Dusty Plasma
Megan Mark

Abstract
Perfect plasma environments easily occur in the natural world, instead, plasmas are often mixed with neutral particles and other trace elements, giving it the name of dusty plasma. Dusty plasma physics is a subject that is being researched extensively in the fields of space science, astrophysics, semiconductors, nuclear fusion, nanotechnology, and crystal physics.

From research conducted, dusty plasma chambers are possible. A major dusty plasma chamber that can be used for reference is the Naval Research Lab’s DUPLEX chamber. This chamber creates a dusty plasma within a clear chamber, in which all experiments can be easily observed. A dusty plasma chamber will serve as an asset to Embry-Riddle Aeronautical University for conducting research in plasma physics which has applications to a myriad of fields, as listed above. The purpose of this project is to construct the chamber to certain requirements and to accomplish the creation of dusty plasmas. The main requirements are: the chamber walls shall be constructed from a clear material so the operator or observer will be able to directly observe the chamber and the environment results in a charging of the dust grains.

Dusty Plasma consists of background plasma (electrons, ions, and neutral atoms) and charged microparticles (i.e., “dust”). A dusty plasma is an ionized gas containing dust particles, with sizes ranging from tens of nanometers to hundreds of microns. The interaction of the dust particles with the plasma and ambient environment results in a charging of the dust grains. The charged dust can be in the shape of spheres of rods or irregularly shaped particles. They are typically much more massive than the electrons and ions. The dust particles acquire an electric charge in the plasma (a very interesting feature), usually a negative one. Dusty plasma physicists and students for many years. The proposed Dusty Plasma Chamber design was based on the Dusty Plasma Experiment conducted at the Naval Research Laboratory [1]. The original proposed chamber consists of an 8-inch tall, 12-inch diameter, polycarbonate tube which contains the plasma and serves as the overall structure for the chamber, as seen in Figure 2. However, several design changes have been made to accommodate for a more functional chamber and to fit within a small budget, in which the new design is seen in Figure 3.

The polycarbonate tube is transparent, which allows for visual observations of experiments. Metal flanges are mounted on the top and bottom of the tube are the primary structure for the top and bottom of the Dusty Plasma Chamber. The flanges planned for this experiment include a gas feedthrough, a thermocouple feedthrough, and an electrical feedthrough.

The vacuum in the chamber will go to 10⁻6 torr for the duration of an experiment. This will be achieved by a roughing pump and a turbomolecular pump.

Inside the Dusty Plasma Chamber, the primary features are an anode and a cathode disk, which together generate the electrical field which ionizes the gas and produces the plasma. The anode-cathode pair will range from 8 inches to 12 inches, depending on the size of the experiments. The power source used is a DPC 4000 Power Supply.

Methods and Materials
The primary purpose of this project is to construct, calibrate, and test a dusty plasma chamber to be used by plasma physicists and students for many years. The proposed Dusty Plasma Chamber design was based on the Dusty Plasma Experiment conducted at the Naval Research Laboratory [1]. The original proposed chamber consists of an 8-inch tall, 12-inch diameter, polycarbonate tube which contains the plasma and serves as the overall structure for the chamber, as seen in Figure 2. However, several design changes have been made to accommodate for a more functional chamber and to fit within a small budget, in which the new design is seen in Figure 3.

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Raymond Mark at Machining Solutions: Gave mechanical and machining advice. Assisted with the machining portion of parts on the CNC machine.
Joseph Mouszynski at Nortline (Graubman): Gave vacuum advice and is a contact for donations.
Dave Bruderick at Sparton Electronics: Gave the main contact for donations through Sparton Electronics (vacuum).
Earl Mark at Sparton Electronics: Gave mechanical advice and is a contact for donations from Sparton Electronics (small parts).

Results
The DPC is currently being prepared to start testing for a voltage drop and creation of a plasma. The major work and modifications completed thus far include:
- “Duster” designs were added to the chamber to safely release dust into the chamber along with other additions and changes.
- Removing the acrylic flanges and adding a boss to the flanges.
- The top and bottom flanges were redesigned to account for the dustors and for the mounting system.
- A mounting system was designed to hold the chamber vertical, allow space for the vacuums, and provide a work area/desk.
- Testing of the roughing pump and vacuum pump with the chamber in small increments and applying modifications to compromise leaks.
- Placement of the anode/cathode and prepping for a test with the power source.

Once every component is in place and the vacuum is at our goal vacuum (10⁻6 torr), the power source will be turned on to very low current and a low voltage. The voltage will be increased in very small increments and the current will be increased only a small amount. Once the chamber has proven reliable with a combined vacuum

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Literature Cited

Further Information
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