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ORIGINAL ARTICLE

Bianchi type-V bulk viscous string cosmological model in Saez-Ballester scalar-tensor theory of gravitation

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Abstract In this paper, a spatially homogeneous and anisotropic Bianchi type-V cosmological model is considered in a scalar-tensor theory of gravitation proposed by Saez and Ballester (in Phys. Lett. A 113:467, 1986) when the source for energy momentum tensor is a bulk viscous fluid containing one dimensional cosmic strings. The field equations being highly non-linear, we obtain a determinate solution using the plausible physical conditions (i) the scalar of expansion of the space-time is proportional to shear scalar (ii) the barotropic equation of state for pressure and density and (iii) the bulk viscous pressure is proportional to the energy density. It is interesting to observe that cosmic strings do not survive in this model. Some physical and kinematical properties of the model are also discussed.

Keywords String model · Bianchi-V model · Scalar-tensor theory · Bulk viscous model

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1 Introduction

In recent years there has been a lot of interest in constructing cosmological models in general relativity and in alternative theories of gravitation to study the structure formation and early stages of evolution of the universe. Among the alternative theories of gravity Brans and Dicke (1961) and Saez and Ballester (1986) scalar-tensor theories of gravitation are quite important. Brans-Dicke theory includes a long range scalar field interacting equally with all forms of matter (with the exception of electromagnetism) while in Saez-Ballester scalar-tensor theory the metric is coupled with a dimensionless scalar field in a simple manner. This coupling gives a satisfactory description of weak fields. In spite of the dimensionless character of the scalar field an antigravity regime appears. This theory also suggests a possible way to solve the” missing” matter problem in non-flat FRW cosmologies.

The field equations given by Saez and Ballester (1986) for the combined scalar and tensor fields are

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

and the scalar field ϕ satisfies the equation

$$2\phi^n\phi^{,i}_{;i} + n\phi^{n-1}\phi_{,k}\phi^{,k} = 0 \quad (2)$$

Also

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

Here ω and n are constants, T_{ij} is the energy momentum tensor of the matter, R_{ij} is the Ricci tensor, R is the Ricci scalar and comma and semicolon denote partial and covariant derivatives respectively.

Scalar-tensor theories have many interesting properties and have been extensively discussed in literature. The most