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Ion Traps as Quantum Detectors for Millicharged Dark Matter: A Quantum-Mechanical Description

Detection of millicharged dark matter with trapped ions has emerged as a powerful technique. Millicharged particles scatter off the ions, producing detectable signals either through individual quantum jumps or via an increase in the ions'overall heating rate. Prior studies have shown that this approach can probe a vast parameter space for superheavy mCPs in the $10^2 \sim 10^9$ GeV mass range. By treating the ion-mCP interaction fully quantum mechanically, the sensitivity can be extended even further. In what follows, I present the quantum-mechanical framework for this scenario and project the resulting improvement in reach.

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