

MODELING AND OPTIMIZING RF MULTIPOLE ION TRAPS

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Radio frequency (rf) ion traps are very well suited for spectroscopy experiments thanks to the long time storage of the species of interest in a well defined volume. The electrical potential of the ion trap is determined by the geometry of its electrodes and the applied voltages. In order to understand the behavior of trapped ions in realistic multipole traps it is necessary to characterize these trapping potentials. Commercial programs like SIMION or COMSOL, employing the finite difference and/or finite element method, are often used to model the electrical fields of the trap in order to design traps for various purposes, e.g. introducing light from a laser into the trap volume. For a controlled trapping of ions, e.g. for low temperature trapping, the time dependent electrical fields need to be known to high accuracy especially at the minimum of the effective (mechanical) potential. The commercial programs are not optimized for these applications and suffer from a number of limitations. Therefore, in our approach the boundary element method (BEM) has been employed in home-built programs to generate numerical solutions of real trap geometries, e.g. from CAD drawings. In addition the resulting fields are described by appropriate multipole expansions. As a consequence, the quality of a trap can be characterized by a small set of multipole parameters which are used to optimize the trap design. In this presentation a few example calculations will be discussed. In particular the accuracy of the method and the benefits of describing the trapping potentials via multipole expansions will be illustrated. As one important application heating effects of cold ions arising from non-ideal multipole fields can now be understood as a consequence of imperfect field configurations.