Abstract for an Invited Paper
for the DAMOP07 Meeting of
The American Physical Society

Broida Prize Talk: Stable and Accurate Single-Atom Optical Clocks[1]

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The potential for high stability and accuracy of optical clocks based on narrow transitions of single ions has begun to be realized [1-3]. At NIST, we have constructed and are operating two single-ion optical clocks; one based on the $^2S_{1/2}$ $(F = 0) \leftrightarrow$ $^2D_{5/2}$ $(F = 2, m_F = 0)$ electric-quadrupole transition ($\lambda = 282$ nm, $\nu = 1.064$ PHz) of a single, laser-cooled $^{199}Hg^+$ ion held in a cryogenic rf Paul trap, and one based on the $^1S_0 \leftrightarrow {}^3P_0$ intercombination line ($\lambda = 267$ nm, $\nu = 1.124$ PHz) of a single $^{27}Al^+$ ion held in a linear trap [4]. The burden of cooling, state preparation and state detection of the Al^+ ion are borne by an auxiliary Be^+ ion using quantum logic methods [5]. In a recent comparison of these two standards, we have achieved a relative fractional frequency instability of less than $7 \times 10^{-15}(\tau/s)^{-1/2}$, reaching 4×10^{-17} in 30 000 s. We have also compared the frequency of the Hg^+ optical clock to that of the cesium fountain standard NIST-F1, for which we obtained fractional frequency inaccuracies below 10^{-15}. Repeated measurements of the frequency ratios of the clock transitions of all three standards provide intriguing possibilities for laboratory tests of fundamental physics, such as testing for the "constancy" of the fundamental constants. We will report the results of measurements conducted over the course of five years and discuss the implications of these results as a constraint to present-day temporal variation of the constants [6].

References

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[1] Supported by ONR, DTO, and NIST.