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GEOMETRICAL OPTIMIZATION OF SPHERICAL AND CYLINDRICAL ION TRAPS

Houshyar Noshad
Amirkabir University of Technology (Tehran Polytechnic), Iran

Quadrupole ion traps with spherical as well as cylindrical geometries are designed and analyzed. It is worth noting that for a traditional ion trap, the so-called the Paul trap, higher order electric multipole components inside the trap appear. These components are attributed to truncation of the hyperbolic-shaped electrodes of a Paul trap. As a consequence, the electric multipole components higher than an electric quadrupole one have nonlinear effects on the equations of motion for an ion confined in a trap. This nonlinearity might cause an anomalous effect on the operation of an ion trap. To overcome this problem, the Laplace equation is solved for the electric potentials inside the traps with spherical and cylindrical geometries. Afterwards, geometrical optimization is computationally carried out in order to suppress the contribution of the electric octupole component in the potentials inside the traps. It is concluded that a spherical ion trap with electrode caps having the polar angle of 49° can be properly considered as a pure quadrupole ion trap, whereas, for the cylindrical geometry, the diameter to height ratio of 1.20 makes it possible to operate very similar to the pure quadrupole ion trap. Under these conditions, the optimized traps behave like a practical Paul trap. This claim is confirmed by excellent agreement between the three stability regions computed for the optimized traps with those obtained for a Paul trap. In addition, fabrication and miniaturization of the spherical and cylindrical traps are much simpler than a hyperbolic Paul trap. Geometrical optimization of a spherical ion trap has not been reported in the literature previously.

hnoshad@aut.ac.ir