CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Dylan E. Moore

Project Number
31354

Project Title
Finding Harmonics in Plasma

Abstract

Objectives/Goals
Electroluminescent tubes ionized at a high frequency demonstrate a distinct beading pattern characterized by bright, equally spaced plasma beads or oscillations. The purpose of the project was to discover what causes this phenomenon and predict the oscillation spacing comapring the relationship between gas pressure, tube diameter and the distance between oscillations.

Methods/Materials
Glass tubes 50cm long with diameters of 6mm, 8mm, 10mm, 12mm, 15mm and 20mm were evacuated and backfilled with neon at pressures of 5torr, 10torr, 13torr, 15torr, 20torr, 25torr, 30torr and 35torr. Each tube of gas was ionized separately using the same transformer and photographed. With the digital images, the distance between the plasma oscillations were measured and analyzed.

Results
The plasma oscillations in the tubes were the visible result of plasma behaving sympathetically to an electromagnetic standing wave produced by out of phase 25kHz electromagnetic pulses transmitted from the electrodes at the ends of the tube. The bright centers of the plasma beads coincided with the antinodes of this standing wave and distance between them was measured to find Ln, the wavelength of the nth harmonic. The frequency of the nth harmonic, fn, was calculated with a model based on harmonic motion equations, designed so that pressure and tube diameter could be related to fn.

Conclusions/Discussion
Linear relationships were discovered in the comparison of diameter and pressure to the distance between antinodes. These were used to find the equation: Ln = (-0.0734)(P) + (0.5631)(D)+5.9029 which directly related Ln to pressure (P) and diameter (D) and produced relatively accurate projections. The effect of different tube diameters and pressures on plasma oscillations demonstrated the tendency of plasma to self-organize differently under various boundary conditions. For this project, the plasma waves were contained in cylindrical tubes and could therefore be examined linearly. With more time and experience, the Vlasov-Maxwell equations could be used to model the behavior of plasma waves in higher dimensions with a wider set of boundary conditions.

Summary Statement
This project predicted harmonics in standing plasma waves in electroluminescent tubes by analyzing the relationship between gas pressure, tube diameter and the distance between plasma oscillations.

Help Received
The tubes were fabricated at the Crucible, an industrial arts school in Oakland, and there was adult supervision during all experiment trials.