Shuyue Guo
Princeton Undergrad '12

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PPST Summer 2010 Intern written report

In the summer of 2010, I was able to work on plasma research in the Princeton Electric Propulsion Lab under the guidance of graduate student Ben Jorns and Professor Edgar Choueiri by means of the PPST scholarship. In this 10-week long internship, I came to understand the creation and characteristics of plasma from knowing next to nothing before the program. In this report, I will detail my ten weeks in the EP lab and hope to convey some of what I learned.

I spent my first few weeks familiarizing myself with the equipment setup I will be working with for the rest of the summer. In order to both take some useful data and get some insight into the equipment, I started by taking magnetic field measurements inside of the container for holding the plasma. The container itself, as pictured in Figure 1, is a piece of 4-feet long Pyrex glass tube, enclosed in two identical sets of five magnetic coils. On the surface of the glass are the heating and radio frequency (RF) antennas.

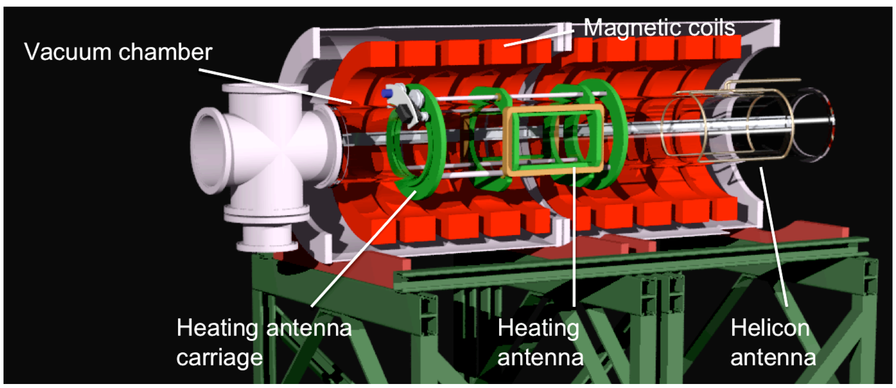

Fig. 1: equipment setup

Ideally, the plasma data we want to be taking should be from an area of uniform magnetic field, which has been assumed to exist in the middle region of the tube. However, upon taking actual field measurements upon setting the same current through both sets of coils, I found that the second sets of coils were somehow producing a weaker field than the first set, resulting in non-uniform magnetic field inside the chamber, as seen in Figure 2. I then proceeded to alter the currents applied to each set of coils in order to achieve a uniform field, as show in Figure 3. The resulting current ratios for coil 1 at 5A, 15A, and 25A were 6.6A, 19.5A, and 30A.

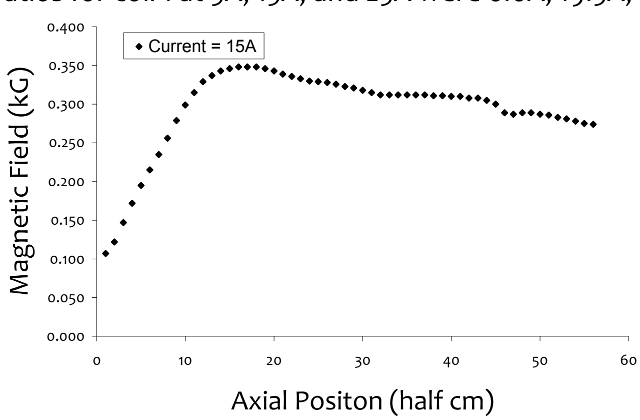

Fig.2: B-field for uniform current = 15A

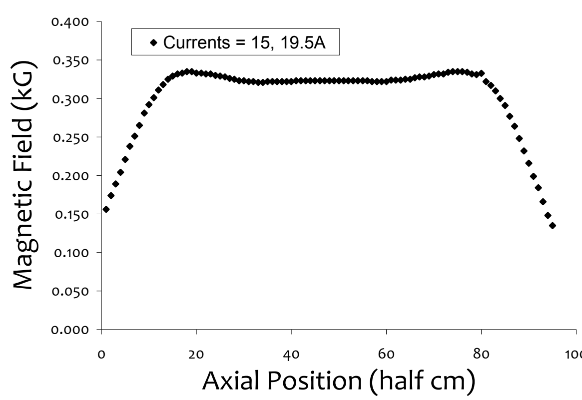

Fig.3: B-field for currents = 15, 19.5A

After determining that the magnetic field in the middle of the coils is now stable, I began research on methods of collecting data from the plasma within the probe. This research soon turned into my main focus for the rest of the summer and my following presentation, whose contents can be seen in the corresponding Powerpoint file.

As indicated in the 8th slide in my Powerpoint, there are three popular methods of determining plasma parameters: Interferometry, Thompson Scattering, and Langmuir probes. Given our current setup, the most plausible method was Langmuir probes, as a single Langmuir probe has already been built and used inside the plasma. After further research about the different types of Langmuir probes and their uses, we settled on the Triple Langmuir Probe in order to instantaneously measure plasma parameters.

Further literary review indicated a typical pattern of density jumps measured in plasma as a function of input RF power. These jumps indicate the border between different plasma operational modes, labeled as Capacitive, Inductive, and Helicon. With the triple probe, we would be able to see the changes in modes directly on an oscilloscope in order to affirm the behavior of our plasma in an RF ramp.

The data collected from the triple probe that we subsequently built after much trial and error were collapsed into the fourth-to-last slide in the accompanying Powerpoint, in which the mode change from Capacitive to Inductive is clear. What is also clear is the effect of background pressure on the location of the mode transition: increased pressure led to a later mode jump. These findings coincide with patterns found in previous similar research, and the process of which confirmed the convenience and advantages of the triple Langmuir probe.