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ORIGINAL ARTICLE

Sign of the amount of nonconservation energy in entropic cosmology

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Abstract In the framework of Friedmann-Lemaitre-Robertson-Walker cosmology modified by entropic issues, the sign change of the inhomogeneous term associated with the nonconservation energy equation for cosmic fluid is discussed; specifically, this is a bare/effective study of the equation of state for this fluid through a bare (ω)/effective (ω_{eff}) description. In the bare case, where there is a nonconserved equation of state, the change in the sign of the inhomogeneous term at different times of the cosmic evolution is described. By redefining the adiabatic ω-parameter, the usual scheme for cosmic evolution can be recovered. In the effective case, if evolution is driven by dust or the cosmological constant, the universe evolves towards thermal equilibrium. However, by incorporating a quantum correction, only the cosmological constant can lead to thermal equilibrium. This correction avoids the future singularity that is present when it is not incorporated.

Keywords Entropic · Cosmology · Modified gravity

1 Introduction

In order to provide answers for cosmic evolution problems in early and late stages of the universe, several classical formalisms have been developed from Einstein theory and modified schemes thereof. Although some of these appear to be good candidates for explaining both current accelerated expansion (the cosmological constant or dark energy models, for instance) and the early universe (the R^2-model according to Planck 2013 results. XXII, see Planck Collaboration 2013), the observational data do not appear to show many signs of the thermal equilibrium between different cosmic species (cosmic fluids) or the thermal equilibrium between the bulk and the boundary of the universe throughout its evolution. This last fact is an important point to consider from a theoretical point of view and so we will inspect a formalism in which first, holographic and entropic ideas are incorporated, and second, emphasis will be placed on a nonconservation equation of state for the dominant cosmic fluid in each stage of cosmic evolution.

So, the holographic principle (Bousso 2002) is considered along with the entropic idea (Barrow 1999a,1999b; Pan and Wang 2011), i.e., temperature and entropy associated with the cosmological boundary. This consideration results in changes in the usual Friedmann equations and allows for more apparent thermodynamics effects. In this philosophy, two scopes can be visualized: the first establishes that space is generated from thermodynamics on a holographic screen. Here the information is the main ingredient for deriving gravity and the input is the holographic principle: the information is encoded at the boundary. The second scheme is based on the incorporation of surface terms in the gravitational action, but gravity is still a fundamental theory. Both schemes lead to modifications in the usual Friedmann equations of the standard Friedmann-Lemaître-Robertson-Walker (FLRW) cosmology. Whether or not these approaches provide new understanding of gravity is a controversial issue (Kobakhidze 2011; Li and Pang 2010; Gao 2011; Chichian et al. 2011).

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