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EXPLORATION OF TRANS-NEPTUNIAN OBJECTS USING THE DIRECT FUSION DRIVE

Abstract

The Direct Fusion Drive (DFD) is a nuclear fusion engine that will produce thrust and electrical power for any spacecraft. It is a compact engine, based on the D -^{3}He aneutronic fusion reaction that uses the Princeton field reversed configuration for the plasma confinement and an odd parity rotating magnetic field as heating method to achieve the fusion [1]. The propellant fluid is deuterium, which is heated by the fusion products and then expanded into a magnetic nozzle, generating an exhaust velocity and thrust.

In this work we present possibilities to study the outer border of the solar system using such an engine. The objective is to reach some trans-Neptunian object (TNO) in the Kuiper belt and beyond, such as the dwarf planets Makemake, Eris and Haumea in less than 10 years with a payload mass of at least of 1000 kg, so that it would enable all kind of missions, from scientific observation to in-situ operations. Each mission profile chosen is the simplest possible, which is the so-called thrust-coast-thrust profile. For this reason, each mission is divided into 3 phases: i. the spiral trajectory to escape Earth gravity; ii. the interplanetary travel, since the exit from sphere of influence to the end of the coasting phase; iii. maneuvers to rendezvous with the dwarf planet. Propellant mass consumption, initial and final masses, velocities and ΔV for each maneuver are presented. The analysis of trajectories is performed for two cases: the ideal case, in which the TNOs have no inclination on the ecliptic plane and the real case, when the real angle of inclination is considered. Calculations to reach a vicinity at 125 AU for the study of the Sun magnetosphere as well as Eris via fly-by are also presented, with interest on the influence of different acceleration phases.

Our calculations show that a spacecraft propelled by DFD will open unprecedented possibilities to explore the border of the solar system, in a limited amount of time and with a very high payload to propellant ratio.

References:

[1] S. A. Cohen et al., Direct fusion drive for interstellar exploration, JBIS 72, 37 – 50 (2019)