

Thrust Stand Measurements of a Conical Pulsed Inductive Plasma Thruster

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I. INTRODUCTION

Pulsed inductive plasma thrusters [1–3] are spacecraft propulsion devices in which electrical energy is capacitively stored and then discharged through an inductive coil. The thruster is electrodeless, with a time-varying current in the coil interacting with a plasma covering the face of the coil to induce a plasma current. Propellant is accelerated and expelled at a high exhaust velocity ($\mathcal{O}(10 - 100 \text{ km/s})$) by the Lorentz body force arising from the interaction of the magnetic field and the induced plasma current.

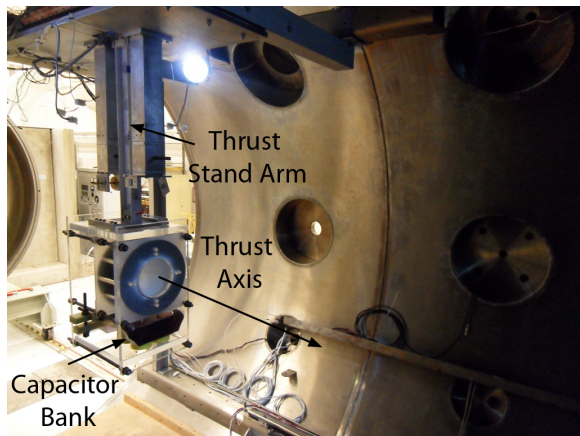


FIG. 1: MAD-IPA thruster mounted on the thrust stand. The thrust axis is towards the right foreground.

While this class of thruster mitigates the life-limiting issues associated with electrode erosion, pulsed inductive plasma thrusters can suffer from both high pulse energy requirements imposed by the voltage demands of inductive propellant ionization, and low propellant utilization efficiencies. The Microwave Assisted Discharge Inductive Plasma Accelerator (MAD-IPA)[4], shown in Fig. 1 is a pulsed inductive plasma thruster that is able to operate at lower pulse energies by partially ionizing propellant with an electron cyclotron resonance (ECR) discharge inside a conical inductive coil whose geometry serves to potentially increase propellant and plasma plume containment relative to flat coil geometries. The ECR plasma is created with the use of permanent magnets arranged to produce a thin resonance region along

the inner surface of the coil, restricting plasma formation and, in turn, current sheet formation to areas of high magnetic coupling to the driving coil.

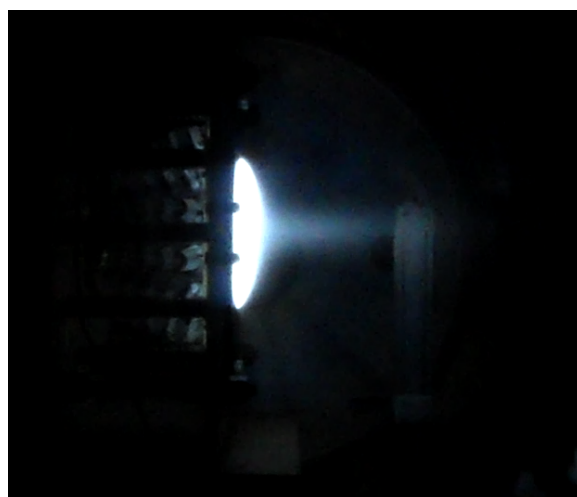


FIG. 2: MAD-IPA thruster with the preionization stage initiated. The thrust axis is to the right.

II. EXPERIMENT

Thrust stand measurements were performed to characterize the performance of the MAD-IPA thruster. Impulse data were obtained for various experimental conditions to determine how the amount of energy stored in the capacitors, the mass flow rate of injected propellant, and the cone angle affect the thrust of a propulsion device employing a conical inductive coil in the presence of preionized propellant. A maximum in impulse is found with respect to these three controllable parameters. Dependencies on these experimental parameters are explained based upon both a Paschen-like breakdown processes occurring during thruster firing, and previous semi-empirical modeling of the effect of inductive coil geometry on thrust efficiency [5].

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