Toward a mercury optical lattice clock: Development of a dipole lattice trap

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The performance of optical atomic clocks is improving at a high pace. Their stability is surpassing atomic fountain clocks based on the ^{133}Cs microwave hyperfine transition defining the S.I. second [1-4]. Furthermore, Optical lattice clocks using strontium atoms have demonstrated uncertainties at the 10^{-16} level [3]. Currently, the blackbody radiation (BBR) shift is the largest correction and the largest contribution to the strontium clock uncertainty. In the future, the BBR shift will be severe limitation at the 10^{-17} level. Owing to its low sensitivity to blackbody radiation [5], a mercury atom standard has the potential to achieve an uncertainty at the low of the 10^{-18} and to compete with the best single ion optical clocks [1]. After achieving magneto-optic trapping (MOT) of mercury [5, 6] and after preliminary measurement of the clock absolute frequency on laser cooled free falling atoms [6], the next important step is to demonstrate the feasibility of dipole lattice trapping at a magic wavelength. This is a challenging task in many respects, due to several aspects specific to mercury atom, such as the comparatively low polarizability, the relatively high power requirement at a difficult and yet significantly uncertain wavelength, the fact that 2 photon ionization for the excited clock state is energetically allowed, etc.

In this talk, I will report on our work toward the realization of a dipole lattice trap at the magic wavelength suitable for the $^1S_0$-$^3P_0$ transition in neutral Hg. This work includes the development of a suitable laser source at the predicted magic wavelength of 362 nm, the detailed characterization of the MOT[7] which will be the starting point to load the lattice trap, the development of a detection system with suitably low noise and the first observation of the neutral mercury atoms in shallow dipole traps[8]. The previous Doppler-free spectroscopy using clock laser source referenced on an ultra-stable cavity with instability of $10^{-16}/\sqrt{\tau}$ will be briefly reviewed, together with some renewed results corresponding to the characterization of the sub-hertz's linewidth laser[9].

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