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ORIGINAL ARTICLE

Satellite motion in a Manev potential with drag

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Abstract In this paper, we consider a satellite orbiting in a Manev gravitational potential under the influence of an atmospheric drag force that varies with the square of velocity. Using an exponential atmosphere that varies with the orbital altitude of the satellite, we examine a circular orbit scenario. In particular, we derive expressions for the change in satellite radial distance as a function of the drag force parameters and obtain numerical results. The Manev potential is an alternative to the Newtonian potential that has a wide variety of applications, in astronomy, astrophysics, space dynamics, classical physics, mechanics, and even atomic physics.

Keywords Manev potential · Aerodynamic drag · Circular orbits

1 Introduction

The Bulgarian physicist Professor Georgi Manev has introduced a classical potential in order to modify the celestial mechanics in accordance with the general-relativistic description: to describe the motion of a particle of mass m in the static field of universal gravitation due to mass M, Manev (1924, 1925, 1930a, 1930b) replaced the mass m with:

$$m = m_0 e^{\left(\frac{GM}{c^2 r}\right)} \tag{1}$$

where m_0 is an invariant and G is the Newton's constant. This led to the following modification of the Newtonís gravitational law takes the form (Hagihara 1972):

$$F_M = -\frac{GMm}{r^2}\left(1 + \frac{6GM}{c^2 r}\right) \tag{2}$$

where m of a particle (satellite in our context), moving at the distance r from a field-generating body (primary) of mass M. Therefore the corrected Newtonian potential becomes:

$$V = -\frac{GMm}{r}\left(1 + \frac{3GM}{c^2 r}\right) \tag{3}$$

where the Manev correction to the Newtonian potential is simply the term:

$$V_M = -\frac{3G^2 M^2 m}{c^2 r^2} \tag{4}$$

as it's given in Hagihara (1972); see also Manev (1924, 1925, 1930a, 1930b) Manev's potential was the candidate in the explanation of the historical anomaly of the Moon's perihelion precession (Manev 1924, 1925, 1930a). Furthermore, one knows that the perihelion advance of the inner planets (especially that of Mercury) could not be entirely explained within the framework of the classical Newtonian law, even resorting to the theory of perturbations. The laws that exist usually answered the question that relates to the perihelion advance, but failed to explain other issues (such as the secular motion of the Moon's perigee). However, the

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