Guiding and manipulating Rydberg positronium using inhomogeneous electric fields

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The short ground-state lifetime of Positronium (Ps) makes it challenging to perform precision-spectroscopy studies that require long interaction times. However, when excited to Rydberg states the annihilation rate of Ps becomes negligible [1], and the lifetime is dominated by fluorescence to low lying states. In addition, Rydberg Stark states with large Stark energy shifts have significant electric dipole moments which provide a mechanism by which forces can be applied to Ps atoms using inhomogeneous electric fields [2].

In a recent series of experiments we selectively excited individual Stark-states of Ps [3], guided the atoms using inhomogeneous electric fields in an atomic guide [4], and modified the guide to select a portion of the velocity distribution of the atoms with kinetic energies of ∼45 meV [5]. Having a beam of slow Rydberg Ps atoms will lead to a number of applications including trapping Ps, measuring the Rydberg constant in a purely leptonic system [6], scattering and merged beams experiments, and potential antimatter gravity measurements.

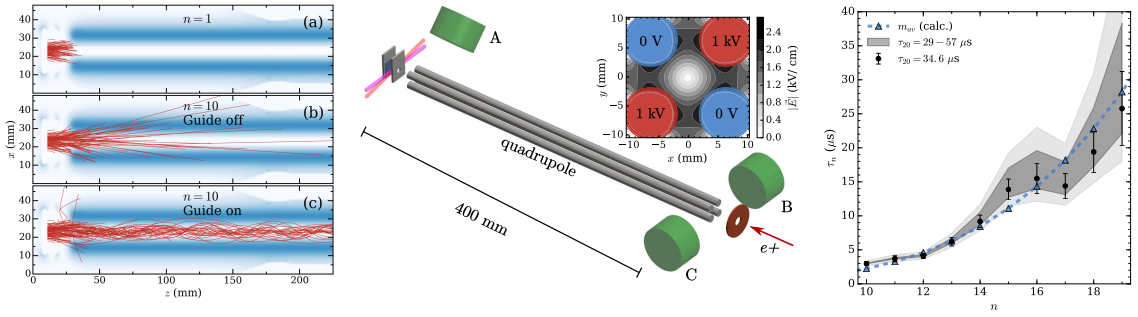

Figure 1: (Left) Trajectory simulation for Ps in the ground state (a), $n = 10$ (b) and guided $n = 10$ with inhomogeneous electric fields. (Center) Experimental setup and detector position. (Right) Measured and calculated fluorescence lifetimes of Rydberg states ranging $n = 10$ to 19.

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