Paper ID: 25514
student

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (2) (2)

Author: Dr. Daniel Garcia Yarnoz
Advanced Space Concept Laboratory, University of Strathclyde, United Kingdom

Prof. Colin R. McInnes
University of Strathclyde, United Kingdom

COUPLED ORBIT-ATTITUDE DYNAMICS OF A CAPTURED ASTEROID DURING FLYBYS

Abstract

The recent interest in the capture of asteroids for scientific purposes or exploitation has generated a series of proposals for asteroid retrieval missions to various target orbits. A few of these proposals utilise swing-bys of the Moon and/or Earth to reduce the infinite velocity and the associated insertion burns into the final capture orbit.

Given the large mass and inertia of asteroids, and the usually irregular shape of the smallest bodies in the NEO family, which represent the best candidates for capture with current technology, a close swing-by of a massive body will induce large variations in the rotational state and possibly the structure of the asteroid.

In order to study the effect of the coupling between attitude and orbit dynamics for this particular case, three simple models have been implemented to provide insight into the rotational state upheaval and the chance of break-up of the minor body during the close approach:

1. An equal mass dumbbell of a fixed length: as the simplest of models it already shows the large dependence of the rotational state on the conditions at pericentre of the flyby,
2. An equal mass contact binary: with gravitational attraction between the two spheres conforming the asteroid, no sliding between boulders, and the possibility of separation when the rotation increases,
3. A circular orbit binary: with two small asteroids with common gravitational attraction, with a mass split of 60/40, and initially following circular orbits around the baricentre.

The orbit and range of rotational speeds of asteroids 2004 MN4 (Apophis) and 2006 RH120 are selected as the test cases for these three simple models. Their infinite velocity is selected as that of their close approaches to Earth on years 2029 and 2028 respectively. Their size, shape and structure are however modified to match the assumptions of the different models. The evolution of the rotational state and structure of the binaries is studied for the hypothetical cases of a single lunar swing-by, a single Earth swing-by, and a double Moon-Earth swing-by prior to capture. The final conditions are shown to be highly dependent on the initial rotational state, the B-plane parameter or distance to the swing-by body, and, most importantly, the relative attitude of the asteroid to the local vertical at pericentre.