Paper ID: 7697
student

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1)

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EXTENSION OF LOW THRUST PROPULSION TO THE COPLANAR CIRCULAR RESTRICTED FOUR BODY PROBLEM WITH APPLICATIONS TO FUTURE TROJAN ASTEROIDS MISSIONS

Abstract

The use of continuous low-thrust propulsion in space missions could enable a range of new, potential applications for several fields such as space physics, human exploration, planetary science, asteroid observation and many more. Such a continuous thrust can be applied to force a spacecraft out from a "natural" orbit, into an "artificial" equilibrium point. The potential of low-thrust propulsion for such analysis has so far been confined to include low-thrust propulsion systems in the two and three-body problems.

In this paper the Coplanar Circular Restricted Four Body Problem is considered with the objective of identifying completely new orbits for future mission applications. In this study the position of the third primary is set to correspond to the triangular Lagrangian point of the circular restricted three body problem. A low-thrust, 1000 kg spacecraft that can generate a force of magnitude between 0 and 300 mN is taken. For this low thrust model "artificial equilibrium" solutions are identified that have the potential to be exploited in future science missions.

Results show that, with zero thrust, there are unstable equilibrium points close to the third primary (referred to as an "asteroid" since we set its mass to be much smaller that the other two Primaries). However, artificial equilibrium points, displaced from the natural ones, can be generated with the use of constant low thrust. Furthermore, these points are proved to be stable in certain regions about the asteroid. This is particularly advantageous since it means that it would be possible to maintain these strategic observation points continuously without the need for a feedback control. This implies that these artificial points could be exploited for future mission applications, such as investigation of the Trojan asteroids

Missions to the Jovian Trojans have been recognized as the key to unlock and extend the knowledge of a solar system as a whole.

To this end, the particular case of the Sun-Jupiter-Asteroid-Spacecraft CRFBP is analyzed. In this case the asteroid mass is taken to be small to reflect estimates of asteroid masses predicted to be trapped at these points. Surfaces of artificial equilibrium points are identified, which include displaced orbits above and below the orbital plane of the asteroid. Furthermore, a stability analysis of the artificial equilibrium points reveal a region where they are stable.