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MULTIPLE–SPACECRAFT TRANSFERS TO SUN–EARTH DISTANT RETROGRADE ORBITS FOR ASTEROID DETECTION MISSIONS

Abstract

The international interest towards Near Earth Objects is exponentially growing because of the awareness of the danger some asteroids or comets pose to the Earth. If a Tunguska-class or smaller Potentially Hazardous Asteroid (PHA) approaches the Earth from the Sun direction, its detection from ground is very difficult or even impossible.

In a previous work, the feasibility of a spacecraft constellation for PHAs detection from a family of Distant Retrograde Orbits (DROs) in the Sun–Earth system was demonstrated. DROs extend beyond the Earth–L1 distance; therefore, they can be selected as operational orbits for space observation of PHAs. In particular, since part of the orbit is spent in between the Earth and the Sun, spacecraft carrying visible band telescopes can cover a region of space that is usually forbidden using ground–based telescopes to monitor PHAs that may intersect the Earth from the Sun–Earth direction.

Initially, the complete map of periodic orbits is built. Four families of simple periodic orbits – named a, c, f (the DROs) and g – around the Earth and the L1 and L2 libration points are studied. Differential correction, coupled with numerical continuation, is employed to refine the orbits in the Sun–Earth planar Circular Restricted Three–Body Problem (CR3BP).

Then, the transfers to DROs are designed, again exploiting the dynamics of the CR3BP. Different options of Earth–to–DROs trajectories are studied: in case of small DROs, transfers exploiting the stable manifolds of intermediate periodic orbits – tangent to the target DRO – are designed. The intermediate orbits are planar orbits around L1 and L2, and simple-periodic prograde orbits (g–family). When large DROs are studied, transit trajectories making use of the stable and unstable manifold structure are investigated. In order to improve the transfer performances, an optional use of lunar gravity assist can be envisaged, in the framework of the Moon-perturbed Sun–Earth CR3BP. As a constellation of multiple spacecraft is studied, different strategies are adopted to deploy properly all the spacecraft: on the one hand, they follow the same trajectory to the target DRO, but with a time delay; on the other hand, they share the same starting location but fly along different paths.

Finally, a trade-off on the DRO amplitude and the number of spacecraft in the constellation and the transfer cost is performed. This will allow the selection of the operational orbit for a multiple telescope network system for PHAs detection.