Quantum metrology with lattice-confined ultracold Sr atoms

Jun Ye

JILA, National Institute of Standards and Technology and University of Colorado Boulder, CO 80309-0440, USA

Quantum state engineering of ultracold matter and precise control of optical fields have allowed accurate measurement of light-matter interactions for applications in precision tests of fundamental physics. State-of-the-art lasers now maintain optical phase coherence over one second. Optical frequency combs distribute this optical phase coherence across the entire visible and infrared parts of the electromagnetic spectrum, leading to direct visualization and measurement of light ripples. An the same time, ultracold atoms confined in an optical lattice of zero differential-Stark-shift between two clock states allow us to minimize quantum decoherence while strengthening the clock signal. For ^{87}Sr, we achieve a resonance quality factor $>2 \times 10^{14}$ on the $^1S_0$ - $^3P_0$ doubly forbidden clock transition at 698 nm [1]. The uncertainty of this optical atomic clock has reached 1×10^{-16} and its instability approaches 1×10^{-15} at 1 s. [2] These developments represent a remarkable convergence of ultracold atoms, optical phase control, and ultrafast science. Further improvements are still tantalizing, with quantum measurement and precision metrology combining forces to explore the next frontier.

[1] M. M. Boyd *et al.*, Science **314**, 1430 (2006).

[2] A. D. Ludlow *et al.*, Science **319**, 1805 (2008).