe, been sufficiently appreciated. For, from a post-Newtonian perspective, the requirement that all causal interaction in the material world be limited to the communication of motion by impact may appear as an entirely arbitrary restriction on the basic principles governing the exchange of momentum, and there is then no reason, from this point of view, that a direct (equal and opposite) exchange of momentum at a distance via universal gravitation may not be viewed as a perfectly legitimate example of causal interaction.[9] At the time when Newton was first formulating this theory, however, everyone took it for granted that one substance could act on another by efficient causality only if the one is locally present to the other: this principle was shared by contemporary Aristotelians, by mechanical philosophers, and (as we have just seen) by Newton himself. Everyone also took it for granted that the clearest and most fundamental example of causal agency is the creative activity of God. Newton's metaphysics of space then made it possible for him to maintain that universal gravitation involves an immediate exchange of momentum across empty space (as his physics requires) while, at the same time, preserving the more traditional ideas

[8] Immediately following this passage Newton adds (ibid.): "In him all things are contained and moved, but he does not act on them nor they on him." And, at the very end of the General Scholium, after pointing out that he has "not yet assigned a cause to gravity," and that, nonetheless, it is not to be reckoned among the "occult qualities," but is rather derived by induction from the phenomena, Newton continues (p. 93): "A few things could now be added concerning a certain very subtle spirit pervading gross bodies and lying hidden in them; by its force and actions, the particles of bodies attract one another at very small distances and cohere when they become contiguous; and electrical bodies act at greater distances, repelling as well as attracting neighboring corpuscles;…" If, in accordance with the above passage from Query 31 of the *Optics*, we suppose that this "very subtle spirit" is also the cause of gravitational attraction, it would follow that it is this (presumably immaterial or massless) "spirit" which mediates gravitational action in line with the letter to Bentley. God's own active agency would then be confined to creating both matter and the spirit in question, which then *interact* with one another to produce the phenomena of gravitational attraction.

[9] This, for example, is how Robert DiSalle views the matter in his excellent recent philosophical history of space-time physics. In particular, according to DiSalle (2006, p. 42): "[I]n the Newtonian view, any interaction is physically intelligible as long as, and just to the extent that, it conforms to the laws of motion." This, however, was not the view of Newton himself; rather, it is a (certainly very natural) conception arising in a post-Newtonian context where Newton's physics itself is then taken as a reliable guide to metaphysics – for example, as we shall soon see, in Kant.

of causality and agency he shared with his contemporaries. Indeed, from Newton's own point of view, his conception of the creation of matter by God makes maximal room for divine creative activity, and thereby avoids the threat of atheism opened up by the Cartesian conception of material substance.[10]

Kant, in the pre-critical period, attempts to fashion a direct unification of Leibnizean and Newtonian ideas, by starting with a Leibnizean metaphysics of monads and then building a Newtonian metaphysics of space, as it were, on top of this monadic metaphysics. The primary reality remains a non-spatial realm of ultimate simple substances, but these substances, for Kant, now have *both* purely internal, intrinsic properties *and* external or extrinsic relations. Such external relations among the monads are not necessary for them to be the simple substances which they are, but they are necessary for them to exist – or, more precisely, to co-exist – together in a common world. In this way, God's creative activity has two distinguishable aspects: one act by which the simple substances themselves are created in the first place, and a second by which a number of such simple substances are joined together into a single world. This second act occurs in conformity with what Kant calls a "schema of the divine intellect," and it is in virtue of just such a schema, in the end, that what we know as the laws of nature then arise. More precisely, what we know as the fundamental forces of matter (attraction and repulsion) – together with the laws that govern them – are a direct expression of the divinely instituted external relations (of *co*-existence) between monads; and what we know as space is then the phenomenal expression of this same system of divinely instituted relations. Space is thus a secondary reality, derivative from the monads and their external relations, but, since the external relations between monads, for Kant, are just as real as their internal properties, it is a reality nonetheless – and not, as in Leibniz, a merely ideal "well-founded phenomenon." Indeed, since the fundamental force of attraction, for Kant, is explicitly modelled on Newtonian universal gravitation (as an immediate action at a distance through empty space), Kant explicitly links his pre-critical conception of space with the Newtonian conception of divine omnipresence.[11]

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[10] Of course Newton's conception of divine agency is highly unorthodox, and, from a more traditional point of view, one would certainly not constrain God's creative activity by the requirement of local presence governing the interactions of material substances. From this point of view, it is Newton who opens up the threat of atheism (or rather pantheism) by seeming to materialize God. However, although Leibniz, for example, thus stands on firmer theological ground than Newton, he does not have a competing metaphysics adequate for natural philosophy and physics. Kant's problem was precisely to construct such a competing metaphysics along broadly Leibnizean lines, while simultaneously doing full justice to Newtonian physics.

