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Optimization of spherical and cylindrical ion traps

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Statement of the Problem: 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 a Paul trap, higher order electric multipole components inside the trap are appeared. These components are attributed to the 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 Paul trap. This nonlinearity causes an anomalous effect on the operation of an ion trap.

Methodology & Theoretical Orientation: To overcome this problem, the Laplace equation is solved for the electric potentials inside the traps with spherical and cylindrical geometries. Afterwards, an optimization is carried out in order to suppress the contribution of the electric octupole component in the potentials inside the traps.

Findings: It is concluded that a spherical ion trap with the electrode caps having the polar angle of 49 degrees can be 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.

Conclusion & Significance: Under these conditions, the optimized traps behave like a practical Paul trap. This claim is confirmed by excellent agreement of 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 is much simpler than a hyperbolic Paul trap.

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