mini-High Powered Helicon

Reducing the size of the HPH plasma experiment

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Abstract

The High Powered Helicon (HPH) is a plasma experiment that consists of a helical coil wrapped around a quartz tube, set inside an electromagnet and driven by a high power radio frequency supply. The power supply switches hundreds of amps of current at radio frequencies in the helical antenna to couple energy into the plasma. The input of energy results in a high speed beam of plasma to be ejected downstream from the antenna. To evaluate theories about the coupling of energy into the plasma the physical properties of the plum are measured. The HPH has been funded as a possible in space plasma propulsion device and theorized as a source of Whistler wave coupling in plasma for physics research. As a thruster the HPH creates a very high velocity exhaust much faster than anything possible with conventional chemical rockets but with a much smaller mass than current Electrical Propulsion devices. The goal of this modification was to reduce the physical size of the HPH even more by creating a 2 cm diameter antenna vs. the current 7 cm diameter antenna. Comparing data gathered on HPH to measurements on the new miniHPH will help in better understanding of the physics involved in the concept at a different scale. Reducing the size of the device also allows for a higher energy density to be realized or the possible use of less power in a thruster concept. Lower power and size are desirable for space propulsion because of the limits of the current in-space power technology and expense of on-orbit mass. The physical characteristics of the plasma generated by miniHPH will be studied using Langmuir probes and an ion energy analyzer as plasma diagnostics. This poster is a report on the concept and characteristics of the miniHPH.and characteristics of the miniHPH.

Experimental Operation

The miniHPH is a plasma experiment requiring a vacuum to operate appropriately. The magnetic coil, radio freqency antenna and power supply are all mounted inside a small vacuum chamber. A LabView operating program coordinates the firing of an experimental shot

1. Power Supply Capacitor Charged
2. DC electromagnet turned on, up to 500 G
3. A small amount of gas is passed through an electric arc for seed plasma
4. A square wave function from a function generator drives the solid state switches
5. Currents up to 500 Amps are driven at 400 kHz in the Helicon Antenna
6. High powered radio frequency further ionizes seed plasma and accelerates it
7. Tight beam of high velocity plamsa is ejected from the coil
8. Current in the coil and downstream plasma density measurements are measured

A typical HPH experiment shot last 100 microseconds with antenna currents of about 1 kA.

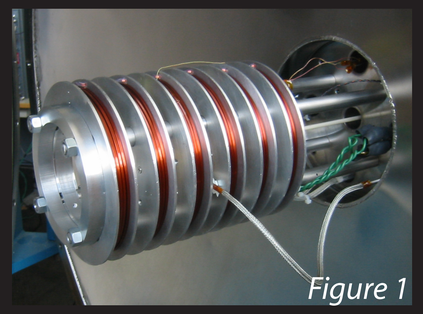

Figure 1

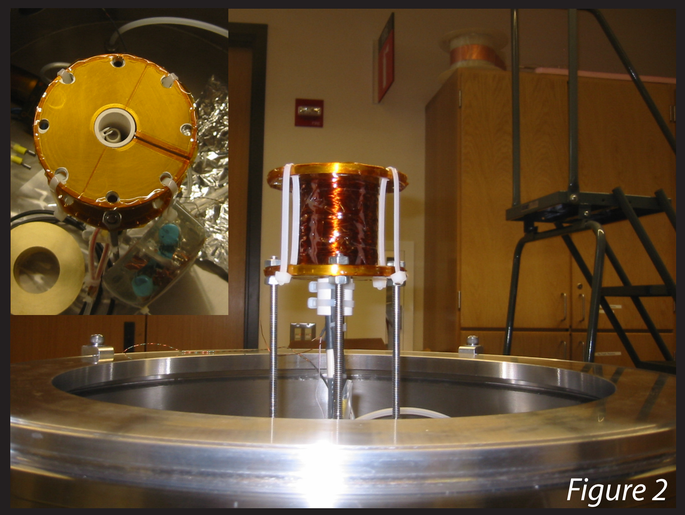

Figure 2

Figure 1 above shows original HPH experiment mounted on the door of the large stainless steel vacuum chamber. Figure 2 to the right shows the new miniHPH mounted inside the bell jar vacuum chamber. Inset in the top left is an overhead view of the miniHPH, showing the ingniter and internal langmuir diagnostic.