[11] Kant makes this connection in the *New Exposition of the First Principles of Metaphysical Cognition* and the *Universal Natural History and Theory of the Heavens*, both appearing in 1755. For discussion, and references, see Friedman (1992, pp. 5–14). As I point out there, an echo of the Newtonian doctrine of divine omnipresence occurs as late as the Scholium to section 22 of the *Inaugural Dissertation* (1770). (Kant of course had no knowledge of Newton's unpublished *De Gravitatione*, but, as observed above, essentially the same metaphysics of space surfaces in such well-known published writings as the General Scholium to the *Principia* and the Queries to the *Optics*.) For further recent discussions of Kant's pre-critical metaphysics see Laywine (1993), Schönfeld (2000), Watkins (2005). A recent volume of translations is Walford and Meerbote (1992).

It is in the *Inaugural Dissertation* of 1770 that Kant makes a fundamental break with the Leibnizean philosophy – and, in a somewhat different fashion, with the Newtonian philosophy as well. Kant here first articulates his characteristic distinction between two independent rational faculties of the human mind – the pure understanding or pure intellect, on the one side, and pure sensibility or pure intuition, on the other. The former embodies the traditional categories and concepts of rational (Leibnizean) metaphysics, but it is the latter, for Kant, which now embodies the concepts and principles of pure mathematics. In particular, Kant now holds that mathematical knowledge is in no way purely intellectual, but is rather essentially intuitive or sensible, requiring the forms of pure sensibility, space and time. The world as we know it therefore bifurcates into two: the intellectual world described by traditional metaphysics (the Leibnizean metaphysics of ultimate simple substances as modified by the earlier Kant), and the sensible world as described by mathematics and mathematical physics in space and time. Although something like Newtonian space therefore remains as the foundation of this sensible world, space can no longer be conceived, as in Newton, as the sensorium of God – it is rather, as it were, the form of *our* sensorium, the form of our pure sensibility. Yet it is an unresolved problem, in the *Inaugural Dissertation*, how these two worlds are now supposed to be related, and, in particular, how the world described by mathematics and mathematical physics (the world as it appears to us) is related to the ultimate metaphysical reality of the intellectual world.

It is precisely this problem which finally gives birth to the critical philosophy in 1781. Kant now declares that purely intellectual, metaphysical knowledge – whether of immaterial things like God and the soul or of the ultimate simple substances which (according to both Leibniz and the pre-critical Kant) underlie the material world – is completely impossible, at least from a theoretical point of view. The pure intellect, considered entirely on its own and independently of any possible relation to sensibility, can issue only in the empty logical forms of Aristotelian syllogistic: in what Kant calls the "logical forms of judgement." And, while it is true that these forms then yield, in what Kant calls the "metaphysical deduction," the pure concepts or categories of the understanding (substance, causality, community, possibility, actuality, necessity, and so on), such pure concepts of the understanding are themselves entirely empty and without any "relation to an object" (again from a purely theoretical point of view) considered independently of our particular (human) forms of sensibility – space and time.[12]

[12] Kant takes particular pains, in the second (1787) edition of the *Critique*, to emphasize that his conception of space and time as pure forms of sensibility is the only real alternative to the – theologically disastrous (compare note 10 above) – Newtonian view (B 71–72): "In natural theology, where one thinks an object that is not only no object of sensible intuition for us, but cannot even be an object of sensible intuition for itself, one takes care to remove the conditions of space and time from all of its intuition (for all of it cognition must be intuition and not *thought*, which is always a manifestation of limitations). But with what right can one do this, if one has previously made both into forms of things in themselves – and, indeed, into forms which, as a priori conditions of the existence of things, even remain when one has annihilated the things themselves? (For, as conditions of all existence in general, they must also be conditions for the existence of God.)

