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TWO CONCEPTS FOR SPACE PROPULSION BASED ON THERMAL NUCLEAR FUSION

Abstract

In the present work, two different concepts for fusion based space propulsion are compared. While the first concept is based solely on propulsion by hypothetic ejection of fusion products and hence may be called "ash drive", the second one uses an additional coolant for thrust enhancement. Since this coolant was initially assumed to be gaseous and to do most of the propulsion work, the name of "working gas drive" has been proposed.

The comparison is based on the evaluation of analytic models describing the system from the fusion plasma to propulsion subsystems. The plasma models use a generalised Lawson criterion [1] including both reactants and products. Characteristic timescales, temperature and mixture ratios are considered as parameters. The plasma models yield volume specific parameters as a function of the temperature. Further models scale system masses assuming generic spherical geometries and manage the system power flow. The propellant mass flow rate is estimated considering ash production [1] for ash drives and cooling requirements for working gas drives [2]. The model for specific exhaust velocities respects relativistic effects in view of prospectively high thrust power. The thrust is calculated classically from exhaust velocity and mass flow rate. The models for both types of fusion drives are evaluated for four major fusion reactant couples (D–T; D–3He; 3He–3He; 11B–p) [3]. In working gas drives, hydrogen is considered as coolant due to its caloric and propulsive properties.

The results of the comparison show that while ash drives excel working gas drives in terms of specific exhaust velocities the latter yield considerably more thrust than ash drives. Another major drawback of the ash drives are relatively small thrust efficiencies. The plasma power has to be disposed of nearly entirely as waste heat leading to prohibitive radiator masses.

References:

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