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ORIGINAL ARTICLE

Kaluza-Klein dark energy cosmological model in scale Co-variant Theory of Gravitation

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Abstract A five dimensional Kaluza-Klein dark energy model with variable EoS parameter is investigated in the scale co-variant theory of gravitation proposed by Canuto et al. (in Phys. Rev. 39:429, 1977) in a five dimensional Kaluza-Klein space-time in the presence of perfect fluid source. Using the special law of variation for Hubble's parameter proposed by Berman (in Nuovo Cimento B 74:183, 1983), we have obtained a determinate solution which represents a dark energy cosmological model in the theory. We have also used the result that the scalar expansion is proportional to shear scalar of the space-time. It is observed that the EoS parameter, skewness parameter in the model turn out to be functions of cosmic time. Some physical and Kinematical properties of the model are also discussed.

Keywords Dark energy · Kaluza-Klein model · Scale co-variant theory

1 Introduction

Several cosmological observations indicate that the observable universe is undergoing a phase of accelerated expansion (Riess et al. 1998; Perlmutter et al. 1999; Bennet et al. 2003). There are two major approaches to address the problem of cosmic acceleration either introducing a dark energy component in the universe, study its dynamics interpreting it as a failure of general relativity or consider modifying general relativity theory termed as 'modified gravity approach'. Although both approaches have novel features, with some deep theoretical problems we focus here only on the modified gravity approach. One of the earlier modifications of Einstein's general relativity termed as Brans and Dicke (1961) gravity in which besides a gravitational part, a dynamical scalar field is introduced to account for variable gravitational constant. This modification has been introduced due to lack of compatibility of Einstein's theory with the Mach's principle. Later Saez and Ballester (1986) introduced a scalar tensor theory of gravity in which metric is coupled to a scalar field. Here the strength of the coupling between the gravity and the field is governed by a parameter w. With this modification, they were able to solve 'a missing mass problem'. Another modification of Einstein's theory is the scale covariant of gravitation proposed by Canuto et al. (1977). This theory also admits a variable G and is a viable alternative to general relativity (Wesson 1980; Will 1984). In the scale-covariant theory Einstein's field equations are valid in gravitational units where as physical quantities are measured in atomic units. The metric tensors in the two systems of units are related by a conformal transformation given by the equation

$$\overline{g_{ij}} = \phi^2(x^k) g_{ij} \tag{1}$$

where in Latin indices take values $1, 2, 3, 4$ bars denote gravitational units and unbar denotes atomic quantities. The gauge function $\phi (0 < \phi < \infty)$ in its most general formulation is a function of all space-time coordinates. Thus, using the conformal transformation of the type given by Eq. (1), Canuto et al. (1977) transformed the usual Einstein equa-

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