Shaping the chameleon

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I. INTRODUCTION

The source density is $\rho(\mathbf{x})$. Different geometrical shapes of this source (such as ellipses, rectangles, triangles, etc) will yield different gravitational potentials, and will alter how the chameleon scalar responds.

The effective potential for the chameleon is

$$V_{\rm eff} = \frac{\Lambda^5}{\phi} + \frac{\rho(\mathbf{x})}{M}\phi. \tag{1.1}$$

The equations governing the chameleon scalar and gravitational potential are

$$\nabla^2\phi = \frac{\mathrm{d}V_{\rm eff}}{\mathrm{d}\phi}. \tag{1.2a}$$

$$\nabla^2\Phi = -\rho(\mathbf{x})/M_{\rm pl}^2 \tag{1.2b}$$

The force on a test particle, due to the gravitational and chameleon scalars are given by

$$\mathbf{F}_{(\phi)} = -\tfrac{1}{M}\nabla\phi, \qquad \mathbf{F}_{(\Phi)} = -\nabla\Phi. \tag{1.3}$$

The idea is to obtain the source-shape that maximises the force that a test particle will feel, that cannot be explained by forces of a purely gravitational origin.

II. EXPLANATION OF NUMERICAL METHODS

Discretize onto a grid. Using successive over relaxation.

By setting

$$\phi = \sqrt{M\Lambda^5}\,\tilde{\phi}, \tag{2.1}$$

$$\Phi = \frac{M}{M_{\rm Pl}^2}\sqrt{M\Lambda^5}\,\tilde{\Phi}, \tag{2.2}$$

$$x^\mu = \sqrt{M}\left(M\Lambda^5\right)^{1/4}\tilde{x}^\mu, \tag{2.3}$$

the equations become

$$\tilde{\nabla}^2\tilde{\phi} = -\frac{1}{\tilde{\phi}^2} + \rho, \tag{2.4}$$

$$\tilde{\nabla}^2\tilde{\Phi} = -\frac{1}{2}\rho, \tag{2.5}$$

and the force ratio

$$\frac{\left|\mathbf{F}_{(\phi)}\right|}{\left|\mathbf{F}_{(\Phi)}\right|} = \left(\frac{M_{\rm Pl}^2}{M}\right)^2\frac{\left|\tilde{\nabla}\tilde{\phi}\right|}{\left|\tilde{\nabla}\tilde{\Phi}\right|} \tag{2.6}$$

III. RESULTS

IV. DISCUSSION