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ORIGINAL ARTICLE

An expanding Universe with constant pressure and no cosmological constant

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Abstract Thanks to its fitting triumph, the ΛCDM paradigm is assumed to be the most powerful model, for describing the Universe dynamics, over much the myriad of cosmological models. Unfortunately, the quest of a self-consistent model remains not well explained, because it is not clear how to solve the problems of fine-tuning and coincidence, afflicting the ΛCDM framework; as a matter of fact, these theoretical drawbacks do not allow to consider the ΛCDM model, as the final picture of the modern cosmological scenario. Here, we show that the simplest model, which provides a constant equation of state for the pressure, leads to a generalization of ΛCDM, reducing to it in a particular case. Moreover, we highlight the physical mechanisms of this model, describing the thermodynamical reasons why a constant pressure should be negative in an expanding Universe. In addition, we fit the free parameters of our model by minimizing the chi square through the age differential method, involving a direct measurement of H.

Keywords Cosmological constant · Dark energy · Equation of state of the Universe

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1 Introduction

Recent observations have shown that the dynamics of the Universe is characterized by a late acceleration, as pointed out firstly in Riess et al. (1998), Perlmutter et al. (1999).

The physical mechanism behind the acceleration seems to be lacking of some ingredient in the framework of Einstein's theory, because the theoretical predictions of General Relativity describe a decelerated scenario, if one considers as the gravitational source the matter field only. Because this forecast is obviously totally in contrast with what is observed, theorists have mostly investigated the problem of understanding how the acceleration was born (see, for instance, Sheykhi and Bagheri 2011; de la Macorra 2011; Akarsu and Dereli 2011; Saha et al. 2011) and, although the final paradigm has not been developed, the simplest and the most accepted model remains the so-called ΛCDM (Copeland et al. 2006). The underlying philosophy behind this approach lies on the assumption that, together with a matter field, the energy-momentum tensor is composed by an additional part, due to the cosmological constant. Moreover, by definition, the cosmological counterpart leads to a constant energy density term, with a consequent constant equation of state (EoS) for the pressure.

The ΛCDM paradigm pretends to explain the dynamics of the Universe without any other foreknowledge. Unfortunately, despite its excellent experimental success (Tegmark et al. 2004), the model is afflicted by two relevant shortcomings. The first one is due to the interpretation given to the cosmological constant Λ in Quantum Field Theory (QFT). Indeed, if a positive cosmological constant exists, its nature is intertwined with the vacuum energy term in QFT (Weinberg 1989). Unfortunately, the predicted value is different from the observed one by 120 orders of magnitude; this misleading issue is considered as one of the worst conceptual