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ORIGINAL ARTICLE

Some Kaluza-Klein cosmological models in $f(R,T)$ gravity theory

Shri Ram · Priyanka

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Abstract Algorithms are derived for constructing five dimensional Kaluza-Klein cosmological space-times in the presence of a perfect fluid source in the framework of $f(R,T)$ gravity theory proposed by Harko et al. (Phys. Rev. D 84:024020, 2011). Starting from the solution of Reddy et al. (Int. J. Theor. Phys 51:3222-3227, 2012b) some classes of new solutions are generated which correspond to accelerating models of the Universe. The physical and kinematical behaviors of the models are studied.

Keywords Kaluza-Klein theory · Cosmological models · $f(R,T)$ gravity

1 Introduction

It is widely believed that a consistent unification of all fundamental forces in nature would be possible within the space-time with an extra dimension beyond those four observed so for. Higher dimensional theories of Kaluza-Klein (KK)-type have been considered to study some aspects of early Universe (Chodos and Detweiler 1980; Freund 1982; Sahdev 1984; Shafi and Wetterich 1984). In such KK theory it has been assumed that the extra dimension form a compact manifold of very small size undetectable at present day energies. Thus, in such higher dimensional theories one would expect that at the grand unification scale the word manifold has more than one dimension. The Kaluza-Klein theory is attractive because it has an elegant presentation interms of geometry. In certain sense, it looks just like ordinary gravity in free space, except that it is phrased in five dimensions instead of four. Kaluza et al. (1921) and Klein (1926a, 1926b) attempted to unify gravitation and electromagnetism. An interesting possibility known as the "cosmological reduction process" is based on the idea that at very early stage all dimensions in the universe are comparable. Later, the scale of the extra dimension becomes so small as to be unobservable by experiencing contraction. Such cosmological models were investigated by Forgacs and Horvath (1979), Guth (1981), Alvarez and Gavela (1983) observed that during the contraction process extra dimensions produce large amount of entropy, which provides an alternative resolution to the flatness and horizon problem, as compared to usual inflationary scenario. Gross and Perry (1983) have shown that the five-dimensional Kaluza-Klein theory of unified gravity and electromagnetism admits soliton solutions. Further, they explained the inequality of the gravitational and inertial masses due to the violation of Birkoff's theorem in Kaluza-Klein theories, which is consistent with the principle of equivalence. Appelquist and Chodos (1983), Randjbar-Daemi et al. (1984) claimed through solution of the field equations that there is an expansion of four-dimensional space-time while fifth dimension contracts to the unobservable Plankian length scale or remains constant as needed for the real universe.

Recent observations of type Ia Supernovae (SNe Ia) at red shift $z < 1$ provide startling and puzzling evidence that the expansion of the universe at the present time appears to be accelerating, behavior attributed to "Dark Energy" with negative pressure. These observations (Chaterrjee 1992; Frieman and Waga 1998; Carlberg et al. 1996; Ozer and Thha 1987; Freese et al. 1987; Carvalho et al. 1992; Silveira and Waga 1988; Ratra and Peebles 1988), strongly favor a sig-

S. Ram (✉) · Priyanka
Department of Applied Mathematics, Indian Institute of Technology, Banaras Hindu University, Varanasi 221 005, India
e-mail: srmathitbhu@rediffmail.com

Priyanka
e-mail: kyadav910@gmail.com