In short, it is only in virtue of spatio-temporal "schemata" produced by our pure intellect that rational knowledge of the phenomenal world is possible, and the task of showing how the pure intellect thereby injects itself into pure sensibility (space and time) so as to apply the pure categories of the understanding to sensible experience then becomes the problem of the transcendental deduction.[13] Such an injection of *our* pure intellect into *our* pure forms of sensibility now takes the place, as it were, of Kant's pre-critical doctrine that a schema of the divine intellect, by an analogue of Newtonian divine omnipresence, is ultimately responsible for the order we perceive in the physical world.[14]

Pure metaphysical concepts – pure concepts of the understanding – can now be used for genuine (theoretical) knowledge only when applied to spatio-temporal

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There is therefore no alternative, if one does not pretend to make them into objective forms of all things, except to make them into subjective forms of our outer and inner mode of intuition. [This kind of intuition] is called sensible, because it is *not original* – i.e., it is not such that the existence of objects of intuition is itself given through it (which, as far as we can comprehend, can only pertain to the primordial being), but it depends on the existence of the objects, and is thus only possible in so far as the representative faculty of the subject is affected by them." (All translations from Kant's writings are my own, and I cite all writings – except for the first *Critique* – by volume and page numbers of the standard Akademie edition of *Kant's gesammelte Schriften*.).

[13] Since, for Kant, the pure mathematician inscribes figures in space – in the process of Euclidean construction – by this same activity of the understanding, we thereby obtain, at the same time, an explanation of why all empirical objects in the phenomenal world (appearances) are necessarily subject to pure mathematics. This explanation essentially involves the categories of quantity and, in particular, the Axioms of Intuition (A 165–166/B 206): "The synthesis of spaces and time, as the essential form of all intuition, is that which also makes possible the apprehension of the appearance, and thus all outer experience, and therefore all cognition of the objects of experience; and what mathematics in its pure use demonstrates of the former [the essential form of all intuition], it is also necessarily valid for the latter [all outer experience, etc.]." And it is in precisely this way, too, that Kant demonstrates the necessary applicability of mathematics to sensible experience (and forestalls any possible Platonic gap between the two) which Newton secured by his metaphysics of space: compare the paragraph to which note 5 above is appended.

[14] See note 11 above, together with the paragraph to which it is appended. As I observed, there is an echo of the pre-critical theory of divine omnipresence even in the *Inaugural Dissertation*, where Kant has already drawn a fundamental distinction between understanding and sensibility. The question Kant raises there (in the Scholium to section 22) concerns precisely the *causes* of our sensible intuitions, and, in particular, the relationship between our sensible intuitions and the assumed ultimate substances constituting the intelligible world. The answer Kant (tentatively) suggests is that, since both our mind and these "external things" are sustained by a single infinite being, space, as the "sensibly cognized universal and necessary condition for the co-presence of all things" can thus be characterized as (God's) *phenomenal omnipresence*. In light of section 22 itself, it appears that Kant is thereby invoking a pre-established harmony (instituted by God) between the purely intellectual reality of ultimate substances and our spatio-temporal sensibility to explain the necessary connection between this reality as it is in itself and as it appears to us. In section 27 of the second edition transcendental deduction, Kant explicitly rejects such an explanation of the agreement between experience and its objects (which he calls a "**preformation-system** of pure reason") in favor of his new, critical explanation (which he calls an "**epigenesis** of pure reason") – where, as I understand it, the understanding rather creates the a priori order of sensible experience by injecting *itself* into the pure forms of sensibility.

"appearances," and thus only when "schematized" in terms of space and time: substance in terms of permanence, causality in terms of succession, and so on. When we do this, moreover, we find that specifically outer or spatial intuitions are also necessarily required, so that, in particular, "in order to give something *permanent* in intuition corresponding to the concept of substance (and thereby to verify the objective reality of this concept), we require an intuition *in space* (of matter), because space alone is determined as permanent, but time, and thus everything in inner sense, is continually flowing" (B 291). There is no longer any room (among the objects of theoretical knowledge) for mind-like or spiritual substances in the traditional sense, and there is no such room, therefore, for Leibnizean simple substances having only purely internal properties:

