Experimental Progress on the NIST $^{27}\text{Al}^+$ Optical Clock

CHIN-WEN CHOU, DAVID B. HUME, JEROEN C.J. KOELEMEIJ$^1$, TILL ROSEN-BAND, JAMES C. BERGQUIST, DAVE J. WINELAND, National Institute of Standards and Technology — A recent measurement of the frequency ratio between single-ion optical clocks based on $^{27}\text{Al}^+$ and $^{199}\text{Hg}^+$ at NIST showed a combined statistical and systematic uncertainty of $5.2 \times 10^{-17}$[1]. Here we report progress on improving both the accuracy and stability of the $^{27}\text{Al}^+$ optical clock. We have developed a new trap and laser systems that enable the use of $^{25}\text{Mg}^+$ for sympathetic cooling and clock-state detection of $^{27}\text{Al}^+$. These developments should reduce time-dilation shifts caused by harmonic motion of the ions and thus lower the dominant systematic uncertainty below $10^{-17}$. In the new clock apparatus we have demonstrated spectroscopy of the $^{27}\text{Al}^+\, ^1S_0$ to $^3P_0$ transition with a quality factor of $Q = 3.5 \times 10^{14}$ and simultaneously a contrast approaching unity. In addition, we have developed techniques for the sympathetic laser cooling and quantum logic spectroscopy of multiple aluminum ions with the goal of further improving measurement stability [2]. *supported by ONR and NIST [1] T. Rosenband et al., Science 319, 1808 (2008) [2] D. B. Hume et al., Phys. Rev. Lett. 99, 120502 (2007)

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