

Modified Gravity and Chaplygin Gas Dynamics on a Brane

Kouros Nozari and N. Alipour

Department of Physics, Islamic Azad University, Sari Branch, Sari, Iran
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We study the cosmological dynamics of an extended DGP scenario such that the induced gravity is modified and there is a Chaplygin component on the brane. Our motivation is to study the possible impact of $f(R)$ gravity and Chaplygin behavior on the brane. We explore the cosmological dynamics of this setup in the presence of the Gauss-Bonnet curvature effect. We show that modified gravity has the potential to mimic a Chaplygin gas behavior and effective phantom nature in some subspaces of the model parameter space. This model also provides a natural framework for a smooth crossing of the phantom divide line.

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I. INTRODUCTION

The outcome of the supernova redshift-luminosity distance and also other observational probes, that the universe is undergoing an accelerated phase of expansion, has stimulated a lot of research to explain this unexpected feature. Since the dynamics of the universe is described by the Friedmann equation, which follows from the Einstein field equations in four dimensions, all modifications of the Friedmann equation ultimately affect the Einstein field equations. In terms of the Einstein field equations, $G_{\mu\nu} = \kappa T_{\mu\nu}$, such models are simply modifying the right hand side, including in the stress-energy tensor something more than the usual matter and radiation components. Focusing on the matter sector of the Einstein field equations, a well-studied model introduces into $T_{\mu\nu}$ a dark energy component called the Chaplygin gas (see [1] and references therein). This model is similar to the Dvali, Gabadadze, and Porrati (DGP) model, in the sense that it is also characterized by a cross-over length scale below which the gas behaves as pressureless dust and above which it approaches the behavior of a cosmological constant. This length scale is expected to be of the same order of magnitude as the crossover scale of the DGP model. An accelerating Chaplygin gas combined with the decelerating braneworld DGP model can produce an overall accelerated expansion of the order of magnitude seen [2]. However, both the self-accelerating DGP model in flat space and the standard Chaplygin gas model have problems in fitting the present supernova data.

As a radically different approach, one can also try to leave unchanged the source side, but rather modify the left hand side. In a sense, one is therefore interpreting the cosmic speed up as a first signal of the breakdown of the laws of physics as described by the standard General Relativity (GR). Since this theory has been experimentally tested only up to the Solar System scale, there is no a priori theoretical motivation to extend its validity