> Only that is internal in an object of pure understanding which has no relation at all (with respect to its existence) to anything different from itself. By contrast, the internal determinations of a substantia phaenomenon in space are nothing but relations, and it itself is nothing but a totality of mere relations. We are only acquainted with substance in space through forces that are active in space, either driving others into [this space] (attraction) or stopping their penetration into it (repulsion and impenetrability). We are acquainted with no other properties constituting the concept of a substance which appears in space and which we call matter. As object of the pure understanding, on the other hand, every substance must have internal determinations and powers, which pertain to [its] internal reality. However, what can I entertain as internal accidents except those which my inner sense presents to me—namely, that which is either itself a thought or is analogous to it? Therefore, Leibniz, after he had taken away everything that may signify an external relation, and therefore also composition, made of all substances, because he represented them as noumena, even the constituents of matter, simple substances with powers of representation—in a word, **monads**. (A 265–266/B 321–322)

The entire conception of the Leibnizean monadology – along with the more traditional conception of purely mental or spiritual substances – is now seen to rest on a fundamental mistake: neglecting the necessary spatio-temporal schematization of the pure concepts of the understanding.

But it now follows, similarly, that our basic concepts of action and efficient causality – by which one substance effects a change in another – must also be limited to the necessary conditions of specifically outer or spatial intuition (B 66–67): "[E]verything belonging to intuition in our cognition (and thus excluding the feeling of pleasure and displeasure, and the will, which are certainly not cognitions) contains nothing but mere relations—[relations] of position in an intuition (extension), change of position (motion), and laws in accordance with which this change is determined (moving forces). But what may be present in the position, or what may be active in the thing itself aside from the change of position, is not thereby given." Aside from the intuitively presented laws governing the spatio-temporal changes of phenomenal substances, in other words, we have absolutely no conception of inter-substantial efficient causality at all – at least, once again, from a purely theoretical point of view.

It is in the *Metaphysical Foundations of Natural Science* of 1786 (appearing between the first and second editions of the first *Critique*) that Kant develops

the "special metaphysics of corporeal nature" governing matter or material substance.[15] In particular, in the second or Mechanics chapter, the three Analogies of Experience governing the pure categories of substance, causality, and community are here specifically instantiated or realized by what Kant calls the three "laws of mechanics" – the conservation of the total quantity of matter, the law of inertia, and the equality of action and reaction – which Kant takes to be very close to (although not completely identical with) the three Newtonian Laws of Motion. In the case of matter or material substance, therefore, its possible changes and interactions are entirely delimited by these laws, in the sense that what it now *means* for one (material) substance to exert a causal action on another (so as, in this case, to effect a change of motion in it) is simply for a well-defined exchange of momentum to take place between the two. Thus, if two bodies exchange momentum at a distance across empty space (as, in Newton's theory of universal gravitation, they must), then they do in fact causally interact with one another at a distance, and there are absolutely no remaining grounds for raising metaphysical or theological objections.[16]

The second or Dynamics chapter introduces the two fundamental forces of repulsion and attraction – the one responsible for impenetrability, the other for gravitation. Proposition 7 states (Ak. 4, 512): "The *attraction essential to all matter* is an immediate action of matter on other matter through empty space." And, in the first remark to this proposition, Kant argues that to confine the activity of matter by the condition of contact would be an entirely arbitrary restriction (Ak. 4, 513):

> [T]o say that matters cannot act immediately on one another at a distance, would amount to saying that they cannot act immediately on one another except through the forces of impenetrability. But this would be as much as to say that repulsive forces are the only ones whereby matter can be active, or that they are at least the necessary conditions under which alone matters can act on one another, which would declare attractive force to be either completely impossible or always dependent on the action of repulsive forces. But these are both groundless assertions.

Once we conceive both impenetrability and gravitation as impressed forces in the Newtonian sense, governed solely by the Newtonian laws of motion, then there is no longer any reason to take one to be more intrinsically intelligible than the other.

In the second remark to the same proposition, however, Kant goes on to make a much stronger claim—that, in explicit opposition to Newton, gravitational attraction *must* be conceived as an essential active power of matter, operating immediately at a distance through empty space (Ak. 4, 515):

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[15] All translations from this work are taken from Friedman (2004).

[16] Leibniz's main theological objection to the Newtonian force of gravity, it will be recalled, was that it would be a "perpetual miracle" if a body could persist in orbital motion (without flying off along the tangent in accordance with the law of inertia) unless the material in a celestial vortex acted upon it by impact or pressure to maintain this orbital motion. Since Newton himself shared the wide-spread rejection of action at a distance at the time, he could not give the straightforward rejoinder later available to Kant: the sun itself causes the planets to persist in their orbits, by precisely its immediate attraction across empty space. Compare notes 9 and 10 above, together with the paragraph to which they are appended.

