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SOLAR RADIATION PRESSURE ASSISTED TRANSFERS BETWEEN LISSAJOUS ORBITS OF THE SUN-EARTH SYSTEM

Abstract

This article investigates a propellant-free transfer between two Lissajous orbits in the circular restricted three body problem of the Sun-Earth system. Lissajous orbits are quasi-periodic orbits that vary in size and shape that are useful for specific missions as they add flexibility for mission planning. They also require a relatively simple Earth-Satellite communication link. Transfers between Lissajous orbits are advantageous for reaching higher amplitude orbits or to change the orbit phases to avoid an eclipse by the Earth. The strategy proposed uses the geometry of the phase space around the L1,2 equilibrium points of the Sun-Earth system to change the amplitudes and phases of the initial Lissajous orbit. In this paper, the invariant manifold theory is exploited to reach the desired orbit by cancelling out the instabilities through maneuvers enhanced by solar radiation pressure acceleration. The effect of the Sun's radiation complicates the geometry of the phase space, where the initial collinear equilibrium points are now moving in the x-y and x-z planes. Thus, after the effect of the manoeuvre the spacecraft tends to move towards the geometry of the new equilibrium point. In this case, the accelerations required during the manoeuvre are controlled by the change in the spacecraft reflectivity or by re-orienting the spacecraft's angle of incidence of the Sun-line direction.

Changes in reflectivity are analysed for the Sun-pointing case, where the equilibrium points are free to move along the x-axis. Due to constraints in the solar radiation pressure direction, changes in reflectivity are only permitted from higher to lower values. In this case, it is not possible to remain close to the initial Lissajous orbit after the manoeuvre as it is first necessary to leave the unstable manifold before inserting the spacecraft into the target orbit. Changes in reflectivity allow transfer along the x-axis with the effect of increasing the Ax and Ay orbit amplitudes. In the case of re-orienting the spacecraft, the equilibrium points move in the x-y plane; where, due to the displacement, the in-plane centre manifold tends to a stable or unstable focus. Thus, the analytical solution is extended for the case of solar radiation pressure when a focus occurs. An analysis in the magnitude of the stable and unstable manifolds after a manoeuvre is presented for different Lissajous orbit amplitudes and reflectivity in order to understand where it is possible to exploit this propellant-free technique to avoid an eclipse by the Earth.