DAMOP13-2013-000144

Abstract for an Invited Paper
for the DAMOP13 Meeting of
the American Physical Society

^{88}Sr^{+} 445-THz Single-Ion Reference at the 10^{-17} Level[1]

ALAN MADEJ, National Research Council of Canada, Measurement Science and Standards

We report experiments and precision measurements on a trapped and laser cooled single ion of ^{88}Sr^{+} which when probed on the narrow $5s\ ^2S_{1/2} - 4d\ ^2D_{5/2}$ transition at 445-THz (674 nm) provides a reference yielding an evaluated fractional inaccuracy of 2.3 x 10^{-17} and which significantly outperforms the current realization of the SI second. The extremely low systematic shifts obtained are a result of our ability to evaluate, control and in some instances cancel some of the main perturbations that the trapped ion experiences. The fractional uncertainty on the micromotion induced shifts of the trapped ion has been evaluated to better than 1 x 10^{-18}. This is achieved by minimizing any spurious displacement of the ion from trap center using DC trim electrodes and operating the system at a "magic" trap frequency where there is anti-correlation between the micromotion induced second order Doppler and Stark shifts resulting in near complete cancellation of this form of perturbation. The electrical quadrupole shift seen in many trapped ion systems is reduced to the 10^{-19} level by averaging the measured shifts of several pairs of Zeeman components. As in many optical frequency references, the dominant source of uncertainty arises from the blackbody radiation shift. We have been able to reduce the uncertainties associated by this shift using a recent theoretical evaluation of the differential scalar polarizability of the reference transition together with experimental measurements of the trap heating behavior and modeling of the blackbody field at the ion location. The present measurements are performed with resolution of spectral features down to the 4 Hz level (1 part in 10^{14}) together with continuous measurement periods exceeding a few days allowing the possibility for the device to be used as an optical atomic time standard. As part of the effort to link this ultra accurate standard with current time/frequency standards, an absolute frequency measurement of the reference was performed over a two-month period relative to a H maser referenced to the SI second via GPS time transfer. A centre frequency of the transition of 444 779 044 095 485.5(9) Hz was obtained. Comparison of the reference frequency between two different ion trap systems is currently underway which may further improve our knowledge on key shift parameters. Results will be reported at the meeting.

[1]Work partially supported by the Natural Sciences and Engineering Research Council.