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State-dependent Optical Lattices for the Strontium Optical Qubit

NEVEN SANTIC, ANDR HEINZ, ANNIE JIHYUN PARK, JAN TRAUTMANN, Max Planck Institute of Quantum Optics, SERGEY G. PORSEV[1], MARIANNA S. SAFRONOVA[2], Department of Physics and Astronomy, University of Delaware, Newark, Delaware 19716, USA, IMMANUEL BLOCH[3], SEBASTIAN BLATT, Max Planck Institute of Quantum Optics — We demonstrate state-dependent optical lattices for the clock states in strontium at the tune-out wavelength for the $^1S_0$ ground state, where its dipole polarizability vanishes. Using a novel spectroscopic method, we measure an absolute frequency of 434,972,130(10) MHz for this tune-out wavelength in Sr-88, one of the most precise and accurate measurements of a tune-out wavelength to date. Our method can be applied to thermal gases of atoms, molecules, or to trapped ions. Furthermore, in a proof-of-principle experiment, we trap 3P0 atoms in a one-dimensional optical lattice at the tune-out wavelength, suppressing the effect of the lattice on ground state atoms by more than four orders of magnitude. This highly independent control over the qubit states removes inelastic excited state collisions as the main obstacle for quantum simulation and computation schemes based on the Sr optical qubit. Our results also reveal large discrepancies in the atomic data used to calibrate the largest systematic effect of Sr optical lattice clocks.

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