Abstract: On the Existence of Spacetime Structure

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November 15, 2007

The revival of the debate over the ontic status of spacetime in the philosophical community in recent years can trace its roots, in part, to its revival in the physical community. Belot (1996) and Belot and Earman (2001),[1] for instance, claim that philosophers ought to take the debate seriously because many physicists do. I do not think that fact suffices as a good reason for philosophers to take the debate as sensical and so enter into it. The active work of physicists on our best physical theories, considered in the most positive of lights, should provide the greatest part of the fodder for the work of the philosopher of physics most of the time. Sometimes, however, the physicists are confused, or just mistaken, and it is then our job to try to help set matters straight. I believe we find ourselves in the latter circumstance in this matter.

I begin the argument with an analysis of Einstein's Hole Argument, the impetus behind much of the revived interest in the debate. I conclude that the argument is a red herring. It relies on a distinction between regions of spacetime devoid of and occupied by ponderable matter, which turns out on inspection to have no bearing on the issue it purports to address, whether one can make sense of the idea of a bare spacetime point-manifold in the absence of metrical structure. This point comes out clearly in the light of a brief discussion of the initial-value formulation of the Einstein field-equation.

The argument of the paper then takes a dialectical turn. In sequential sections I offer novel arguments in favor of, respectively, the positions that one cannot and that one can characterize the structure of spacetime as a bare point-manifold in the absence of metrical structure. In the first, I use a construction of limiting families of spacetimes, due to Geroch (1969), to argue that, in the context of theoretical investigations that rely on certain forms of idealization and approximation in the modeling of physical systems, which points of spacetime one ends up attributing existence to in one's model, as it were, depends sensitively on the metrical structure that defines the construction of the model from the limiting family. In the second, I argue that all structure accruing to a spacetime, considered simply as a differential manifold that represents the collection of all possible (or, depending on one's modal predilections, actual) physical events, can be given adequate definition with clear physical content, in the absence of any metrical structure. The argument takes the form of the construction of the point-manifold of a spacetime, its topology, its differential structure and all tensor bundles over it from a collection of primitive objects that, when the construction is complete,

[1]It is not clear to me whether either Earman or Belot would endorse the position today, but those papers seem to me the clearest and strongest statements in favor it.

acquire a natural interpretation as the family of continuous scalar fields on the manifold. The techniques the construction involves, like those in the first argument, most naturally come into play only in investigations of a particular sort, in this case that of the experimental mapping of the structure of a region of spacetime from the observed values of the physical fields that occupy it.

I conclude that the soundness of the conclusions of each argument does not bear on that of the other, precisely because the arguments rely on different criteria for the attribution of existence or physicality to entities. One cannot *a priori* favor one set of criteria over the other, because each is more or less natural and useful in the context of the type of investigation it appears in, but not in that of the other. Using this observation as a starting point, I invoke both abstract semantical and concrete physical considerations to argue that the debate between substantivalists and relationalists has never been well posed, and likely never will be, just because different sorts of investigation will rely on different notions of physicality, none privileged over the rest.

I conclude the paper by showing that all the arguments extend themselves naturally beyond the realm of the debate over the existence of spacetime points, which besides being of interest in its own right provides further support for the cogency of the arguments. The type of physicality one attributes to, say, Maxwell fields will differ from that one does to Killing fields. A manifold's global topological structure, including invariants such as its Euler number, orientability and first Betti number, offers fertile ground for a search for senses one might want to give to a concept of existence or physicality for putative entities and structures on and of spacetime, variously useful, or at least illuminating, in investigations of different sorts. In some of these senses, I suspect, one will rightly say spacetime points exist. In others, one will not. The words we use to further all the sorts of scientific and philosophical investigations we pursue do not matter, only the concepts behind the words, some of which find natural application in some investigations and some of which do not.

References

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