Evaluation of the JILA 1D Wannier-Stark optical lattice clock

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Abstract

The new JILA 1D optical lattice clock utilizes ultracold atoms in Wannier-Stark states of a shallow vertical lattice. The system features unprecedented atomic coherence over 30 s, with the clock measurement precision reaching 6E-21, resolving the gravitational redshift below 1 mm (1). Operating at a shallow lattice is also essential for reducing systematic errors. By engineering the atomic interaction between s-wave and p-wave components around a "magic lattice depth"(2), we cancel the collisional frequency shift at the 1E-20 level. The *in-situ* imaging also provides a microscopic map of residual clock frequency shift throughout the sample. Besides reducing the Raman scattering, the low lattice light intensity also reduces the AC Stark shift, one of the most important contributions to the overall systematic uncertainty of the lattice clock. We present an evaluation of the lattice light shift at the 5E-19 level, including the measurement of the multipolar polarizability and precise control and measurement of motional effects (3).

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(2) A. Aeppli et al., "Hamiltonian engineering of spin-orbit coupled fermions in a Wannier-Stark optical lattice clock." Science Advances, in press (2022). arXiv:2201.05909.
(3) Kyungtae Kim et al., in preparation (2022).

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