Combined Thermal Desorption and Electrical Propulsion of Sailcraft using space environmental effect

Elena Ancona[1]*, Roman Ya. Kezerashvili[2]

[1] Telespazio VEGA Deutschland GmbH, Darmstadt, Germany
[2] New York City College of Technology, City University of New York, Brooklyn, USA

Abstract

For extrasolar space exploration it is suggested to use space environmental effects such as solar radiation heating and a proton component of the solar wind to accelerate a solar sail coated by materials that undergo thermal desorption at a particular temperature.

The solar radiation consists of two parts: electromagnetic and corpuscular radiation. Typically, when considering solar sails, the interest is in the electromagnetic radiation, since photons can transfer momentum to the sail and guarantee a continuous thrust. But what if also the corpuscular part of solar radiation could be exploited for the sailcraft propulsion? In this study we investigate the advantage related to the electrical propulsion of a solar sail by the solar wind plasma, a mixture of protons and electrons that moves away from the Sun. Due to the fact that the proton mass is almost two-thousand times bigger than the electron's, the total momentum carried by the proton flux is significantly higher than that of the electron component. Besides electrical repulsion, another mechanism could be convenient to accelerate the sailcraft: thermal desorption, a physical process of mass loss which can provide additional thrust as heating liberates atoms, embedded on the surface of a solar sail [1,2,3].
We propose the following scenario: the sail is carried as a payload to a relatively small heliocentric distance (0.1 - 0.3 AU); once at the perihelion, the sail is deployed and accelerated by thermal desorption. When the desorption process ends, the sail is electrically charged by a device. The sail experiences additional propulsive force due to the strong repulsion of the positive charged sailcraft with the solar wind protons. Neutralization phenomena are also addressed in the present study [4].

Particularly we are considering the following scenarios: i. Hohmann transfer, plus thermal desorption, plus electrical propulsion. 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 and then be deployed there. Then desorption occurs, which provides a thrust and boosts the sailcraft to its escape velocity. When the desorption acceleration ends, the positively charged sail is accelerated by photon pressure and, due to the electrical propulsion, by extracting the momentum from the proton component of solar wind ii. Elliptical transfer plus Slingshot, plus thermal desorption, plus electrical propulsion. In this scenario the transfer occurs from Earth's orbit to Jupiter's orbit. A Jupiter's fly-by leads to the orbit close to the Sun, where the sail is deployed when it reaches the perihelion. After that the sailcraft is accelerated as in the previous case.

We demonstrate that thermal desorption and electrical propulsion come as an additional source of sailcraft acceleration, beside traditional propulsion systems that provide to a sailcraft the speed of about 0.001c for extrasolar space exploration.

Keywords: Electrical propulsion, Propulsion due to thermal desorption, Hohmann transfer, Slingshot

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*Corresponding author, elena.ancona@gmail.com