LRS Bianchi type-II Universe with cosmic strings and bulk viscosity in a scalar tensor theory of gravitation

R.L. Naidu · B. Satyanarayana · D.R.K. Reddy

Abstract A spatially homogeneous and anisotropic Bianchi type-II cosmological model is obtained in a scalar tensor theory of gravitation proposed by Saez and Ballester (Phys. Lett. A 130:467, 1986) when the source for energy momentum tensor is a bulk viscous fluid containing one-dimensional cosmic strings. Some physical and kinematical properties of the model are also discussed.

Keywords Viscosity · Bianchi type-II universe · Cosmic strings · Scalar tensor theory

1 Introduction

In recent years there has been lot of interest in scalar tensor theories of gravitation which are considered to be essential to describe the gravitational interactions near the planks scale, string theory, extended inflation and many higher order theories imply scalar field. Brans and Dicke (1961) Scalar tensor theory of gravitation introduces an addition scalar field ϕ besides the metric tensor g_{ij} and a dimensionless coupling constant "ω". This theory goes to general relativity for large values of the coupling constant $\omega > 500$.

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Saez and Ballester (1986) formulated a scalar—tensor theory of gravitation in which the metric is coupled with a dimensionless scalar field in a simple manner. This coupling gives a satisfactory description of the weak fields. In spite of the dimensionless character of the scalar field an anti gravity regime appears. This theory also suggests a possible way to solve missing matter problem in non-flat FRW cosmologies.

The study of string theory has received considerable attention in cosmology. String cosmological models are attracting more and more attention of research workers since cosmic strings are important in the early stages of evaluation of the universe before the practical creation. Spontaneous symmetry breaking in elementary practical physics has given rise to topological defects known as cosmic strings. The gravitational effects of such objects are of practical interest since they are considered as possible seeds for galaxy formation and gravitational lenses. Letelier (1983), Krori et al. (1990), Mahanta and Mukherjee (2001), Battacharjee and Baruah (2001) have studied several aspects of string cosmological models in general relativity.

Cosmological models with bulk-viscosity are important since bulk-viscosity has a greater role in getting accelerated expansion of the universe popularly known as inflationary phase. Bulk-viscous cosmological models in general relativity have been discussed by several authors (Barrow 1986; Padmanabhan and Chitre 1987; Pavon et al. 1991; Martens 1995; Lima et al. 1993; Roy and Tiwari 1983; Mohanty and Pattanaik 1991; Mohanty and Pradhan 1992; Singh and Shriram 1996; Singh 2005). Recently Wang (2004, 2005, 2006), Bali and Dave (2002), Bali and Pradhan (2007), Tripathy et al. (2009, 2010) have studied the Bianchi type cosmological models in the presence of cosmic strings and bulk viscosity.

Bulk viscous cosmological models have been discussed in Brans–Diche theory of gravitation by Johri and Sudharsan