Another Go-Around on Leibniz and Rotation

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Abstract

This essay comments on the complexity of the task of accommodating Leibniz's account of relational motion with his dynamics, as evident in Anja Jauernig's (2008) *Leibniz Review* article, and suggests some possible strategies for overcoming these obstacles.

There are few endeavors more problematic for the Leibnizian commentator than striving to shed some clarity on his various accounts of motion, a task which invariably ensnarls one in a thicket of associated, equally problematic issues, such as space, time, and force. In a recent essay, Anja Jauernig (2008) has made a concerted effort to untangle some of these difficulties. In what follows, I will lay out of the some of the problems that I believe reside in her approach, along with a few suggestions on a more adequate alternative. Not surprisingly, many of the difficulties pertain to rotation, which has long been recognized as the weak link in a relational theory of motion, i.e., the doctrine that all motion is the relative motion of bodies, with Leibniz's "Equivalence of Hypotheses" (EH) doctrine comprising an instance of a relational theory (or so it seems). The discussion of Leibniz's explanation of rotation, and why he thought it was still compatible with the EH (despite the claims of the Newtonians), will draw from his "Specimen Dynamicum" (AG 1989, 117-137). In brief, Leibniz claims that the apparent centrifugal force manifested in a rotating body is not a problem for his theory of motion, since the individual particles that make up the rotating body do uphold the EH in their respective collisions with the surrounding plenum particles; hence the force effect is merely a result of these collisions, and, in fact, also explains the body's solidity, thereby undermining the claim that the centrifugal force effects of motion support absolute motions (in an absolute space).

In her detailed investigation of the EH, which is informative in many ways, Jauernig explores the possibility of separating the phenomenal from the dynamical aspects of Leibniz's physical theory (where phenomenal pertains to the level of bodies, and dynamic to the minute corporeal substances that underlie phenomena; 12). The rationale behind this strategy is to establish that Leibniz's theory can employ both absolute and relational elements at these different levels, phenomenal and dynamic. Jauernig allows two possibilities (nicely summarized on 29-30), (1) that the structure of spacetime is Leibnizian at the phenomenal level and Galilean at the dynamical level, or (2) that it is Galilean at both levels. (Incidentally, the name "Leibnizian" is a modern designation for a spacetime structure that may, or may not, be applicable to Leibniz's own views of space and motion.)

There are problems with both (1) and (2), however. On a Leibnizian spacetime scheme, the trajectory of any body or reference frame (a smooth timelike curve) can be mapped into any other (given various limitations; see, Earman 1989, chapter 2, for an analysis), since there is no distinction between inertial (non-accelerating) and accelerated reference frames in this scenario, whereas a Galilean structure can make these distinctions. Accordingly, on (1), the rotating body would not be a problem for Leibniz, since in a Leibnizian spacetime it would only constitute an "acceleration (or rotation) difference" between, say, the body and the plenum, and thus one could assign the rotation to *either* of the two.[i] Yet, Leibniz obviously did grasp that rotation was a major problem for his physics, since he invoked a story where the relational motions of the constitutive particles (in collision with the plenum particles) account for the mere "appearance" of the centrifugal effects of the body's motion, as well as explain its solidity. In other words, Leibniz's explanation (where the constitutive collisions of the particles save his relationism) attributes both the motion and the force effects to the body, and not to the plenum—but this construction breaks the symmetry of the "relative rotation difference" at the *phenomenal level,* so the structure of phenomenal spacetime cannot be Leibnizian. If the structure at the macroscopic level of bodies is truly Leibnizian, then the assignments of rotation, force and solidity, would have to be completely reciprocal (which is not the case: only the body rotates and is supposedly solid—put differently, Leibniz does not ascribe rotation, or centrifugal force or solidity, to the plenum that surrounds the body).[ii] Moreover, the tangential conatus that Leibniz assigns to the constitutive particles of the rotating body already undermines a Leibnizian structure for the spacetime at the phenomenal level, since these linear motions are arranged around, and centered upon, the *body's* axis of rotation, thereby invoking an inertial structure at the phenomenal level of the body that transcends the dynamical, local level of each particle; in fact, it is difficult to grasp the meaning of Leibniz's approach as regards the tangential motions of the body's particles without presupposing a Galilean structure for the whole body. Presumably, one could still claim that the phenomenal structure is Leibnizian, but that the behavior at the dynamical level merely makes it appear that this structure is being violated by the body's behavior—but then it is unclear what work Leibnizian structure is doing any more at the phenomenal level. Overall, the only way to resolve these issues, at least partially, is to assign a Galilean spacetime structure at both levels, since force and solidity need not be assigned reciprocally to the plenum or rotating body using this structure, and then claim that the presence of these forces (in the body, and not the plenum) are due to the reciprocally assignable motions ("relative speed/velocity difference") of the colliding pairs, thus upholding ("relative speed") relationism at the dynamical level. Indeed, that seems to be Leibniz's presupposition, an approach that is perfectly compatible with a Galilean spacetime structure.

