TWO NOTES ON THE FOUNDATIONS OF THERMODYNAMICS: OBJECTIVITY OF ENTROPY AND THE ORIGIN OF GIANT FLUCTUATIONS

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ABSTRACT

The standard formulations of statistical mechanics and the explanations of irreversibility rely on the way we describe physical systems. They use concepts such as coarse-graining, macroscopic states, and probabilistic states that depend on the observables we measure, the precision with which we measure them, or the information we have about the microstate of a system. Some of these elements of arbitrariness can be removed from the formulation of statistical mechanics using an observable-dependent entropy that was already used by Einstein in his studies of fluctuations [1]. The observable-dependent entropy, together with the ergodic hypothesis, characterizes the irreversible behavior of specific observables, both micro- or macroscopic [2]. On the other hand, equilibrium and the entropy of a system cannot be defined without choosing the observables used to describe its state, and this choice seems to involve an unavoidable arbitrariness. Finally, we present a new mechanism for the origin of states with low entropy based on symmetry-breaking transitions [2,3]. This mechanism replaces the controversial "past hypothesis" [4], namely, the assumption that the universe started in a low-entropy state, with the simpler scenario of an environment with decreasing temperature.

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