Astrophys Space Sci (2012) 338:179–185
DOI 10.1007/s10509-011-0910-8

ORIGINAL ARTICLE

Bianchi type-I cosmological models for binary mixture of perfect fluid and dark energy

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Received: 1 August 2011 / Accepted: 27 October 2011 / Published online: 12 November 2011

Abstract We consider a self consistent system of Bianchi Type-I cosmology and Binary Mixture of perfect fluid and dark energy. The perfect fluid is taken to be obeying equations of state $p_{PF} = \gamma \rho_{PF}$ with $\gamma \in [0, 1]$. The dark energy is considered to be obeying a quintessence-like equation of state where the dark energy obeys equation of state $p_{DE} = \omega \rho_{DE}$ where $\omega \in [-1, 0]$. Exact solutions to the corresponding Einstein field equations are obtained. Some special cases are discussed and studied. Further more power law models and exponential models are investigated.

Keywords Bianchi type-I · Perfect fluid · Dark energy

1 Introduction

In physical cosmology, astronomy and celestial mechanics, dark energy is a hypothetical form of energy that permeates all of space and tends to increase the rate of expansion of the universe. Dark energy is the most accepted theory to explain recent observations that the universe appears to be expanding at an accelerating rate. In the standard model of cosmology, dark energy currently accounts for 73% of the total mass-energy of the universe. Two proposed forms for dark energy are the cosmological constant, a constant energy density filling space homogeneously, and scalar fields such as quintessence or moduli, dynamic quantities whose energy density can vary in time and space. Contributions from scalar fields that are constant in space are usually also included in the cosmological constant. The cosmological constant is physically equivalent to vacuum energy. Scalar fields which do change in space can be difficult to distinguish from a cosmological constant because the change may be extremely slow. High-precision measurements of the expansion of the universe are required to understand how the expansion rate changes over time. In general relativity, the evolution of the expansion rate is parameterized by the cosmological equation of state (the relationship between temperature, pressure, and combined matter, energy, and vacuum energy density for any region of space). Measuring the equation of state for dark energy is one of the biggest efforts in observational cosmology today. Adding the cosmological constant to cosmology's standard FLRW metric leads to the Lambda-CDM model; this has been referred to as the "standard model" of cosmology because of its precise agreement with observations. Dark energy has been used as a crucial ingredient in a recent attempt to formulate a cyclic. Although the precise nature of the dark energy (DE) is currently unknown, it is felt that DE is non-baryonic in origin (Sahni 2004). It is believed that the dark energy has large negative pressure that leads to accelerated expansion of the universe. The discovery that the expansion of the universe is accelerating (Bahcall et al. 1999) has prompted the search for new types of matter that can behave like a cosmological constant (Cadwell et al. 1998; Zlatev et al. 1999; Sahni and Starobinsky 2000) by combining positive energy density and negative pressure. This type of matter is often called quintessence. In quintessence models of dark energy, the observed acceleration of the scale factor is caused by the potential energy of a dynamical field, referred to as quintessence field. Quintessence differs from the cosmolog-

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