Electrical Breakdown of Low Pressure Gases

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Introduction

Paschen's law states that the breakdown potential, Vb, of a gas is a function of the pressure multiplied by the distance between the electrodes. There will generally be a minimum value for Vb and that value is constant for a given electrode pair in a given gas.

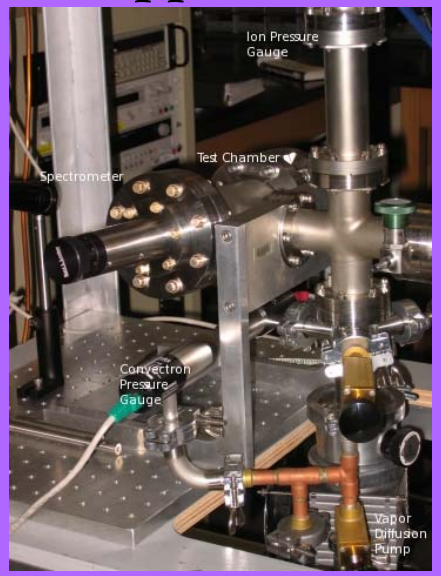
The Vb vs PD curve is found by applying a voltage across two electrodes in a vacuum chamber. The voltage is increased until current crosses the gap. The pressure is then adjusted and the process is repeated.

$$V_{max} = \frac{A\,pd}{ln\,(pd) + B}$$

$$A = \frac{V_i}{1.013\times10^5\ \text{Pa}\ \ l_o}$$

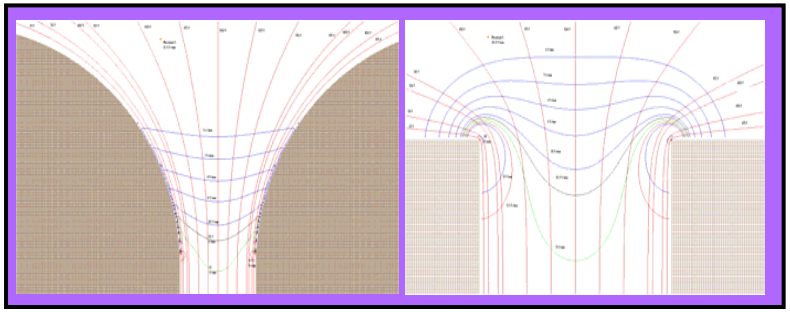
$$B = -\ln\left(1.013\times10^5\ \text{Pa}\ \ l_o\ \ln\left(1+\frac{1}{\gamma}\right)\right)$$

Apparatus



Electric Fields

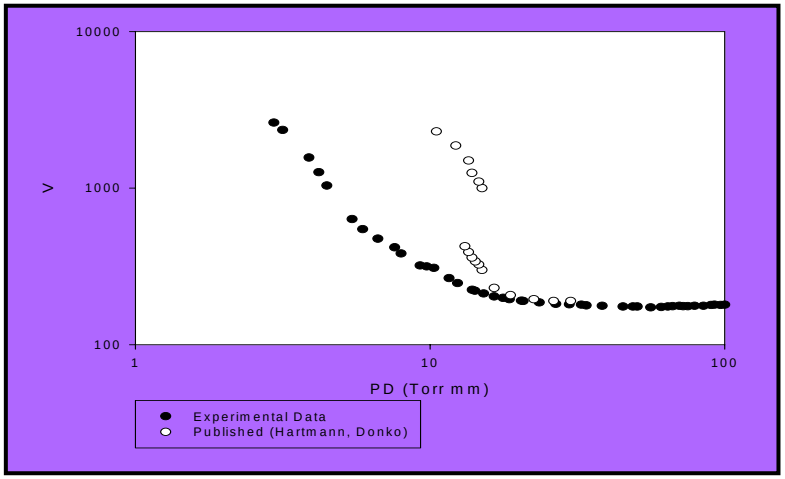
Paschen curve's are valid only for electrodes with uniform electric fields. In a uniform field, the maximum E value occurs in the middle of the gap, and the values drop off at the edge. For a cylinder with square edges, the field increases at the edge.



These images are from a Simion model and show the magnitude of the E field off rounded and square electrodes. The red lines show potentials, while the blue show electric field.

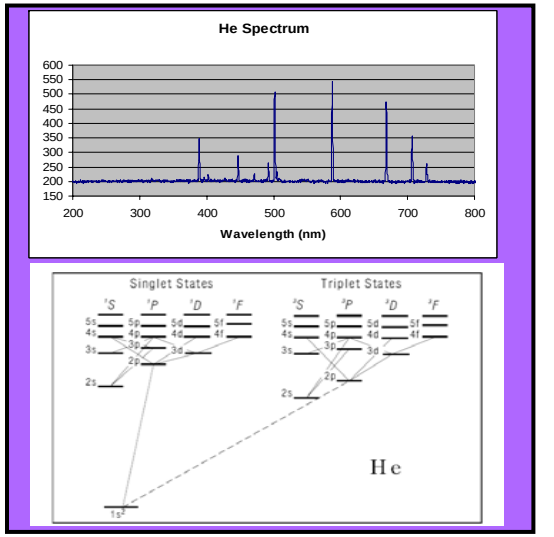
Current Status

We have completed our homogenous field electrodes, made of Copper, and are ready to begin using them to test monatomic gases. Below is shown a sample curve we have obtained, along with the observed emitted light spectrum.



Spectrum

We only see a few very discrete wavelengths of light. This because the energy levels of electrons in an atom are quantized. Since the electron can exist only at certain values, it will only give off specific wavelengths of light, as illustrated below.



Future Work/Applications

- We will continue to use our system to analyze various gases, include eventually looking at a simulated Martian atmosphere.
- This research has vital applications to many technical fields, as well as for future planetary exploration missions. Landers could be damaged by electrical discharges while in the atmosphere of another planet, like Mars.

References

- M.S. Naidu, V. Kamaraju, 1995, *High Voltage Physics.* McGraw-Hill, New York.
- M. J. Druyvesteyn and F. M. Penning, *The Mechanism of Electrical Discharges in Gases of Low Pressure*, Rev. Mod. Phys. 12, 87 (1940).
- P. Hatrmann, Z. Donko, 2004, *Basic Phenomena in Low Pressure Noble Gas Discharges.*