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DYNAMICS OF A SPACECRAFT IN THE VICINITY OF BINARY ASTEROIDS

Abstract

There is growing interest in the exploration of asteroids, as they are believed to hold information about the early stages of the Solar System. With several on-going and upcoming dedicated asteroid missions, combined with the fact that a number of asteroids exist in pairs, it is likely that future missions will include exploration of binary asteroid systems. Thus, it is of interest to study the motion of a spacecraft in the vicinity of such systems, which is the purpose of this paper.

The system is modelled as the restricted **full** three-body system. The mass of the third body (the spacecarft) is assumed small enough such that it does not affect the motion of the primary bodies (the binary asteroid system). The shape, size, mass distribution, and rotation of the asteroids are included in the analysis, which leads to a non-uniform, time-varying gravitational field. Using the Lagrangian approach, the equations governing the translational motion of the spacecraft are derived, for prescribed motions of the asteroid pair. In the general case, the asteroids are arbitrarily shaped, moving in perturbed elliptic orbits around the system's barycentre. The resulting equations of motion are nonlinear and coupled, and must therefore be solved numerically. This paper presents numerically computed trajectories for sample cases. Examples include systems with ellipsoidal, pear-shaped, or peanut-shaped asteroids.

In the special case where the primary bodies move in near-circular orbits, analytical results can be obtained. As expected, five quasi-equilibrium points exist, similar to the Lagrangian points in the classical three-body problem with point-masses. The location of these Lagrangian-like points varies according to the asphericity of the asteroids. Surprisingly, in some cases with highly aspherical asteroids, additional equilibrium points can be found close to the surface of one or both of the primary bodies. The stability of each equilibrium point is evaluated.

By considering approximate solutions, the motion of the spacecraft near a quasi-equilibrium point is studied. A category of solutions are bounded orbits near a collinear point, similar to the Lissajous orbits in the classical problem. However, perturbations due to asphericity of the asteroids grow over time, leading to unstable orbits.