On (2), Jauernig claims that the structure of phenomenal space is Galilean, but she interprets this in such a way that "proposition 19 [roughly the EH] corresponds merely to Galilean relativity", and that "there cannot be any bodies that are in non-uniform or curvilinear motion" (23)—and this is presumably at the phenomenal level. Now, this strategy has two possible interpretations given the discussion, the first being that there are accelerated motions at the phenomenal level, but that the EH only applies to inertial, non-accelerated motions at this level. Yet, if this is a correct interpretation of her discussion, then it is contradicted by the texts, where Leibniz refers to the EH in the context of the elliptical motions of the planets ("On Copernicanism", AG, 91-92; and, again, in the "Specimen Dynamicum", 131). Alternatively, Jauernig's suggestion might be that there are simply no rotational or accelerated motions at the phenomenal level at all (as well as at the dynamical level), and thus the EH applies by default to only inertial motions at this level: "since, . . . as a matter of physical possibility, there cannot be any bodies that are in non-uniform or curvilinear motion, proposition 19 [EH] would still be strong enough to ground the relativity of *all* actual and physically possible motions . . ." (23). Besides being a burdensome demand to place on Leibniz's physics, this idea is contradicted by Leibniz's own analysis of free-fall, although many other examples could be invoked as well. Leibniz's proof of the *vis viva* law in the *Discourse on Metaphysics* (AG, 49-50) relies upon the incremental build up of speed, i.e., their non-instantaneous accelerations, as the means of defeating Descartes' conservation law for the quantity of motion: *vis viva* is being used in this context to measure the body's motion for an extended period of time and distance, where the body is undergoing an acceleration (using the modern terminology), and thus the texts demonstrate that mv_2 is conserved at that level of bodily phenomena, and not merely at the dynamical realm of the substances that underlie phenomena: so there is very good evidence to accept real accelerations (i.e., non-instantaneous change in velocity) at the phenomenal level. Finally, this last example would constitute another problem for (1), since only inertial reference frames will generally uphold the conservation law.

On the whole, a potential prospect for upholding something like Jauernig's suggestion is to say that Leibnizian structure can be applied in cases where motion is conceived kinematically (where forces are not present or under consideration), but Galilean structure comes into play when motion is conceived dynamically, i.e., when the forces are taken into account. That is, bodily phenomena do not favor any reference frames, and so one could claim that the EH allows a Leibnizian spacetime interpretation, but only when motion is considered kinematically without regard to forces. This would explain why circular motions are under consideration in the "On Copernicanism" tract, since there is no mention of force in these discussions, but only of the relative simplicity of different perspectives, Ptolemaic or Copernican, for viewing celestial motions: hence, whether the earth rotates around the sun, or visa versa, is not at issue, and this symmetry nicely accords with an interpretation utilizing the backdrop of Leibnizian structure.

However, when force is taken into account, then the EH is restricted to those perspectives which preserve the conservation law (since only those types of motions uphold mv^2), and thus the structure is Galilean, of course. This interpretation would also nicely tie into those passages where Leibniz seems to say that any assignment of rest or motion is possible, but, once force is taken into account, the assignments of motion are much more narrowly constrained (e.g., the *Discourse,* AG, 51).[iii] This reading of the EH also dovetails with how motion, and even mv^2, can be viewed from the perspective of bodies at the phenomenal level (free-fall), or at the dynamical level of constitutive particles (collisions in the center of gravity frames). In short, different spacetime structures can be assigned to any level, phenomenal or dynamic, depending on whether or not force is taken into consideration—and this accords with Leibniz's numerous claims that portray motion as ideal, while forces are real. Force constrains how motions are constructed or perceived in any particular scenario, but the constraints must be invoked so as to allow for the least possible assignment of individual motions to any relative speed difference (by this means, he must reckon that the relational character of motion is preserved: maybe this is the true meaning of the EH; but see endnote 3). Of course, this observation, that the EH allows different perspectives, Leibnizian or Galilean, is not meant to be taken as supporting any sort of ontological or epistemological equality of these different structures as regards Leibniz's dynamics. Since Galilean structure is required to make sense of Leibniz's conservation law, Galilean structure is indeed privileged given his overall natural philosophy, albeit with the important proviso that one can still judge motion from a Leibnizian perspective given certain purposes and restrictions (i.e., force is not under consideration). Put differently, since Leibniz tends to associate the EH with the *relative* simplicity (intelligibility, truth, etc.) of different assessments of motion—e.g., "the Ptolemaic account is the truest one in spherical astronomy" ("On Copernicanism", AG 1989, 92)—the most plausible interpretation of the use of the weaker Leibnizian structure would seem to be one that is based on a limited set of methodological goals (such as the astronomy case above).

