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ORIGINAL ARTICLE

Bianchi type-III bulk viscous string cosmological model in Brans-Dicke theory of gravitation

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Abstract A spatially homogeneous and anisotropic Bianchi type-III space-time is considered in the framework of a scalar-tensor theory of gravitation proposed by Brans and Dicke (Phys. Rev. 124:925, 1961) in the presence of bulk viscous fluid containing one dimensional cosmic strings. We have found a determinate solution of the field equations using the plausible physical conditions (i) a barotropic equation state for the pressure and density, (ii) special law of variation for Hubble's parameter proposed by Berman (Nuovo Cimento B74:182, 1983), (iii) shear scalar is proportional to scalar expansion and (iv) the trace of the energy tensor of the fluid vanishes. We have also assumed that bulk viscous pressure is proportional to energy density. Some physical and kinematical properties of the model are, also, discussed.

Keywords Bianchi III model · Brans-Dicke theory · String model · Bulk viscous model

1 Introduction

Brans-Dicke (BD) theory of gravity (1961) is one of the most important scalar-tensor theories of gravity due to its vast cosmological implications. (Bertolami and Martins 2000; Banerjee and Pavon 2001).

The latest inflationary models (Mathiazhagan and Johri 1984), possible "graceful exit" problem (Pimental 1997) and extended chaotic inflations (Linde 1990) are based on BD scalar-tensor theory. This theory introduces a scalar field ϕ which has the dimension of the inverse of gravitational constant and which interacts equally with all forms of matter. BD field equations for combined scalar and tensor fields are

$$R_{ij} - \frac{1}{2}g_{ij}R = -8\pi\phi^{-1}T_{ij} - \omega\phi^{-2}(\phi_{,i}\phi_{,j} - \frac{1}{2}g_{ij}\phi_{,k}\phi^{,k}) - \phi^{-1}(\phi_{i;j} - g_{ij}\phi^{;k}_{;k}) \quad (1)$$

$$\phi^{;k}_{;k} = 8\pi(3+2\omega)^{-1}\mathrm{T} \quad (2)$$

where ϕ is the scalar field, ω is the dimensionless constant (this should be constrained as $\geq$40,000 for its consistency with solar system bounds; Bertotti et al. 2003; Felice et al. 2006), T_{ij} is the energy momentum tensor R_{ij} and R have their usual meaning.

Also,

$$T^{ij}_{;j} = 0 \quad (3)$$

is a consequence of the field equations (1) and (2). Here a semicolon indicates covariant derivative and comma denotes ordinary derivative with respect to x^k.

Several aspects of BD theory have been investigated by many authors. Singh and Rai (1983) have presented a comprehensive review of the work done in BD theory. The study of cosmological models in scalar-tensor theories of gravitation is significant in view of the fact that scalar fields play a vital role in inflationary cosmology. In particular, spatially homogeneous and anisotropic Bianchi type cosmological models are important to study the possible effects of anisotropy in the early universe (Chimento et al. 1997). Johri

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