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PHASE SPACE EVOLUTION OF A TUMBLING SOLAR SAIL AND IMPLICATIONS FOR END-OF-LIFE DEORBITING

Abstract

Among the passive strategies that can be adopted to de-orbit a spacecraft at the end-of-life, the scientific community is showing the major hesitation towards a practical exploitation of a solar sail.

Although recent works have shown its viability on the basis of simplified and non dynamical models (Alessi et al., CMDA 2019 and Rossi et al., Acta Astron. 2020), the main concern is that the sail needs to be controlled to be effective. In this work, we will address this problem, by modeling the variation in eccentricity due to the coupled effect of the solar radiation pressure and the Earth's oblateness, assuming a value of area-to-mass ratio that is changing periodically. Starting from the 1DOF model developed previously, the evolution of the phase space is modeled using a dynamical systems tool known as Lagrangian Descriptors (LDs) (Mancho et al. Commun Nonlinear Sci Numer Simulat 2013).

LDs were originally inspired by the desire to explain the intricate geometrical flow patterns that are responsible for governing transport and mixing processes in geophysical flows. So far, LDs have been widely used in fluid mechanics and chemical reaction dynamics, unveiling regions with qualitatively distinct dynamical behavior, with a relatively low computational effort.

The results of this work will show whether and when a tumbling sail stops to be effective to de-orbit naturally and the possible implications for the design of a solar sail. Besides, a new tool to depict the dynamics will be presented to the astrodynamics community.