Finally, it is important to examine the rotation issue in the context of the conservation law, since it pushes Leibniz into having to postulate strange global and holistic hypotheses on the forces that underlie his plenum, hypotheses that may undermine the very possibility of constructing a dynamics based on the EH and mv^2 (see Slowik 2006, for more on this problem). In short, since mv^2 is dependent on motion (as the v in mv^2), and is a property of each pair of colliding bodies, it thus becomes quite problematic to understand how the plenum can unite, in such a way that the body is struck in just the right manner, and thereby accounts for the solidity (and perceived, but not actual) centrifugal force of the body. This constitutes a form of circularity problem for Leibniz (pardon the pun): mv^2 is dependent upon the relational motion (as a speed difference) among each colliding pair of bodies, but somehow the conservation of mv^2 is involved in the mass unison movement of the plenum that preserves the relational account of motion (EH) of each colliding pair! The only way out of this dilemma, it would seem, is to admit a perspectival aspect to the conservation law itself: namely, if only physical forces are implicated, then there may be a more basic level of force (of a more teleological sort), that brings about mv^2 and its conservation, but which lies both beyond our understanding and at a more fundamental level than the mere measure of mv^2. This admission would thus explain the global, teleological elements implicit in Leibniz's natural philosophy as a whole (e.g., pre-established harmony, and his numerous other hypotheses of a similar ilk), but it would also, unfortunately, demonstrate that his physics is crucially incomplete or partial. Jauernig's comment that the issues of solidity, etc., are "tricky, but, to my mind, not unanswerable" (28), thus vastly underestimates the truly devastating consequences that Leibniz's continued espousal of relational motion, and the EH, entails for the construction of his dynamics. Put differently, these problems are potentially resolvable, but the answers likely reside in his metaphysics, and not his physics, thus ceding the day to his Newtonian adversaries, who postulated no comparable limitations on the implementation of their physics. But, then again, Leibniz did associate his dynamics with the more metaphysical disciplines, given its reliance on force, and so maybe he would have gladly accepted that his dynamics, at least in its fundamental orientation, comprised one of the last chapters in the long tale of Aristotelian/Scholastic natural philosophy.[iv]

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[i] Throughout this essay, “acceleration”, will simply refer to Leibniz’s account of velocity change, and/or rotation (e.g., the body rotates, or changes velocity), regardless of whether the change in velocity is truly instantaneous or rather occurs in discrete increments (the latter being Leibniz’ preferred view). As Ric Arthur reminds me, Leibniz’s account does not exactly match the modern conception of acceleration, so the use of modern terminology is merely an approximation (which, for our purposes, is sufficient given the topic). Alternatively, the brief discussion of different spacetime structures above can be regarded as automatically incorporating the modern analogue of Leibniz’s conceptions, since the relevant feature in this context is the *difference* between a straight line trajectory or a curved trajectory (even if that curve is composed of many differently-directed miniscule straight line segments).

[ii] Indeed, if the rotation were ascribed to the plenum, and not the body, then, assuming the axis of rotation is the same, the particles of the plenum would move away, in an outward radial direction, from the resting body. As a consequence, there would be no collisions at all between the rotating plenum particles and the particles of the resting body.

[iii] Although, in this passage from the *Discourse* (and elsewhere), Leibniz seems to break the Galilean invariance by demanding an assignment of individual states of motion; and only a spacetime structure stronger than Galilean, such as a Full-Newtonian, is equipped to make those determinations.

[iv] I would like to thanks Ric Arthur and Dan Garber for comments and discussions.