Towards a Yb optical lattice clock with 10^{-18} level instability and inaccuracy

M. Schioppo[1], N. Hinkley[1], T. H. Yoon[1,2], K. Beloy[1], W. F. McGrew[1], R. C. Brown[1], N. B. Phillips[1,3], J. A. Sherman[1], C. W. Oates[1], A. D. Ludlow[1]
[1] *National Institute of Standards and Technology, Boulder, CO, USA*
[2] *Department of Physics, Korea University, Seoul, Korea*
[3] *Stable Laser Systems, Boulder, CO, USA*

Recently, optical lattice clocks have demonstrated fractional instability at the 10^{-18} level [1,2,3]. This measurement capability greatly aids in the study of systematic effects influencing the lattice clock. Here we describe our strategies to control frequency shifts associated with blackbody radiation (BBR), stray static charges and lattice trapping light. We present their contribution towards the final goal of a total clock uncertainty in the 10^{-18} range. The cold atomic sample is enclosed in a room-temperature blackbody shield, thereby enabling determination of the BBR Stark shift with an environmental uncertainty of 5×10^{-19} [4]. This enclosure also serves as a Faraday shield for stray electric fields. By applying high voltage potentials to the shield conductive viewports, we have experimentally confirmed that stray DC Stark clock shifts are below 4×10^{-19}. Utilizing an enhancement cavity, we have characterized lattice Stark shifts over a wide range of trap depths, yielding a precise measure of both hyperpolarizability and scalar polarizability effects.

The sequential nature of clock operation sets an important stability limit known as the Dick effect. We are exploring two approaches to overcome this limit by reducing dead-time in the interrogation scheme and improving the frequency stability of the interrogation laser. An interleaved, anti-synchronized interrogation scheme of two atomic systems is under study to realize a zero dead-time operation, which has the potential to virtually eliminate the aliasing phenomenon responsible for the Dick effect [1]. Additionally, we describe a new interrogation laser that has been recently built. This system is based on a 29 cm long ULE cavity with near-infrared super-high reflectivity mirrors. To reduce the fundamental stability limit due to thermal noise, the cavity is operated near the unstable-resonator regime with 10 m radius of curvature mirrors. This averages the Brownian motion of the dielectric coating over a large beam size [5]. Furthermore, we describe the characterization and optimization of the optical properties of high reflectivity mirrors based on crystalline AlGaAs Bragg reflectors, which have the potential for a lower thermal noise because of their high mechanical quality factor [6].

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