

THE HELICON DISCHARGE IN THE VASIMR EXPERIMENT

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The Advanced Space Propulsion Laboratory (ASPL) of the Ad Astra Rocket Company is performing research on the Variable Specific Impulse MagnetoPlasma Rocket (VASIMR). The VASIMR is a high power, > 10 kW, radio frequency (RF) driven magnetoplasma rocket, capable of very high exhaust velocities, > 100 km/s. In addition, its unique architecture allows in-flight mission-optimization of thrust and specific impulse to enhance performance and reduce trip time. The ASPLs experimental research focuses on three major areas: helicon plasma production, ion cyclotron resonant frequency (ICRF) acceleration and plasma expansion in a magnetic nozzle. A flexible four-magnet system, with a 1.3 Tesla maximum magnetic field strength, is used to study axial magnetic field profile shape effects. Power generated at 13.56 MHz with over 20 kW is used to perform helicon plasma source development. A 2 to 4 MHz RF transmitter capable of 10 kW is coming online for ICRF experiments. The primary diagnostics are: gas mass flow controllers, RF input power, Langmuir probes, retarding potential analyzers (RPA), microwave interferometers, neutral pressure measurements, plasma light emission and spectroscopy.

Helicon research has focused on operation with hydrogen, deuterium, and helium. Others are also being explored as well, nitrogen and argon. Optimization studies have been performed with the magnetic field axial profile shape, gas flow rate, gas tube geometry, RF frequency and antenna geometry. High performing discharges have been found for deuterium where the plasma source performance (ion current per kW) is proportional to the applied magnetic field at the helicon antenna. The present capability of our plasma source is a steady state plasma flux of about 410^{20} /s or almost 80 A of ion current. The operating frequency of the helicon discharge is now several times the lower hybrid frequency, which raises interesting questions regarding the role of the lower hybrid resonance in helicon operation. These high-density plasmas have enabled exciting ICRF experiments that will be discussed in a companion paper by *Brukardt et al.* This paper will highlight the primary results in the development and evaluation of the helicon plasma source.

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5. Before paper by Brukardt et al