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ORBITAL DYNAMICS OF A SOLAR SAIL ACCELERATED BY THERMAL DESORPTION OF COATINGS

Abstract

For extrasolar space exploration it might be very convenient to take advantage of space environmental effects such as solar radiation heating to accelerate a solar sail coated by materials that undergo thermal desorption at a particular temperature [1]. Thermal desorption is a physical process of mass loss which dominates all other similar processes and it can provide additional thrust as heating liberates atoms, embedded on the surface of a solar sail [2].

We are considering a solar sail coated with materials that undergo thermal desorption at a specific temperature, as a result of heating by solar radiation at a particular heliocentric distance, and focus on the orbital dynamics of three scenarios that only differ in the way the sail approaches the Sun; in every case once the perihelion is reached, the sail coat undergoes thermal desorption. When the desorption process ends, the sail then escapes the Solar System having the conventional acceleration due to solar radiation pressure. Our study analyses and compares the different scenarios in which thermal desorption comes beside traditional propulsion systems for extrasolar space exploration, and they are the following:

i. Hohmann transfer plus thermal desorption. In this scenario the sail would be carried as a payload to the perihelion with a conventional propulsion system by an Hohmann transfer from Earth's orbit to an orbit very close to the Sun (almost at 0.1 AU) and then be deployed there.

ii. Elliptical transfer plus Slingshot plus thermal desorption. In this scenario the transfer occurs from Earth's orbit to Jupiter's orbit; then a Jupiter's fly-by leads to the orbit close to the Sun, where the sail is deployed.

iii. Two stage acceleration of the solar sail through thermal desorption. The proposed sail has two coats of the materials that undergo thermal desorption at different temperatures depending on the heliocentric distance. The first desorption occurs at the Earth orbit and provides the thrust needed to propel the solar sail toward the Sun. The second desorption is as in the other scenarios.

References:

1. R. Ya. Kezerashvili, Space exploration with a solar sail coated by materials that undergo thermal desorption, Acta Astronautica **117** (2015) 231-237.

2. G. Benford, J. Benford, Acceleration of sails by thermal desorption of coatings, Acta Astronautica **56** (2005) 593–599.