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ORIGINAL ARTICLE

Thermodynamics in non-linear electrodynamics with anisotropic universe

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Abstract In this work, we consider the framework of non-linear electrodynamics in Bianchi type I universe model composed of matter and electromagnetic field. We deal with electric and magnetic universe separately. In this scenario, we calculate the electric and magnetic fields and their corresponding matter densities using two particular types of interaction terms. We also check the validity of generalized second law of thermodynamics in both universe models enclosed by apparent horizon. It turns out that this law holds on the apparent horizon for a particular range depending upon the parameters. Finally, we discuss the deceleration and statefinder parameters to check the viability of these models.

Keywords Thermodynamics · Non-linear electrodynamics · Statefinder parameters

1 Introduction

Recent data from type Ia supernova (Riess et al. 1998; Perlmutter et al. 1998, 1999) probed that our universe is composed of two major dark components: a pressureless matter dubbed as dark matter (DM) and an unusual form of energy known as dark energy (DE) (it has sufficient large negative pressure driving the present accelerating phase of the universe). These constituents are present in the universe with specific ratio 76 : 24. The cosmological constant Λ, satisfying the equation of state (EoS) $p_\Lambda = -\rho_\Lambda$, is the simplest and economic characterization for this anti-gravity force. A class of scalar field models (quintessence, K-essence, tachyon, phantom, quintom (Chiba et al. 2000; Padmanabhan 2008)) and interacting DE models (Chaplygin gas (CG), holographic DE (HDE), Ricci DE (RDE) (Nojiri and Odintsov 2003; Gao et al. 2009)) has been proposed to understand its nature. Unfortunately, these models fail to explain its origin and nature in a comprehensive way.

The history of expanding universe reveals that there exist two types of singularities: the big bang singularity before inflation at early stage and big crunch singularity at the end stage of the expanding universe. Hawking and Penrose (1970) presented some singularity theorems about the existence of singularities in the past and future universe. There are number of proposals to obtain the non-singular universe such as a creation field cosmology (Narlikar and Padmanabhan 1985), quadratic Lagrangians (Mukhanov and Brandenberger 1992; Brandenberger et al. 1993), cosmological constant (de Sitter 1917), non-minimal coupling (Novello and Salim 1979), vacuum polarization (Berej and Matyjasek 2002) and non-equilibrium thermodynamics (Salim and de Olivera 1988). The occurrence of the cosmological singularity in the initial universe and the evolution of the scale factor are two basic problems that lead to develop non-linear Lagrangian.

De Lorenci et al. (2002) gave the idea of non-linear extension of the standard Maxwell electromagnetic Lagrangian and showed that these terms play an important role in the removal of primordial and future singularity. The Lagrangian along with non-linear terms provide large negative pressure at very early stage which leads to accelerating universe for late times. For this purpose, the Maxwell equations are modified in early universe by keeping large electromagnetic field. The physical laws are mathematically inconsistent and the standard models become physically incomplete at sin-

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