MARBLE: Multiple Ambipolar Recirculating Beam Line Experiment

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Although linear electrostatic ion traps have been in existence for only a decade, they have already found a number of applications, including commercial [1]. Based on the underlying electrostatic-optical principles of a single linear trap, we have devised means to trap and store multiple ion beams and electron populations simultaneously in a single compact device, the MARBLE.

Because electrostatic mirrors consist of equipotentials, and not material surfaces as is the case with photon reflectors, any region in space with a favorable electric field can serve as a reflector for particles of one energy band, but also allow the unimpeded passage of higher-energy particles, thus performing the dual role of mirror as well as lens. An electrode geometry can easily be found wherein positive and negative particles with a multitude of energies are contained in a single linear electrostatic trap, with each group of particles contained on stable orbits. While a conventional electrostatic ion trap is characterized by a small volume in phase space which exhibits stable trapping, the MARBLE concept in principle allows for a large number of trapped energy bands, each one subject to separate and largely independent density and stability constraints. This in turn facilitates higher total trapped particle numbers and recirculating currents.

When immersed in a modest axial magnetic field, the MARBLE exhibits good electron confinement for *all* energies, reminiscent of electron beam ion traps. Near the ion turning points, Penning-trap type electromagnetic fields are established which enable substantial low-energy localized electron populations. Such electrons may serve to ionize a neutral gas, thus acting as a source for ions, and also can partially neutralize ion beams near their turning surfaces, where the effects of space charge are most severe. Possible applications of this concept include inertial electrostatic confinement (IEC) nuclear fusion neutron generators [2].

An overview of the technology will be presented, and we will discuss preliminary data from a prototype MARBLE device that has recently been constructed.

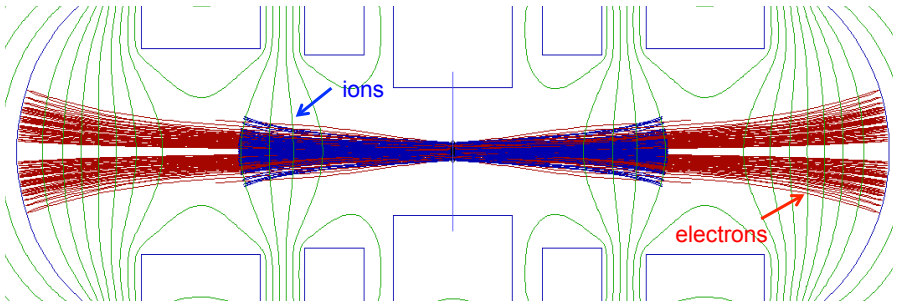

Figure 1. Charged Particle Optics (CPO) simulation, 2-D cylindrical, equi-spaced equipotentials shown. This figure depicts a few simple cylinders that form an electrode configuration which contains stable trapped positive ion (inner, blue) and negative electron (outer, red) orbits. The kinetic energy of both ion and electron beams in the center is 40 keV.

References

[1] http://www.brooks.com/

[2] R. Hirsch, J. Appl. Phys. 38, 4522 (1967)

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