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Title

Analysis of perturbative effects of a momentum flux probe in a plasma plume

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Abstract

The use of electric thrusters on satellite platforms is increasing. Electric thrusters are more efficient than conventional thrusters owing to their larger specific impulse, but this technology is characterized by a low thrust-to-weight ratio and vacuum use only. One of their most important performance parameters is the thrust; measuring it during ground testing can be challenging. One way is to use a thrust balance [1]. In this configuration, the thruster is mounted on a pendulum inside a vacuum chamber. The thrust force deflects the pendulum. After calibration, a measure of the pendulum displacement yields the thrust. Unfortunately, some test conditions or thruster configurations prevent the use of such balances. Another way to measure the thrust is to measure with a probe the momentum flux in the plasma jet. This probe is constituted of a target, which intercepts the plasma [2]. Like a pendulum, the target measures the thrust by its deflection. The thrust measured by these probes is in good agreement with balance measurements [3]. However, introducing such a probe in the thruster plume perturbs the plasma. One can ask how the probe alters the plasma properties and if the momentum flux measurement remains accurate.

In this study, we first measure the momentum flux of a cold gas source in a vacuum chamber. A flowmeter keeps the gas pressure low enough to be in a free molecular flow. A highly sensitive probe measures the radial pressure profile in the cold gas jet. The probe is composed of a custom-built MEMS accelerometer mounted on a metal housing [4]. Experimental data are then compared to a simulation of the experiment performed with a Direct Simulation Monte-Carlo code. Second, to assess the perturbation in the case of a plasma jet, we use a particle-in-cell code to model the probe immersed in an expanding plasma jet. The simulation represents the conditions typically found in ONERA's electron-cyclotron resonance (ECR) thruster with its magnetic nozzle. The perturbation induced by different probe designs at different potentials is modeled. The momentum flux measured by the probe is then compared to the momentum flux without perturbation to quantify the extent of the perturbation.

References

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