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Particle-in-Cell Simulations for Studies of Space Charge Effects in Ion Trap and Ion Transport Devices

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One of the least intuitive phenomena in ion trap or ion transport devices is the effect of large numbers of charged particles, also known as space charge, on the performance of the device. Space charge can shield applied DC and RF fields, leading to poor transport efficiencies and increased spatial and energy distributions. Robust simulation methods must be employed in order to mitigate these effects and to gain a better understanding of the device in the presence of space charge. However, standard ion optics software, such as SIMION [1], have limited ability to handle space charge, or are not optimized to efficiently study the system of interest. Therefore, other, more specialized, techniques must be used.

The particle-in-cell (PIC) method has been used to study plasmas and gravitational systems for decades, typically employing 2D or 3D coordinate systems. Thorough treatments of the subject can be found in [2, 3]. Modern desktop computing hardware make 3D PIC simulations with millions of super particles possible in a reasonable amount of time without requiring a high-performance computing cluster. The 3DCylPIC package [4] was developed to study devices at FRIB/NSCL, such as RF carpets, gas cells, radiofrequency quadrupole cooler/bunchers, MR-TOFs, etc., that need to operate effectively in the presence of large amounts of space charge. In this talk I will describe how 3DCylPIC operates and present the results of simulations of devices that are currently in use, making comparisons to measurements where possible.

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