Jacob Portes

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What About Metric Field Substantivilism?

Ever since its formulation in 1973, the "metric field substantivalist" characterization of space-time has been held in high regard by both physicists and philosophers alike. One philosophically significant aspect of this characterization is that while it taxonomically belongs to the substantivilist camp, there are strong reasons to relegate this contemporary view of space-time to the relationist camp, or even to a third category of its own. This paper introduces metric field substantivilism within the context of traditional substativilism and relationism, weighs various arguments for and against various modes of categorization, and ultimately concludes that the traditional dichotomous categories are not actually meaningful.

Before dealing with the overarching question of how to philosophically understand contemporary notions of space-time, a simple description of the *physics* and *mathematics* of space-time is in order. In Einstein's theory of general relativity, the widely accepted theory of space-time developed nearly a century ago, the metric tensor is the fundamental object of study. The metric tensor (or "metric") can be thought of as a sort of generalized *field* that defines notions such as distance, volume, curvature, angle, future, and past. The metric itself is a covariant and symmetric tensor on a four dimensional manifold (which in turn is just a topological space that resembles Euclidean space near each point). While general relativity is not the only space-time theory, it is the most elegant and most widely accepted. But how does this relate to substantivilism and relationism?

Traditional substantivilism is the thesis that space and time are entities in their own right that exist independently of things in the universe. Relationism, on the other hand, is the thesis that space and time are *not* entities in their own right, and that it only makes sense to talk about the relationship between objects with respect to each other and not about the relationship of an object with respect to some separate, metaphysical notion of space. Historically, Isaac Newton and Gottfried Leibniz stood at opposite ends of the discourse on the nature of space and time. While Newton believed in a privileged "absolute" space, Leibniz believed that space was nothing more than relations between objects.[1] The basic Newtonian and Leibnizian philosophies dominated the discourse on the nature of space and time until the development of special and general relativity at the turn of the twentieth century.

Much like the theory of electricity and magnetism developed only a few decades before it, the theory of general relativity is a *field theory*. A field theory is defined as a theory that associates certain mathematically describable properties (such as scalars, vectors, tensors, spinors, field operators, gauge fields, etc.) with every point of space and time, while a *particle theory* associates certain properties with objects (particles) and nothing more. Implicit in any sort of field theory is the assumption that there *are* points in space and time to assign properties to! Thus field theories can all be roughly categorized as substantivilist.

Unlike electromagnetic theory, however, general relativity employs the notion of manifolds. And manifolds are somewhat problematic metaphysically – a four-dimensional differentiable topological manifold *M* doesn't quite have the properties of traditional space-times. Roughly put, past and future cannot be distinguished on M, and distance relations cannot be defined either. Stephen Hawking and George Ellis were the first to treat a manifold M and metric tensor **g** together as a single mathematical model for space-time (as opposed to treating

[1] The main points of the debate are expressed in the Leibniz Clarke correspondence.

just M as the model for space-time) in 1973.[2] This specific characterization of space-time is called *metric field substantivilism.*

The natural way to think about substativilism would require that one could strip a point in space-time of its various properties, leaving some sort of "primitive identity." However, in the case of general relativity, the space-time points are always "occupied" by the metric – they cannot really be decoupled! There would no longer be anything *contained* in space-time. While this is of course a simplified understanding of general relativity, it calls into question the relevance of the substantivilist/relationist paradigm to general relativity.

Another criterion for substantivilism advanced by John Earman and John Norton is that of "Leibnizian equivalence." In his correspondence with Newton's protégé Samuel Clarke, Leibniz asked how the universe would differ if God had rearranged all objects in absolute space by changing east into west while maintaining the relations between all objects (say the relative distances between objects were maintained, but they were rotated in absolute space).[3] While Leibniz, who did not believe in absolute space, argued that such a scenario would be theologically problematic (by violating his Principle of Sufficient Reason), Earman and Norton suggest that a contemporary form of this scenario would be problematic for the simple reason that there would be "distinct states of affairs which no possible observation could distinguish."[4] Substantivalists would *have to* claim that there were two separate states; if they claimed otherwise, they wouldn't be substantivalists! This presents a particularly troubling criticism, as

[2] "The mathematical model we shall use for space-time, i.e., the collection of all events, is a pair (M, **g**) where M is a connected Hausdorff C^∞ manifold and **g** is a metric..." *The Large Scale Structure of Space-Time*, p. 56

[3] "Now from this it follows (supposing space to be something in itself, besides the order of bodies among themselves) that it is impossible there should be a reason why God, preserving the same situations of bodies among themselves, should have placed them in space after one certain particular manner and not otherwise – why everything was not placed the quite contrary way, for instance, by changing east into west." Leibniz's Third Letter, Leibniz Clarke Correspondence how can the *relationist* properly characterize points of space-time that have not yet been "occupied" but which possibly may be "occupied" in the future -- and thus become actual "events"?

[4] Earman, p. 515

this would be at odds with standard modern texts in general relativity that accept the equivalence in specific cases of manifolds with metrics.[5]

In light of the objections above, it seems that calling the manifold metric model substantivilist would be misleading. The only reason it seems to be categorized as substantivilist in the first place is related to its tangential similarity to traditional substantivilist field theories. And while it is easy to think that the model should be considered relationist instead, there are few reasons to believe otherwise. How does *relationism* properly deal with points of space-time that have not yet been "occupied," and possibly may be "occupied" in the future? The manifold and metric seem to be pretty bizarre mathematical structures.

Philosopher Robert Rynasiewicz challenges the relevance of the substantivilist/relationist paradigm all together – after all, present day physicists use language that tools that are quite different from the tools of Newton and Leibniz. He also adds that the biggest mistake is to assume that "the alleged issue can be stably formulated in terms that transcend any particular historical or conceptual context."[6] Rynasiewicz deals with this issue much more thoroughly in his 1996 paper "Absolute Versus Relational Space-Time: An Outmoded Debate?"

In conclusion, there do not seem to be compelling reasons to consider the manifold metric model either substantivilist or relationist in the traditional sense. Who knows? Maybe there is a tertium quid to this centuries old debate waiting to be included in the discourse.

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[5] Earman, p. 522
[6] Rynasiewicz, p. 306

Works Cited

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2. Leibniz, Gottfried Wilhelm, Samuel Clarke, and Roger Ariew. *Correspondence*. Indianapolis: Hackett Pub. Co., 2000.

3. Rynasiewicz, Robert *Absolute Versus Relational Space-Time: An Outmoded Debate? The Journal of Philosophy*, Vol. 93, No. 6 (Jun. 1996), pp. 279-306