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Adiabatic passage in dissipative Rydberg superatoms

Strong, long-range interactions between atoms in high-lying Rydberg states can suppress resonant Rydberg excitations of closely spaced atoms. Collection of atoms within a certain blockade volume then forms a "superatom" which can accommodate at most one Rydberg excitation. A superatom composed of two-level atoms behaves as an effective two-level atom with the collective ground and symmetric single Rydberg excitation states coupled by collectively enhanced Rabi frequency of the near-resonant laser. With a slightly-more involved level structure of three-level atoms, quantum interference phenomena associated with coherent population trapping states come into play. In a Rydberg superatom composed of three-level atoms in a ladder configuration with short-lived intermediate state, the STIRAP sequence of pulses produces exactly one Rydberg excitation incoherently shared among all the atoms [1]. From the perspective of quantum Zeno effect, the Rydberg blocked atoms repetitively scattering photons effectively monitor a randomly excited atom, which therefore remains in the Rydberg state. Using an auxiliary microwave field to carefully engineer the decay of Rydberg-blockaded atoms to untrapped states, the adiabatic passage can be used to filter out single atoms from trapped ensembles with unknown number of atoms [2]. [1] D. Petrosyan and K. Mølmer, Phys. Rev. A 87, 033416 (2013). [2] D. Petrosyan, D.D. Bhaktavatsala Rao, and K. Mølmer, Phys. Rev. A 91, 043402 (2015).

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