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DYNAMICS OF A SOLAR SAIL NEAR A HALO ORBIT

Abstract

We are interested in the control of a spacecraft around a periodic orbit by means of a solar sail. To model the dynamics of a solar sail we have considered the Circular Restricted Three Body Problem (CRTBP) taking as primaries Earth and Sun and adding the Solar radiation pressure. The force due to the sail depends on the sail orientation and effectiveness.

If the radiation pressure is discarded, it is well known that the CRTBP has five equilibrium points L_i $(i = 1, \ldots, 5)$, three of them are linearly unstable and are placed on the axis joining the two primaries. Around these fixed points, there are two families of unstable periodic orbits, the vertical and horizontal Lyapunov families, and a set of invariant tori. For a certain level of energy the well known family of Halo orbits appears. This family is highly unstable and a station keeping is needed to stay close to it.

We will use dynamical system tools to understand how these invariant objects vary when we add the sail effect and vary its orientation. We will see that for certain sail orientations these families of periodic orbits and invariant tori persist.

Finally we will focus on the family of Halo-type orbits for a solar sail. We will study how the variation on the sail orientation affects the natural dynamics around these families of periodic orbits, i.e. its stable and unstable manifolds. We want to see if it is possible to change the sail orientation to maintain the trajectory of a solar sail close to a Halo orbit. The techniques used in this last part are an extension from the authors previous work [1,2], where the controllability around a fixed point for a solar sail was discussed.

[1] A. Farrés, À. Jorba, "A dynamical systems approach for the station keeping of a Solar Sail", Journal of the Astronautical Science, Volume 56, Number 2, 2008.

[2] A. Farrés, À. Jorba, "Solar sail surfing along families of equilibrium points", Acta Astronautica, Volume 63, Issue 1-4, 2008.