The Arrow of Time in Cosmology

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Abstract

Scientific cosmology is an empirical discipline whose objects of study are the large-scale properties of the universe. In this context, it is usual to call the direction of the expansion of the universe the "cosmological arrow of time". However, there is no reason for privileging the ‘radius’ of the universe for defining the arrow of time over other geometrical properties of the space-time. Traditional discussions about the arrow of time in general involve the concept of entropy. In the cosmological context, the direction past-to-future is usually related to the direction of the gradient of the entropy function of the universe. But entropy is a thermodynamic magnitude that is typically associated with subsystems of the universe: the entropy of the universe as a whole is a very controversial matter. Moreover, thermodynamics is a phenomenological theory. Geometrical properties of space-time provide a more fundamental and less controversial way of defining an arrow of time for the universe as a whole. We will call the arrow defined only on the basis of the geometrical properties of space-time, independently of any entropic considerations, the "cosmological arrow of time". In this paper we will argue that: (i) it is possible to define a cosmological arrow of time for the universe as a whole, if certain conditions are satisfied, and (ii) the standard models of contemporary cosmology satisfy these conditions.

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