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ORIGINAL ARTICLE

Thermodynamics and cosmic expansion in magnetized chameleonic Brans-Dicke universe

M. Sharif · Saira Waheed

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Abstract This study is emphasized to explore the validity of generalized second law of thermodynamics in the context of non-linear electrodynamics (magnetic effects only) with Brans-Dicke chameleon scalar field as dark energy candidate. For this purpose, we consider FRW universe model with perfect fluid matter contents. We evaluate matter energy density and magnetic field by taking interacting and non-interacting cases of magnetic field and matter as well as the power law ansatz for scalar field. The validity of this law is discussed by using the first law of thermodynamics for four different horizons: Hubble, apparent, particle and event horizons. We conclude that this law may hold for all four horizons with small positive red-shift when chameleon mechanism is taken into account in Brans-Dicke gravity. Finally, we investigate the statefinders in order to check the viability of the model.

Keywords Scalar field · Thermodynamical laws · Magnetic field · Cosmic expansion

1 Introduction

Latest observations from numerous astronomical experiments including Supernova (Ia), WMAP, SDSS, galactic cluster emission of X-rays etc. indicate the speedy cosmic expansion in current era (Perlmutter et al. 1998; Riess et al. 1998; Spergel et al. 2003; Tegmark et al. 2004). This rapid cosmic expansion is propelled by some unusual type of matter with hidden nature dominating in the universe composition. A successful description of its hidden nature has become an open gainsay for researchers, consequently, several models have been suggested in this context. Different dark energy (DE) proposals (available in literature) can be categorized on the basis of used terminology in the following two ways: (1) enhancing the ordinary matter contents by the inclusion of some extra functions like cosmological constant, Chaplygin gas (Bento et al. 2002; Caldwell et al. 1998; Chimento 2004) etc. (2) extending the Einstein's original gravitational framework by the inclusion of some additional terms in the action like higher-order curvature terms, scalar or torsion fields (Lobo 2008; Flanagan 2004) etc.

In cosmological scenario, scalar-tensor gravity is a practicable effort involving scalar and tensor fields as basic ingredients for the description of gravitational effects. In order to have a successful explanation of various cosmological mysteries, Brans and Dicke, Nordtvedt, Wagoner, Saez and Ballester formulated some scalar-tensor theories evoking the interest of the researchers (Dirac 1938; Brans and Dicke 1961; Nordtvedt 1970; Saez and Ballester 1985). In this arena, Brans-Dicke (BD) gravity is a promising framework with many interesting particulars like time dependent gravitational constant, direct interaction of geometry with scalar field as well as consistency with various physical laws (Weinberg 1972). The astrophysical bounds coming from the solar-system experiments suggested the BD coupling strength to satisfy the constraint $\omega \geq 40{,}000$ only for the massless scalar field (Bertotti et al. 2003; Felice et al. 2006; Perivolaropoulos 2010). A scalar field with environment dependent mass density is referred to as chameleon field (Khoury and Weltman 2004a, 2004b). Another interesting version of BD gravity can be found by introducing a non-minimal interaction of scalar field with ge-

M. Sharif (✉) · S. Waheed
Department of Mathematics, University of the Punjab, Quaid-e-Azam Campus, Lahore 54590, Pakistan
e-mail: msharif.math@pu.edu.pk

S. Waheed
e-mail: smathematics@hotmail.com