Astrophys Space Sci (2012) 338:327–332
DOI 10.1007/s10509-011-0934-0

ORIGINAL ARTICLE

Energy conditions in $f(G)$ modified gravity with non-minimal coupling to matter

A. Banijamali · B. Fazlpour · M.R. Setare

Received: 29 September 2011 / Accepted: 14 November 2011 / Published online: 1 December 2011

Abstract In this paper we study a model of modified gravity with non-minimal coupling between a general function of the Gauss-Bonnet invariant, $f(G)$, and matter Lagrangian from the point of view of the energy conditions. Such model has been introduced in Nojiri et al. (Phys. Lett. B 651:224, 2007) for description of early inflation and late-time cosmic acceleration. We present the suitable energy conditions for the above mentioned model and then, we use the estimated values of the Hubble, deceleration and jerk parameters to apply the obtained energy conditions to the specific class of modified Gauss-Bonnet models.

Keywords Modified Gauss-Bonnet gravity · Non-minimal coupling · Energy conditions

1 Introduction

Nowadays it is strongly believed that the universe is experiencing an accelerated expansion, and this is supported by many cosmological observations (Perlmutter et al. 1999; Bennett et al. 2003; Tegmark et al. 2004; Allen et al. 2004). This accelerated expansion can be explained in terms of the so called dark energy (for reviews see Copeland et al. 2006; Cai et al. 2010; Li et al. 2011) in the framework of general relativity or by modification of general relativity.

The simplest type of modified gravity models is well known as $f(R)$ gravity where the Ricci scalar in the Einstein-Hilbert action is replaced by a general function of the scalar curvature (see Nojiri and Odintsov 2007, 2008a, 2008b; Sotiriou and Faraoni 2010; Lobo 2008; Capozziello and Francaviglia 2008 for reviews).

There are also other modified gravity models which are the generalization of $f(R)$ gravity and among them, the modified Gauss-Bonnet (GB) gravity i.e. $f(G)$ gravity, is more interesting (Nojiri and Odintsov 2005; Cognola et al. 2007). The GB combination, G, is a topological invariant in four dimensions, so in order to play some roles in the field equations, one needs either couple GB term to a scalar field like $f(\phi)G$, or choose $f(G)$ gravity where f is an arbitrary function of G.

If we compare $f(G)$ gravity with other theories of modified gravity we find some advantages in the Gauss-Bonnet gravity. For example in the context of $f(G)$ gravity there exists a de-Sitter point that can be used for cosmic acceleration (Nojiri and Odintsov 2005; Cognola et al. 2007; Nojiri et al. 2007, 2008). Note that in $f(G)$ gravity, there are no problems (Nojiri and Odintsov 2005; Cognola et al. 2007) with the Newton law, instabilities and the anti-gravity regime. In comparing with the simple $f(R)$ modified gravity we should mentioned that it is not generally easy to construct viable $f(R)$ models that are consistent with cosmological and local gravity constraints. The main reason for this is that $f(R)$ gravity gives rise to a strong coupling between DE and a non-relativistic matter in the Einstein frame (Amendola et al. 2007). However there is no conformal transformation separating G from scalar field, unlike the $f(R)$ theory to obtain and Einstein frame action with a canonical

A. Banijamali
Department of Basic Sciences, Babol University of Technology, Babol, Iran
e-mail: a.banijamali@nit.ac.ir

B. Fazlpour
Babol Branch, Islamic Azad University, Babol, Iran
e-mail: b.fazlpour@umz.ac.ir

M.R. Setare (✉)
Department of Science, Campus of Bijar, University of Kurdistan, Bijar, Iran
e-mail: rezakord@ipm.ir