Non-uniform oscillating electric fields were found to trap charged particles by Wolfgang Paul when he invented the quadrupole ion trap (now known as the Paul Trap). While the Paul Trap is not designed to work on neutral particles, could it—or a higher order multipole—be used on quasi-neutral plasma? This is the topic to be tested by the Multipole Plasma Trap (MPT) at the University of Alaska Anchorage’s Plasma Physics Lab. While the ions and electrons in plasma cannot both be simultaneously, directly trapped by an MPT, trapping a large amount of certain charge will create a potential well thus attracting the opposite charge. Higher order poles have a flatter potential well in the center, thus making it of interest in the design of the MPT.

Simulations were numerically calculated using COMSOL Multiphysics Particle Tracing Module. The simulation sets the voltage at 10 kV, the frequency to 30MHz, and the aperture radius to 3 cm. Particles start at 1 cm away from the center of the aperture with a starting KE (in eV) in which the velocity is pointed radially outwards. The particle is considered "unstable" if the particle hits the electrode or leaves the aperture. Examples of unstable and stable trajectories are shown to the right.

To compare the stabilities of different pole orders, 96 evenly distributed protons around the radius = 1 cm mark are tested for their stabilizes at different starting kinetic energies (in eV). The simulations show that the Octupole traps protons at a higher level of starting energy. The quadrupole starts to become unstable around 300 eV and the hexadecapole becomes unstable around the 100 eV mark, while the Octupole becomes unstable around the 500 eV mark.

A phase portrait is made using 256 protons evenly disputed protons around the radius = 1 cm mark. The particle velocities are normalized to a fraction of the particles max velocity. The higher the order, the longer the flat area of the curve, meaning the potential well is flatter during that range. These results agree with potentials shown in fig 3-5.

Future Goals

- Test with more voltages, frequencies and aperture radii
- Simulate more pole orders
- Simulate different particles (i.e., electrons, ions and antimatter)
- Simulate the stability with a background magnetic field that has the cyclotron frequency matched to the RF frequency
- Attempt to map out the stable regions in the trap volume for each multipole, that is regions where the adiabatic condition of particle trapping is satisfied
- Use simulations to guide the experimental design of MPT electrodes

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