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Author: Mr. Dante Bolatti
Ryerson University, Canada

Dr. Anton de Ruiter
Ryerson University, Canada

SPACECRAFT ATTITUDE IMPACT ON ORBITAL TRAJECTORIES IN ASTEROID MISSIONS

Abstract

The exploration of asteroids has received increased interest in the past decade. Several missions have been planned to these small bodies, requiring close proximity operations, and landing on their surface for sampling purposes. This presents several challenges for the spacecraft's Attitude and Orbital Control System, mainly due to the small body highly irregular gravitational field, and solar perturbations. Additionally, the coupling between the orbital and attitude motions of the spacecraft caused by the spacecraft's size being comparable to the asteroid is no longer negligible. Under these circumstances, the spacecraft can no longer be modeled as a point-mass, and instead it should be studied as a rigid body, considering the orbital and attitude motions coupled. This paper presents a study of the coupled motion of several spacecrafts with varying size in close proximity to three different asteroids (216 Kleopatra, 433 Eros, and 4769 Castalia), focusing on how the spacecraft attitude motion affects its orbital path. It is demonstrated that for close proximity operations, altering the attitude has a large impact on the orbital dynamics, therefore perturbing the spacecraft trajectory significantly. In contrast to other studies, where the small body is modeled as an oblate spheroid or ellipsoid, in this case the asteroid is modeled as a constant density polyhedron, with point-masses distributed in its interior. This allows to capture higher order coupling terms in the force and torque expressions with high resolution, allowing us to account for the orbit-attitude coupling in the rigid body spacecraft dynamics. The perturbations due to solar gravitation, and solar radiation pressure (using a multi-plate model) are considered; as well as the rotation of the asteroid around its largest inertia axis and its orbital motion about the Sun. Numerical propagations of the spacecraft dynamics are performed with a high order numerical integrator, showing how the spacecraft attitude impacts the orbital dynamics for different scenarios. We conclude the paper providing guidelines on how to select the spacecraft attitude for certain orbits about asteroids.