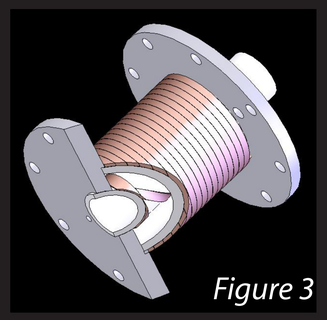

Figure 3

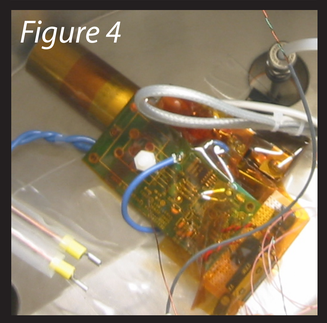

Figure 4

Experiment Design

The purpose of the reduced size of the miniHPH was to compare its results with that of the HPH experiment. The smaller size may lead to lower operating powers and higher densities.

Figure 3 to the left shows a SolidWork drawing of the miniHPH. The cut-away shows the helicon coil wrapped around the internal alumina tube. Currents up to 500 Amps are pulsed throught the helicon coil while a DC electrical magnet establishes up to a 500 Gauss field.

Radio Frequency Power Supply (*Figure 4 left*)
- -Capacitor charged to a max of 250 V
- -Solid state switches drive tuned circuit at 400 kHz
- -Triggered fiberoptcally by a wave generator

Design of the miniHPH:
- -3 turn Helicon Coil wrapped around 2.5 cm diameter alumina tube, coil 5 cm long
- -1200 turn DC magnetic coil wrapped around 5 cm alumina tube
- -10 cm diameter aluminum flanges hold alumina tubes in place
- -20 x reduction in volume over HPH and 7.6 x reduction in face area

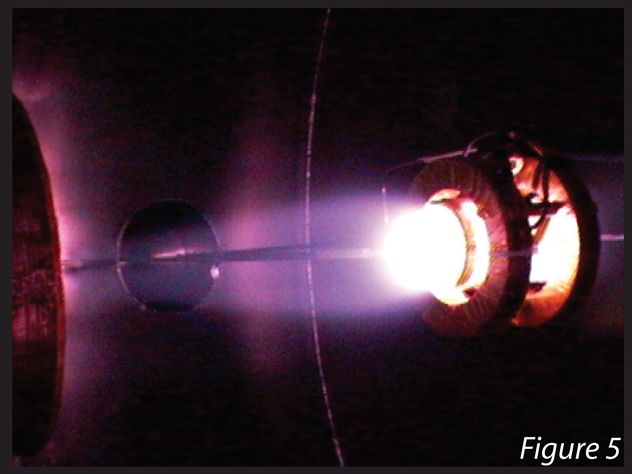

Figure 5

HPH

Figure 5 show the original HPH operating during an experiment. The purple plume is high density plasma driven from the coil by the Helicon antenna.

Typical HPH Data
- -Densities 1x10^19 particles/m^3 in source
- -Temperate 7 eV
- -Exhaust Velocities ~8 km/s
- -Shot duration 100 microseconds

Conclusion & Future Work

miniHPH has been successfully installed in the small bell jar vacuum chamber. All power supplies and diagnostics have also been installed. The miniHPH will have two primary diagnostics. Two langmuir probes which measure the resistance of the plasma will be used to back out plasma densities. These probes can be seen in the bell jar with miniHPH in *Figure 6 & 7,* external and internal langmuir probes respectively. The external langmuir has the capability to translate axially and twist to establish radial distance. With these probes the future work on miniHPH is:

- -Establish operating parameters measuring internal densities
- -Radial and Axial langmuir sweeps to define plasma characteristics
- -Temperature sweep of the langmuir probe
- -Change gas feed system and repeat above measurements for comparison
- -Compare miniHPH data with on going HPH experiment data

Using similar diagnotics to the regular HPH the miniHPH will establish a new operating regime and help to better understand the Helicon plasma wave physics through comparison to the larger HPH. By installing the experiment in the bell jar vacuum chamber changes can be mad to the gas feed rapidly without long pump down times. With this advantage some study of gas

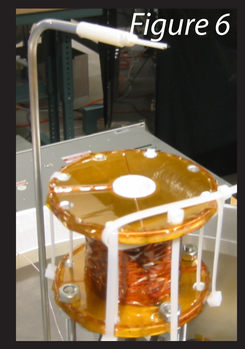

Figure 6

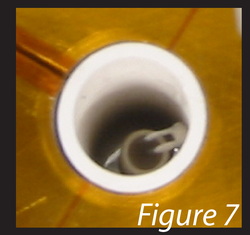

Figure 7

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