What is a Classical Field?

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Relationalists who wish to include fields in their ontology typically assume that a field is something like an extended material object (as opposed to a distribution of properties over points of spacetime). Thus, Gordon Belot writes that

> ...relationalists—and others—can treat fields as they would, say, rigid bodies—as extended objects whose parts stand in determinate spatial relations to one another, and to which differing properties can be attributed ([2000], 224).

In this paper, I argue that relationalists adopting this notion of a field are committed (to whatever degree the substantivalist is committed) to counting diffeomorphic models of GR as representing distinct physical possibilities. Consequences concerning determinism and the development of a quantum theory of gravity are discussed.

My argument follows the argument in (Earman & Norton [1987]) for the claim that substantivalists are committed to counting diffeomorphic models of GR as representing distinct physical possibilities. That argument has two main steps. First, it is argued that substantivalists are committed to manifold realism—that they are committed to the existence of an object in the world corresponding to the M in the relativistic model (M, g_{ab}, T_{ab}). Second, it is argued that substantivalists are committed to counting smooth transformations with respect to this object as representing distinct physical possibilities.

1. First step. The chief complaint against a relational theory of spacetime is that its ontology is too thin to secure the sort of geometric structures that we take to be physically real. Thus, relationalists are frequently charged, for example, with failing to support the inertial structure necessary for a well-defined notion of absolute acceleration. But if fields are extended material objects, then the relationalist has access to an ontology every bit as rich as the substantivalist's. In this case, geometric structures which the substantivalist sees as inhering in a manifold of substantival points can instead be seen as inhering in a plenum of materialized field parts. Such a relationalist will have no trouble making sense of claims along the lines that physical spacetime is smooth, connected, boundaryless, or paracompact. Indeed, this seems to be exactly the sort of picture that Einstein had in mind when he described spacetime as a "structural property of the field" (Einstein [1961], 176). But then the relationalist, no less than the

substantivalist, ought to be seen a realist about the spacetime manifold in the following sense: he thinks that there exists some object in the physical world (namely, a plenum of materialized field parts) whose structure is represented, at least in part, by the M in the model (M, g_{ab}, T_{ab}).

2. Second step. The chief complaint against a substantival theory of spacetime is that it entails the existence of ontologically distinct though qualitatively indiscernible states of affairs. For if spacetime were substantival, then it would be possible to smoothly shift the material content of spacetime in such a way as to produce no qualitative change in the world. Since, it is supposed, this is not possible, spacetime cannot be substantival.

The problem is that relationalists who countenance fields construed as extended material objects are subject to a very similar argument. Here it is. Suppose that a field is an extended material object, each part of which instantiates some set of qualitative properties. Then it is possible to smoothly shift sets of properties in such a way as to produce no qualitative change in the world. Since, it is supposed, this is not possible, fields cannot be material objects.

The traditional shift argument calls for a systematic reconfiguration of location relations. Our modification of that argument calls for a systematic reconfiguration of instantiation relations. Beyond that, the arguments are identical. Indeed, a survey of possible responses (e.g. embrace haecceitism, invoke essentialism, invoke counterpart theory, reject substance-property dualism, etc.) shows that our modification of the traditional argument is just as troublesome for the relationalist as the traditional argument is for the substantivalist.

I do not say that our modification of the traditional argument establishes the conclusion that it purports to establish. What the argument does do, however, is to establish parity between the substantivalist and the relationalist by removing whatever modal differences were supposed to distinguish the views.

3. Diffeomorphic Invariance. So here is what we have. First, the relationalist who countenances fields construed as extended material objects is as much a realist about the M in the model (M, g_{ab}, T_{ab}) as the substantivalist. The only difference is that for the relationalist, the topological and differential structure of spacetime inheres in a plenum of materialized field parts. In Einstein's phrase, spacetime becomes a "structural property of the field." Second, smooth transformations of field-strength properties with respect to this underlying plenum of parts will result in distinct though indiscernible states of affairs. It remains only to point out that diffeomorphisms are the rights sorts of fuctions for representing these sorts of transformations.

Consequently, whatever trouble the substantivalist is supposed to have with interpreting the invariance of models of GR under the group of diffeomorphisms, those same troubles, of equal kind and of equal measure, can be shown to arise for the relationalist.

4. References

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