

Plasma Physics Experiment Summary

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1 Experimental Goals

Our goal is to gain familiarity with the behavior and properties of an argon plasma. To that end, we will:

1. Measure the dependence of plasma breakdown voltage as a function of gas pressure and distance between electrodes (i.e. construct the Paschen curve for our plasma).
2. Measure current and voltage at various points in the plasma using a Langmuir probe to determine the electron density and temperature of the plasma.
3. Collect emission spectra from various parts of the plasma to determine the electron temperature in the plasma.

2 Safety

1. Personal safety
 - (a) Do not touch any components inside the plastic shield when the high voltage supply is on or charged. The green wires are grounded and are safe to touch, but always be careful to never put yourself in between a grounded wire and a high voltage wire.
 - (b) Ensure that the argon canister is always secured
2. Instrument safety
 - (a) Ensure the gas flow system is clear before flowing new argon into the system
 - (b) Vent the vacuum pump after turning it off to prevent intake of pump fluid.
 - (c) Turn the voltage up and down in small increments to ensure that the minimum possible voltage is being used in the system.
 - (d) Do not exceed -1000V applied to the cathode if operating the power supply in manual mode.

3 Tentative Experimental Plan

1. Spectroscopically determine the electron temperature in the plasma
 - (a) Generate a plasma on the clear tube at different pressures and voltages
 - (b) Collect and focus light from the plasma tube into the spectrometer for an appropriate amount of time.
 - (c) Repeat at different points in the tube (particularly those with different colors)
 - (d) Integrate the peaks to determine the temperature of the electrons
2. Construct the Paschen curve
 - (a) Measure the current through the plasma using the series resistor and voltage dividers via software

- (b) Measure the breakdown voltage for different pressures (there is a LabView program to automate the process)
 - (c) Focus on small values of pressure to detect the sharp increase of the breakdown voltage (the mean free path increases)
 - (d) Look up the A, B and γ constants for the gas and the electrode and compute the expected Paschen curve
 - (e) Compare the calculated and measured Paschen curves. Focus particularly on small pressure deviations
3. Determine the electron density and temperature using the Langmuir probe
 - (a) In the stainless steel chamber, replace the window with the Langmuir probe
 - (b) Use the Paschen curve to choose appropriate pressure and distance values (it is best to collect data at low pressure)
 - (c) Use the Keithley SourceMeter to do a manual sweep of the probe and then use the LabView program to automate the data collection

4 Questions

1. When collecting data for the Langmuir probe, what is a low-enough pressure to collect data at? What is the optimal region of the Paschen Curve?
2. Why do we not observe the striations in the plasma?

References

- [1] Stephanie A. Wissel, Andrew Zwicker, Jerry Ross, and Sophia Gershman. The use of dc glow discharges as undergraduate educational tools. *American Journal of Physics*, 81(9):663–669, September 2013. Publisher: AIP Publishing.