Quantum Computation and Simulation with neutral Ytterbium Atoms in Optical Tweezer Arrays

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Neutral atoms trapped in optical tweezer arrays are emerging as a powerful platform for quantum computation and simulation, combining scalability with long coherence times, high-fidelity control, and tunable long-range interactions. The alkaline-earth-like element ytterbium provides a rich internal structure, including a long-lived clock state and single-photon access to Rydberg states.

In our experiment, individual fermionic ^{171}Yb atoms are confined in optical tweezers at a wavelength of 759 nm, enabling triple-magic trapping. We report on the current status of the platform, including trapping and cooling of single atoms as well as first demonstrations of coherent control via clock-state excitation and Rabi oscillations.

We further investigate single-atom loading using light-assisted collisions with light red-detuned from the $^1S_0$–$^3P_1$ transition, achieving loading efficiencies exceeding 80%. The dependence on experimental parameters such as tweezer depth and magnetic field is characterized, identifying optimal operating conditions near the AC-Stark- and Zeeman-shifted resonance.

In addition, we present technical improvements of the experimental platform aimed at enhanced control for quantum simulation and computation.

These results represent ongoing progress towards scalable quantum simulation and computation with neutral ytterbium atoms.

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