Measuring the Magnetic Field Perturbations in a Double-Gun Configuration of the High Power Helicon Thrusters

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Abstract

The high power helicon (HPH) thruster is a plasma propulsion system that utilizes a helicon antenna to ionize a neutral gas and create high energy plasma. Now being investigated is the performance of a double-gun configuration of HPH thrusters. My part of the project has focused on the production of a B-dot probe to measure magnetic field perturbations in the plume of the HPH double-gun configuration. At the end of the B-dot probe are three coils of wire to find the three vector components of changes in magnetic field. The changes in the magnetic field that result when the double-gun configuration is fired will be compared to those that result when only a single HPH thruster is fired. It is expected that the double-gun configuration will produce stronger magnetic field perturbations downstream than will a single HPH thruster. Measuring changes in the magnetic field with the use of a B-dot probe will provide a better understanding of the performance of the double-gun configuration and how it can be improved.

High Power Helicon Thruster

Design of the HPH Thruster:
- Helicon antenna generates helicon wave to ionize gaseous fuel, argon
- Coils of wire produce magnetic field to expel ions at high velocities

Now being investigated is the double-gun configuration, in which two adjacent HPH thrusters are fired simultaneously. Computer models predict the configuration could generate up to 4-5 times the thrust of a single thruster.

The B-dot probe measures changes in the base magnetic field that result when an HPH thruster is fired.

Design of the B-dot Probe:
- Three coils of wire at the end find the vector components of dB/dt
- Ceramic tube prevents plasma from interacting with steel tubing

For the purpose of the double gun, we will have essentially three B-dot probes arranged into a rake structure.

Design of the Rake Structure:
- One B-dot sphere in front of each thruster, third sphere on midline
- All spheres at same axial position

Using an oscilloscope, we will measure the voltage between the leads of each B-dot coil. The data collected can be used to plot a voltage v. time graph.

Next, we will integrate voltage over time in order to obtain an intermediate graph such as the one shown on the left.

We will then divide the y-values of the intermediate graph, which are values of the integral of voltage over time, by a calibration factor of about $1.6 \times 10^{-6} \text{ V/s}$. For a final graph of change in magnetic field v. time.

These graphs are from the firing of a single HPH thruster. The final graph, a change in magnetic field v. time graph, depicts a temporary decrease in magnetic field when the HPH thruster is fired, then a gradual return to initial base magnetic field strength. We are anticipating similar results for the firing of a double-gun configuration. Certainly, the process for analyzing data collected will resemble the process just described above.

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References