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ORIGINAL ARTICLE

Five-dimensional anti-de Sitter bulk with oscillating Friedmann–Robertson–Walker branes

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Abstract We propose a toy model for the five dimensional warped FRW universe of zero spatial curvature, with a stiff matter source in the bulk, whose scale function corresponds to an oscillating brane, with negative acceleration parameter. By considering the matter in the four-dimensional brane as being composed of two coupled perfect fluids, we discuss the form of the interacting term allowing energy exchange between the two fluids. Finally, special attention is given to three cases related to the chronology of the universe and the corresponding densities and pressures are calculated, pointing out non-trivial contributions coming from the fifth dimension.

Keywords FRW universe · 5D branes · Two-fluid scenario

1 Introduction

The idea that our universe may be a brane embedded in a higher dimensional spacetime has a long history, originating in the pioneering work of Kaluza (1921) and Klein (1926).

Somewhat recently, Randall and Sundrum revisited this concept by defining a five-dimensional Anti-de Sitter bulk, in which gravity only propagates, while standard matter and all interactions are trapped on 4-dimensional slices (Randall and Sundrum 1999). Since than, theories formulated on general manifolds have attracted considerable attention, especially after it has been stated that the extra dimensions might play a special role in various observable phenomena (Rubakov 2001).

Compared to the four-dimensional Minkowskian slices which are well understood, within the first-order formalism inspired from supergravity, for generating solutions (Bazeia et al. 2006; DeWolfe et al. 2000), the bent manifolds are more complicated to work with since one needs to go back to the Einstein's equations and solve them to the minute detail.

Coming from the bulk into the visible brane, it has been shown that spatially homogeneous and isotropic Friedmann–Robertson–Walker (FRW) models, with two-fluid (barotropic and dark energy) sources and a suitable scale factor (Amirhashchi et al. 2011; Saha et al. 2011), can explain the transition from the early decelerating to the recent accelerating phase of the universe, revealed by independent observations of distant supernovae (Perlmutter et al. 1997, 1998, 1999; Riess et al. 1998, 2004). Moreover, measurements of the cosmic microwave background (Caldwell and Doran 2004; Huang et al. 2006) are strongly encouraging the idea that our universe is dominated by a component with negative pressure, known as dark energy.

Once the observational data do not put restrictions on the equation of stat (EOS) for dark energy, it has been proved that, for specific couplings between dark energy and dark matter, it may occur a periodic universe with finite-time cosmological singularities, which finally expands and tends to a Minkowski stage, in the remote future (Timoshkin 2009).

Our toy model is following some previous investigations on an oscillating universe, where we have mainly focused on the quantum treatment based on the Wheeler–DeWitt and stationary Schrödinger equations (Dariescu et al. 2013).

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