Ontology of Spacetime: Lessons from Set Theory

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One of the most successful acts of ontological cleansing ever undertaken was carried out by Ernst Zermelo [(1)] in relation to paradoxes of set theory (including Russell's paradox). Zermelo's paradigm answers the core ontological issue of set theory (what is a set?) in the following generic terms: (a) A primitive set exists; (b) Formal rules of construction can be used to establish new sets from pre-existing sets; (c) The proper business of set theory is to discover relationships between constructible sets. Importantly, speculations on the nature of the primitive set are imponderable.

It is argued that Zermelo's paradigm can be adapted to Minkowski spacetime on the back of the following postulates:

(a) A primitive inertial coordinate system exists.

(b) Formal rules of construction [(2)] can be used by inertial observers to build their individual spacetime from the primitive system. These rules establish lines of simultaneity, distance between simultaneous events and time dilation at the site of the inertial observer.

(c) The proper business of Minkowski physics is to explain phenomena with reference to constructed individual-observer spacetimes. Speculations on the nature of the primitive system are imponderable.

In the Zermelo-Minkowski paradigm, constructed spacetime is the core accessible feature of ontological discourse, and is intimately associated with the inertial observer carrying out the construction. It is important to note that constructed spacetime is formal in two senses. Firstly, the rules of construction are not obvious from a priori considerations. Secondly, no comprehension is required of clocks, rulers, synchronisation signals, equivalence principles or other aspects of physical law.

Because of the "follow-the-rules" character of the Zermelo-Minkowski paradigm, a radical simplification can be achieved of many debates of spacetime ontology, including McTaggart's paradox [(3)] and the 3D/4D debate [(4, 5)]. Several examples are discussed, including an analysis of the familiar argument which begins with the premise that "Yesterday's gone and tomorrow may never be mine", and invites the conclusion that for an object to exist, it must exist in the present.

The Zermelo-Minkowski paradigm leads inexorably to a consideration of the ontological status of accelerated-observer spacetimes. These can be created with a simple addition [(2)]

to the given rules of spacetime construction. An instructive accelerated-observer scenario involves line-of-simultaneity diagrams of the type used in mainstream STR texts [6] to solve the Twin Paradox. In these diagrams, lines of simultaneity associated with the accelerated observer/twin can intersect in the constructed spacetime of the inertial observer/twin. This conundrum can be given a logically consistent resolution which leads to a satisfactory method for constructing accelerated-observer spacetimes [2, 7, 8]. This new result is compared with the coordinate patch hypothesis [9].

Finally a glimpse is provided [2] of a scenario in which augmented rules of spacetime construction can lead to spacetimes with innate quantum character, and to spacetimes in which mass is intrinsic.

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