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Title

Design of a 2-axis thrust stand for thrust vectoring diagnostics of an ECR thruster

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Abstract

The use of electric propulsion (EP) systems has grown in the past years in a context of reduced satellite sizes, because of the higher specific impulse of EP in comparison with chemical propulsion. In the meantime, small satellite missions are getting more complex, requiring higher manoeuvrability with low mass penalty. Thus, light thrust vectoring systems are investigated to replace gimbal systems.

The ECR thruster (ECRT) relies on the creation of a plasma by electron cyclotron resonance (ECR) in a coaxial cavity. The electrons are accelerated in a magnetic nozzle (MN) and an induced ambipolar electric field accelerates the ions that detach further downstream. The plasma jet has no net current, hence this technology does not require the use of a neutraliser. Two models designed for 30 and 200 W exhibited efficiencies comparable to other electric thruster in the same power range. Furthermore, MN thrusters may offer good thrust vectoring ability without movements by orienting the magnetic field of the nozzle. In the literature, it has been shown that the ion beam from a double layer helicon thruster can be steered by about 25° using a transverse solenoid [1]. But it is difficult to relate the ion beam deflection with the effective thrust vectoring as indirect thrust measurements for MN thruster is difficult and unprecise [2]. Direct thrust measurements of a vectored helicon thruster were performed in a two steps measurement protocol using a 1-axis thrust stand (TS). A vectoring angle of 7° was estimated [3]. A direct and simultaneous measurement of the two thrust components would increase the confidence in the vectoring angle measurement and give the possibility to optimise a thrust vectoring system.

In order to measure simultaneously the two thrust components of the vectored ECRT, we design a 2-axis thrust stand. Each axis is a hanging deformable parallelogram, this shape providing an independent response to the thruster centre of mass, thus minimising thermal drift error. The targeted resolutions are 10 µN for the main axis and 1 µN for the second axis, corresponding to a 0.2° resolution of the vectoring angle. This work will present the validation of the TS design by demonstrating on a single axis prototype the desired resolution to transverse thrust applied. The thrust components of a vectored ECRT will be non-simultaneously measured using a prototype of vectoring system. A transverse magnetic field will be used for the thrust vectoring. These early results will be used to better understand physical mechanisms at play in magnetic thrust vectoring and to design an optimised magnetic vectoring device.

References

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