> [O]ne cannot adduce this great founder of the theory of attraction as one's predecessor, if one takes the liberty of substituting an apparent attraction for the true attraction he did assert, and assumes the *necessity* of an impulsion through *impact* to explain the phenomenon of [gravitational] approach. He rightly abstracted from all hypotheses purporting to answer the question of the cause of the universal attraction of matter, for this question is physical or metaphysical, but not mathematical. And, even though he says in the advertisement to the second edition of his *Optics*, "to show that I do not take *gravity* for an *essential* property of bodies, I have added one question concerning its cause," it is clear that the offense taken by his contemporaries, and perhaps even by Newton himself, at the concept of an original attraction set him at variance with himself. For he could not say that the attractive forces of two planets, those of Jupiter and Saturn, for example, manifested at equal distances of their satellites (whose mass is unknown), are proportional to the quantity of matter of these heavenly bodies, if he did not assume that they attracted other matter merely as matter, and thus according to a universal property of matter.[17]

Kant's point here, specifically, is that Newton cannot leave the question of the "true cause" of universal gravitation entirely open, without fatally compromising the fundamental property of this interaction that the mutual accelerations in question are directly proportional to the masses or quantities of matter of the two interacting bodies.

I have considered Kant's argument in detail elsewhere,[18] so let me simply state it briefly here. Consider the system consisting of Jupiter, Saturn, and two of their respective moons. Newton's argument in Book III of the *Principia* crucially involves the idea that one can determine the masses of the primary bodies in question by the gravitational accelerations produced in their satellites. Newton assumes, in order to make this determination, that there are also gravitational accelerations of Saturn produced by Jupiter and *vice versa*. Then, in the most important step, Newton applies the equality of action and reaction directly to these two accelerations, so that the acceleration of Jupiter towards Saturn, multiplied by the mass of Jupiter, is equal and opposite to the acceleration of Saturn towards Jupiter, multiplied by the mass of Saturn. Newton assumes, in other words, that we can apply the conservation of momentum directly to this particular exchange, entirely independently of what other matter may or may not be found in between.[19] For Kant, this amounts, from

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[17] The "one question concerning its cause" added to the second edition of the *Optics* is of course Query 21, where Newton famously speculates that a universal "Aetherial Medium" growing denser at greater distances from the heavenly bodies might explain the gravitational interactions between these bodies. However, this aether does not act by impact (as in the vortex theory favored by the mechanical philosophers), but is rather governed by short-range repulsive forces (between the particles of aether) responsible for its pressure (and thus density). So far, therefore, this particular speculation about a possible cause for gravity is consistent with Newton's remarks in the General Scholium to the second edition of the *Principia* (compare note 6 above), where he denies that such a cause can be mechanical (p. 92): [T]his force arises from some cause that penetrates as far as the centers of the sun and the planets without any diminution of its power to act, and that acts not in proportion to the quantity of the *surfaces* of the particles on which it acts (as mechanical causes are wont to do) but in proportion to the quantity of *solid* matter, and whose action is extended everywhere to immense distances, always decreasing as the squares of the distances."

[18] See Friedman (1992, pp. 153–159), and compare Friedman (1990).

[19] As is well-known, Roger Cotes objected to Newton on this score in their correspondence, and argued that Newton himself must therefore assume that gravitational attraction – as an immediate action at a distance – is in fact essential to matter. See Koyré (1965, chapter 7), and also Stein (1967).

a methodological point of view, to assuming, in effect, that no other matter is in fact involved, and that conservation of momentum within such an exchange is both necessary and sufficient for true causal action. So it is at precisely this point, therefore, that any metaphysical conception of cause pretending to compete with the conservation of momentum must now most definitely fall away.[20]

The importance of this argument is underscored, for Kant, by the circumstance that Newton's own inductive inference to the law of universal gravitation crucially involves such direct applications of conservation of momentum to gravitational interactions at a distance (in showing, for example, that Saturn's gravitational acceleration towards Jupiter is proportional to the mass of Jupiter and *vice versa*).[21] And it is further underscored, in particular, by the fact that the resulting determinations of the masses of the primary bodies in the solar system play a central role in Kant's parallel constructive procedure, articulated in the fourth chapter or Phenomenology, for arriving at the true motions of bodies from their apparent motions. We begin with our parochial perspective here on earth, from which we can record both the observable phenomena governed by Galileo's law of fall and the observable relative motions of a variety of satellites in the solar system with respect to their primary bodies (the moon relative to the earth, the planets relative to the sun, the moons of Jupiter and Saturn relative to their planets). The latter are just the phenomena expressed in Kepler's laws, and what we now find is that we can first determine the true state of rotation of the earth (using small deviations from the law of fall manifesting what we now call Coriolis forces), and we can then determine the masses of all the primary bodies in the solar system (at least those actually having satellites) – with the result (as Newton shows) that the center of mass of the solar system is always very close to the center of the sun.

