Physics Lab

D PHYS

Quadrupole Ion Trap

A quadrupole ion trap is a device to capture and store charged particles using dynamic electric field. It is also called a Paul trap in honor of Wolfgang Paul, who was awarded the Nobel prize in Physics is 1989 for his invention of the device. A Paul trap is used as an important component of quadrupole mass spectrometers, trapped ion optical clocks and notably trapped ion quantum computers.

A simple device can be very powerful if correctly used. In this experiment, we are going to use a toylike quadrupole ion trap - a linear Paul trap to trap a single lycopodium ion and investigate the non-trivial trapping mechanism. We will also combine different experimental skills to determine the charge of a trapped lycopodium spore. We will

- Write a script to control the laser module via software and hardware Pulse Width Modulator (PWM) of a Raspberry Pi.
- Control the experiment via any phone/laptop web browser.
- Realize the circuit for a quadrupole ion trap
- Explore different trapping regimes. Understand the nature of the micro-motion.
- Measure the charge/mass ratio of trapped lycopodium spores.
- Measure the averaged diameter of lycopodium spores without a microscope.
- Measure the averaged mass of lycopodium spores without a balance.
- Solve numerically the Poisson equation for the generated electric field using Finite Element Method (FEM), thus deduce the charge of lycopodium spores.

And overall have fun and enjoy the simplicity of the experiment in respecting electricity and laser safety rules.

Prerequisite: None Caution: Lycopodium allergy





A simple setup allows for trapping of a single lycopodium spore. Image recorded with a pi camera. The ion can be observed by naked eye.



0-320 V, 50 Hz

The trapping potential is provided by an oscillating quadrupole field while the gravity is compensated by a DC bias field.



Left: Airy pattern generated by laser diffracted from lycopodium powder. *Right:* Free fall of lycopodium spores in air illuminated by pulsed laser. These measurements allow to estimate the diameter and mass of lycopodium spores.

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