Ytterbium Optical Lattice Clocks Supporting $1 \times 10^{-18}$ Frequency Comparisons

W F McGrew$^1$, X Zhang$^1$, R J Fasano$^1$, S A Schaffer$^1$, K Beloy$^1$, D Nicolodi$^1$, R C Brown$^1$, N Hinkley$^1$, G Milani$^1$, M Schioppo$^1$, T-H Yoon$^1$, and A D Ludlow$^1$

$^1$National Institute of Standards and Technology, 325, Broadway, Boulder CO, USA.  
Contact Phone: +13034976680  
Contact Email: wfm@nist.gov

Time and its inverse, frequency, can be measured more precisely than any other physical quantity, with the current generation of optical atomic clocks reporting fractional performance below one part in $10^{17}$ [1–5]. General relativity dictates that clocks exhibit sensitivity to gravitational potential. Here we demonstrate two optical lattice clocks based on ytterbium with performance that exceeds the present-day capability to determine the gravitational redshift between distant clocks. This performance is manifest in unprecedented levels of clock uncertainty, instability, and reproducibility – three fundamental figures of merit for clock performance. Though gravitational redshifts could degrade the performance of these optical clocks as terrestrial standards of time, this same sensitivity allows clocks to serve as probes of geopotential [5–8]. We measure for the first time in an optical lattice clock the shift from background gas collisions and s-wave collisions arising from imperfect spin-polarization. We also present updates on an ongoing campaign of optical frequency comparisons with the Al$^+$ single-ion clock at NIST and the Sr optical lattice clock at JILA, as well as an absolute frequency measurement of the Yb $^1S_0 \rightarrow {}^3P_0$ transition frequency.

References