Astrophys Space Sci (2013) 348:559–564
DOI 10.1007/s10509-013-1579-y

ORIGINAL ARTICLE

# Stability of viscous fluid in Bianchi type-VI model with cosmological constant

**J. Sadeghi · Ali R. Amani · N. Tahmasbi**

Received: 28 May 2013 / Accepted: 18 July 2013 / Published online: 15 August 2013


**Abstract** In this paper, we investigate Bianchi type-VI cosmological model for the universe filled with dark energy and viscous fluid in the presence of cosmological constant. Also, we show accelerating expansion of the universe by drawing volume scale, pressure and energy density versus cosmic time. In order to solve the Einstein's field equations, we assume the expansion scalar is proportional to a component of the shear tensor. Therefore, we obtain the directional scale factors and show the EOS parameter crosses over phantom divided-line.

**Keywords** Dark energy · Bianchi type-VI model · Viscous fluid · Cosmological constant

## 1 Introduction

Recent cosmological observations strongly indicate that our universe has a accelerating expansion (Perlmutter et al. 1999; Riess et al. 1998). The expansion of the universe means increasing the metric distance between objects with respect to time. The accelerating expansion with negative pressure, called dark energy (DE). As we know, understanding of dark energy is greatest challenge of modern theoretical cosmology. In the standard model of cosmology, it is estimated that 73 percent of the total mass-energy of the universe occupy with dark energy. To explain mysterious dark energy, a variety of the theoretical models have been proposed in the literature such as vacuum energy ($\omega = -1$), phantom ($\omega < -1$), quintessence ($\omega > -1$), quintom (that is the combination of phantom and quintessence), Chaplygin gas, tachyon and etc. Recently, there has been increasing interest for study Bianchi models (Amirhashchi et al. 2011a, 2011b; Pradhan et al. 2011a, 2011b; Saha 2004; Saha et al. 2012; Socorro and Medina 2000; Weaver 2000; Yadav and Saha 2012). On the other hand in cosmology, Bianchi models describe a model of the universe which is homogeneous but not necessarily isotropic. we note here the observation of anisotropies in the Cosmic Microwave Background (CMB) radiation and large scale wave-patterns are responsible for study anisotropic space-time. To consider more realistic models, we added the shear and bulk viscosity into fluid. In cosmic physics, the cosmological constant play important role in expansion universe.

Bianchi type I universe with viscous fluid in the presence of $\Lambda$ term was investigated in Saha and Rikhvitsky (2006). The effect of bulk viscosity, with a time varying bulk viscous coefficient and nonlinear spinor fields in BI universe filled with viscous fluid was studied by Desikan (2000) and Saha (2005). The string-driven inflationary universe in terms of effective bulk viscosity coefficient was achieved by Barrow (1988). The density-dependent viscosity coefficient, Friedmann cosmology with a generalized equation of state and bulk viscosity have shown in Li and Barrow (2009) and Xin-He et al. (2007), also Bianchi type $VI_0$ cosmological models with viscous fluid presented in Patel and Koppar (1991). The magnetized Barotropic bulk viscous fluid massive string in Bianchi type $VI_0$ have been studied by Bali et al. (2008a, 2008b). So, all above information give us motivation to investigate the dynamical effects of bulk and

J. Sadeghi (✉) · N. Tahmasbi
Faculty of Basic Sciences, Departments of Physics, Mazandaran University, P.O. Box 47415-416, Babolsar, Iran
e-mail: pouriya@ipm.ir

N. Tahmasbi
e-mail: N.Tahmasbi@stu.umz.ac.ir

A.R. Amani
Faculty of Basic Sciences, Department of Physics, Ayatollah Amoli Branch, Islamic Azad University, P.O. Box 678, Amol, Iran
e-mail: a.r.amani@iauamol.ac.ir