



Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb



## Self-interacting scalar field trapped in a DGP brane: The dynamical systems perspective

Israel Quiros<sup>a,\*</sup>, Ricardo García-Salcedo<sup>b</sup>, Tonatihu Matos<sup>c,1</sup>, Claudia Moreno<sup>d,1</sup>

<sup>a</sup> Departamento de Física, Universidad Central de Las Villas, 54830 Santa Clara, Cuba

<sup>b</sup> Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada—Legaria del IPN, México D.F., Mexico

<sup>c</sup> Departamento de Física, Centro de Investigación y de Estudios Avanzados del IPN, A.P. 14-740, 07000 México D.F., Mexico

<sup>d</sup> Departamento de Física y Matemáticas, Centro Universitario de Ciencias Exactas e Ingenierías, Corregidora 500 S.R., Universidad de Guadalajara, 44420 Guadalajara, Jalisco, Mexico

### ARTICLE INFO

#### Article history:

Received 16 April 2008

Received in revised form 7 October 2008

Accepted 3 November 2008

Available online 12 November 2008

Editor: M. Cvetič

#### PACS:

04.20.-q

04.20.Cv

04.20.Jb

04.50.Kd

11.25.-w

11.25.Wx

95.36.+x

98.80.-k

98.80.Bp

98.80.Cq

98.80.Jk

### ABSTRACT

We apply the dynamical systems tools to study the linear dynamics of a self-interacting scalar field trapped on a DGP brane. The simplest kinds of self-interaction potentials are investigated: (a) constant potential, and (b) exponential potential. It is shown that the dynamics of DGP models can be very rich and complex. One of the most interesting results of this study shows that dynamical screening of the scalar field self-interaction potential, occurring within the Minkowski cosmological phase of the DGP model and that mimics 4D phantom behaviour, is an attractor solution for a constant self-interaction potential but not for the exponential one. In the latter case gravitational screening is not even a critical point of the corresponding autonomous system of ordinary differential equations.

© 2008 Elsevier B.V. All rights reserved.

### 1. Introduction

Since the discovery that our universe can be currently undergoing a stage of accelerated expansion [1], many phenomenological models based either on Einstein General Relativity (EGR), or using alternatives like the higher dimensional brane world theories [2], have been invoked (for a recent review on the subject see Ref. [3]). The latter ones, being phenomenological in nature, are inspired by string theory.

One of the brane models that have received most attention in recent years is the so-called Dvali–Gabadadze–Porrati (DGP) brane world [4].<sup>2</sup> This model describes a brane with 4D world-volume,

that is embedded into a flat 5D bulk, and allows for infrared (IR)/large scale modifications of gravitational laws. A distinctive ingredient of the model is the induced Einstein–Hilbert action on the brane, that is responsible for the recovery of 4D Einstein gravity at moderate scales, even if the mechanism of this recovery is rather non-trivial [6]. The acceleration of the expansion at late times is explained here as a consequence of the leakage of gravity into the bulk at large (cosmological) scales, so it is just a 5D geometrical effect, unrelated to any kind of mysterious “dark energy”.

As with many IR modifications of gravity, there are ghosts modes in the spectrum of the theory [7,8].<sup>3</sup> Nevertheless, studying the dynamics of DGP models continues being a very attractive subject of research. It is due, in part, to the very simple geometrical explanation to the “dark energy problem”, and, in part, to the fact that it is one of a very few possible consistent IR modifications of gravity that might be ever found.

\* Corresponding author.

E-mail addresses: israel@uclv.edu.cu (I. Quiros), rigarcias@ipn.mx (R. García-Salcedo), tmatos@fis.cinvestav.mx (T. Matos), claudia.moreno@cucei.udg.mx (C. Moreno).

<sup>1</sup> Part of the Instituto Avanzado de Cosmología (IAC) Collaboration, <http://www.iac.edu.mx/>.

<sup>2</sup> For cosmology of DGP brane worlds see Ref. [5].

<sup>3</sup> In fact there are ghosts only in one of the branches of the DGP model; the so-called “self-accelerating” branch, or self-accelerating cosmological phase [9].