Abstract Submitted
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Reducing time-dilation uncertainty in the NIST Al+ quantum-logic clock[1] SAMUEL BREWER, National Institute of Standards and Technology (NIST), JWO-SY CHEN, NIST, University of Colorado at Boulder, AARON HANKIN, NIST, ETHAN CLEMENTS, NIST, University of Colorado at Boulder, CHIN-WEN CHOU, DAVID WINELAND, NIST, DAVID LEIBRANDT, NIST, University of Colorado at Boulder, DAVID HUME, NIST — Previous optical atomic clocks based on quantum-logic spectroscopy of the $^1S_0 \longleftrightarrow {}^3P_0$ transition in $^{27}\mathrm{Al}^+$ have reached an uncertainty of $\delta\nu/\nu = 8.0 \times 10^{-18}$ dominated by time-dilation shifts due to driven motion (i.e., micromotion) and thermal (secular) motion of the trapped ions. Excess micromotion is typically the result of imperfections in trap fabrication while the uncertainty in the thermal motion has been limited by difficulties in determining the ion temperature near the Doppler cooling limit. We report on Raman sideband cooling of $^{25}\mathrm{Mg}^+$ to sympathetically cool the secular modes of motion in a $^{25}\mathrm{Mg}^+$-$^{27}\mathrm{Al}^+$ two-ion pair to near the three-dimensional (3D) ground state. We characterize the residual energy and heating rates of all of the secular modes of motion and estimate a secular motion time-dilation shift of $-(1.9 \pm 0.1) \times 10^{-18}$ for an $^{27}\mathrm{Al}^+$ clock at a typical clock probe duration of 150 ms. This is a 50-fold reduction in the secular motion time-dilation shift uncertainty in comparison with previous $^{27}\mathrm{Al}^+$ clocks. Furthermore, we present a preliminary characterization of the micromotion time-dilation shift uncertainty in an improved ion trap.

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