

Paper Title: Primitive Motion Relationalism

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### Abstract

The paper begins by reviewing three historically common interpretations of spacetime theory; the conventionalist, geometric, and dynamic approaches. According to our analysis, the difficulty with the conventionalist approach is that it takes the Principle of Relativity (PR) for granted without giving it a proper theoretical explanation. The conventionalist approach treats various inertial reference frame as producing empirically equivalent models of the theory. But the isomorphism between models is evidence of a single structure giving rise equivalent representations of spacetime. A difficulty with the geometric interpretation is its treatment of spacetime both as the "background" for material fields, a container wherein the points of material fields reside, and as one field among many other material fields. These two roles seem contradict each other; spacetime is seen both as the container enabling the existence of material fields and as a material substance distinct from material fields, possessing causal powers. The difficulty with the dynamic account is that it refuses to offer an explanation for the universality of the PR. All known dynamic laws obey the the PR, and it has become a general rule of thumb that progress in theoretical physics requires that laws are assumed to be Lorentz-covariant.

In this paper, we provide an interpretation of spacetime that overcomes the difficulties of standard approaches. In our approach, motion is more primitive than space and time. Motions as the fundamental entities of spacetime; points of

coincidence are then conceived as intersections between motions. We restrict our attention to very specialized motions that are self-similar at every intersection and provide an ideal for equal progression in time and space. The connection to physical spacetime would then be to assert that ideal uniform counterfactual motions are the same as inertial motions - free particles and light signals in Galilean or relativistic spacetime. We call these ideal motions Paradigms of Uniform Motion (PUMs). We label *Primitive Motion Relationalism* the view that spacetime can be constructed from PUMs and relations between them.

It is possible to take PUMs as the fundamental entities of spacetime, and events as compound structures comprised of "coincidences" between PUMs, and then construct spacetime theory from these entities. We adapt to our purposes Hilbert's axioms for Euclidean geometry and define segments of equal intervals on PUMs. The axiomatic system defines events as belonging to a set of intersections between motions. It then articulates some axioms for coincidence relations, and continues by articulating axioms for relations of "determinateness" and "congruence" between motion-coincidences.

The axiomatic system we construct for articulating the principles of *Primitive Motion Relationalism* provides a new interpretation of spacetime. First, this interpretation overcomes the difficulties of conventionalist interpretations when it shows how various inertial reference frames produce equivalent representations of spatiotemporal relations. Second, this approach also overcomes the difficulties of the geometric interpretation, since it does not attribute spatiotemporal points real existence nor does it take them to possess causal powers. The coincidence between motions determines the identity of spatiotemporal points. The structure of fundamental PUMs determines the behavior of clocks and rods via the basic motions of their parts. Thus spacetime does not function as the efficient cause of kinematic effects, but as the formal cause of any moving body. Finally, *Primitive Motion Relationalism* overcomes the difficulty of the dynamic interpretation of spacetime since it provides a unifying account of motions. By asserting that all fundamental

motions must decompose to their spatial and temporal components according to the fundamental structure of the motion, any complex motion must inherit the basic symmetries of the fundamental motions. Thus, the PR is shown to be a universal feature of all dynamic laws, as they take their form from the fundamental structure of motions.