Hence we can empirically determine, from the observable phenomena themselves, the true center of motion of the solar system, and this thereby counts as an approximation, for Kant, of Newtonian absolute space. However, since it is also true, for Kant, that the solar system itself rotates around the center of the Milky Way galaxy, this galaxy rotates around the center of a larger system of such galaxies, and so on *ad infinitum*, absolute space (the true center of motion of the entire universe) is in the end what he calls an "idea of reason" – a forever unreachable regulative ideal we can only successively approximate in experience but never fully attain.[22]

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[20] By contrast, for Newton himself, as we have seen, this particular problem is solved by taking the ultimate causal agent here to be immaterial and, indeed, divine (compare again notes 9 and 10 above, together with the paragraph to which they are appended).

[21] Thus, Newton's adherence to a neo-Platonic (Cambridge Platonic) metaphysics of space is not simply an additional (and arbitrary) assumption on his part, one which could easily be dropped. On the contrary, his own inductive argument for universal gravitation, in the context of the prevailing ideas about efficient causation and ultimate (divine) agency, more or less uniquely single out this metaphysics among the available alternatives.

[22] This constructive procedure for approximating absolute space in experience is analogous, in important respects, to the constructive method of Euclidean geometry (compare note 13 above). But the circumstance that the former can never be completed marks an essential difference between the two, closely related to Kant's view that the mathematical principles of pure understanding are *constitutive* with respect to intuition while the dynamical principles are merely *regulative* with respect to intuition (but constitutive with respect to experience): for further discussion see Friedman (1992, pp. 159–164).

Finally, since Newtonian absolute space is thus viewed as a regulative idea of reason, there is also an associated reconfiguration, for the critical Kant, of the relationships among space, the interactions of matter, and the idea of God. For the idea of God, too, is a regulative idea of reason. Indeed, there is an important sense in which it is the ultimate such regulative idea, since all human activity, together with the whole of nature, is ultimately subject to the idea of the Highest Good – the idea of a perfect community of all rational beings in a moral realm of ends, for which our only ground even to hope this could actually be achieved in nature (or, more precisely, successively approximated) is the idea of God (or, more precisely, divine providence). Moreover, Kant saw a deep analogy between the community of all rational beings in a moral realm of ends and the thoroughgoing community effected among all material bodies in the universe by universal gravitation, and this is the basis, in fact, for his late (and very striking) re-interpretation of the Newtonian doctrine of divine omnipresence in a footnote appended to the General Remark to the Third Part of *Religion Within the Limits of Reason Alone* (1793):

> When Newton represents [the universal gravitation of all matter in the world] as, so to speak, divine universal presence in the appearance (*omnipaesentia phenomenon*), this is not an attempt to explain it (for the existence of God in space contains a contradiction), but rather a sublime analogy, in which it is viewed merely as the unification of corporeal beings into a world-whole, in so far as we base this upon an incorporeal cause. The same would happen in the attempt to comprehend the self-sufficient principle of the unification of the rational beings in the world into an ethical state and to explain the latter from the former. We know only the duty that draws us towards this; the possibility of the intended effect, even when we obey this [duty], lies entirely beyond the limits of all our insight. (Ak. 6, 138–139)

For the critical Kant, in other words, the only possible meaning the idea of divine omnipresence (and divine providence) can now have is a purely *practical* meaning, in so far as we unconditionally obey the command of morality to strive to realize the realm of ends here on earth, and, accordingly, we take the whole of that material nature of which we are a part to be in principle *capable* of such a realization (or, more precisely, its successive approximation). Kant thereby brings the characteristic mode of metaphysical investigation into the relationships among space, God, and matter practiced by his predecessors to a close, and transforms it – without remainder – into transcendental philosophy.

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