Paper ID: 33922
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Orbital Dynamics (1) (6)

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DYNAMICS OF SPACECRAFT ORBITAL MOTION AROUND ASTEROID APOPHIS

Abstract

Some space missions to send a spacecraft to an orbit around an asteroid or cometary nucleus have been realized and are currently being prepared or proposed. In frame of a study of a possible mission to "dangerous" asteroid Apophis, the orbital motion of a spacecraft near the asteroid is investigated in this paper. The characteristics of the short-term movement of the main spacecraft and long-term movement of the mini-satellite (probe) around the asteroid are studied by numerical integrations of equations of spacecraft motion relative to Apophis, taking into account three perturbations: the gravitational effects of far celestial bodies (Sun, Earth, Moon, Venus, and Jupiter), non-spherical structure of Apophis and solar radiation pressure (SRP). The effects of these perturbations acting on the spacecraft trajectory are studied in isolation at first, and the joint effects of these forces are also investigated. The analysis shows that the main influence on spacecraft motion around Apophis is usually given by perturbations from non-spherical structure of the asteroid and SRP. The effect of SPR increases with the raise of initial orbital radius, while the effects of central gravity and non-sphericity decrease. Specifically, we study a class of orbits that are stable against SRP perturbations over long time spans. Perturbations from celestial bodies are usually small, they become visible only on close approach of Apophis with the Earth in 2029. The joint effects of the three perturbations can disturb the stability of the orbit in a short period of time. The main result of the analysis performed is that it is possible to choose the orbit of the main SC (with initial radius of about 500 m) and the orbit of the mini-probe (with initial radius of about 1500 m) for which their motions will be stable long enough - during about five weeks for the main SC and during about 9 years (from 2020 till approach to the Earth in 2029) for mini-probe.