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ORIGINAL ARTICLE

Existence of equilibrium points and their linear stability in the generalized photogravitational Chermnykh-like problem with power-law profile

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Abstract We consider the modified restricted three body problem with power-law density profile of disk, which rotates around the center of mass of the system with perturbed mean motion. Using analytical and numerical methods, we have found equilibrium points and examined their linear stability. We have also found the zero velocity surface for the present model. In addition to five equilibrium points there exists a new equilibrium point on the line joining the two primaries. It is found that L_1 and L_3 are stable for some values of inner and outer radius of the disk while other collinear points are unstable, but L_4 is conditionally stable for mass ratio less than that of Routh's critical value. Lastly, we have studied the effects of radiation pressure, oblateness and mass of the disk on the motion and stability of equilibrium points.

Keywords Photogravitational · Oblateness · RTBP · Chermnykh-like problem

1 Introduction

The problem, after imposing a restriction as one body of the three body problem is of an infinitesimal (negligible) mass and remaining other two are of finite masses, is known as restricted three body problem (RTBP). The governing force of motion of the RTBP is mainly the gravitational forces exerted by the finite masses also known as primaries. In the RTBP if we take bigger primary as a source of radiation, the problem is called photogravitational RTBP which is generalized by taking smaller primary as an oblate spheroid.

The Chermnykh-like problem which was first time studied by Chermnykh (1987), deals the motion of an infinitesimal mass in the orbital plane of a disk which rotates around the center of mass of the primaries with constant angular velocity n. Goździewski (1998) examined the problem in the sense of nonlinear stability of equilibrium points and also obtained the range of parameter for the same.

The Chermnykh-like problem has a number of applications in different areas in celestial mechanics and chemistry, those have been discussed by Goździewski and Maciejewski (1999); Strand and Reinhardt (1979). Also, the importance of the problem have been in the extra solar planetary system as cited by Rivera and Lissauer (2000) and Jiang and Ip (2001).

Further the effect of disk is very helpful in the study of resonance capture of Kuiper Belt Objects (KBOs) as given in Jiang and Yeh (2004). Papadakis (2005) analyzed the equilibrium point and zero velocity curve taking assumptions as constant mass parameter and variable angular velocity parameter. Jiang and Yeh (2006) examined the Chermnykh problem with $\mu = 0.5$ and shown a deviation in the result of classical RTBP; also they have found the new equilibrium points in spite of Lagrangian points. Yeh and Jiang (2006) have found the condition of existence of new equilibrium points analytically and numerically.

Ishwar and Kushvah (2006) examined the linear stability of triangular points with P-R drag. Again Kushvah (2008) examined the stability of collinear points and found them unstable.

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