

Simultaneity without Cosmology

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Global simultaneity is a necessary condition for genuine becoming. Defenders of global simultaneity typically invoke a preferred cosmological frame defined in terms of the homogeneity and isotropy of the universe. I present an alternative account of global simultaneity based on the distinction between topological and metrical relations: Since simultaneity is a topological relation, it is frame-independent and in no wise dependent upon a preferred cosmological rest frame. Cosmological considerations come into play solely for frame-relative metrical relations.

The special theory of relativity presents two potential impediments to a unique global simultaneity relation. First is the empirical indeterminacy of the one-way speed of light, which ostensibly renders distant simultaneity conventional within a single inertial frame. However, the mere fact that we cannot measure the one-way speed of light in no wise implies that the one-way speed of light is itself indeterminate, and the most sensible assumption is that the instantaneous speed of light is a constant equal to its average round-trip speed. The second potential impediment, which can come into play only once the first has been disposed, is the relativity of distant simultaneity among inertial frames, which precludes a unique distant simultaneity relation. But in general relativity the validity of special relativity is limited to infinitesimally small regions of space and time, thus obviating the frame-relativity of distant simultaneity.

In general relativity itself, we encounter the same two impediments, but now in guise of diffeomorphism equivalence with respect to the conventionality of distant simultaneity, and general covariance with respect to the frame-relativity of distant simultaneity. However, the considerations that speak for diffeomorphism equivalence in the context of Einstein's "hole argument" do not similarly speak for the equivalence of different foliations of time within a single coordinate system. Instead, given our assumption of a determinate one-way speed of light, diffeomorphism equivalence in general relativity is limited to three-dimensional spatial diffeomorphisms. Moreover, as Kretschmann demonstrated early on in the history of general relativity, general covariance is not a sufficient condition for the realization of a generalized principle of relativity and there is realized in Einstein's theory of gravity no generalized principle of relativity such as could underwrite the equivalence of accelerated frames of reference. Thus, we encounter in general relativity no substantive impediment to global simultaneity.

Finally, since any gravitational trajectory is determined relative to the gravitational field itself, the local gravitation field at each point must be regarded as at rest, thus furnishing a preferred frame relative to which metrical effects such as Lorentz contraction and clock retardation may be referred. But global simultaneity, as a frame-independent topological relation, requires no preferred frame and should rather be presupposed on intuitive-

philosophical grounds, cosmological considerations aside. Cosmological considerations come into play solely for metrical phenomena such as, for instance, the age of the universe or the uniform temperature of the cosmic microwave background. Were the universe not homogeneous and isotropic, then clocks at different places in the universe would run at different rates, with the result that different parts of the universe would have different ages and the universe as a whole would not have an age. But these very cosmological alternatives presuppose a unique global simultaneity relation, for otherwise different parts of the universe could not at present be compared. In general relativity, then, the distinction between topological and metrical relations gives us back what special relativity took away: a unique and global simultaneity relation.