Towards developing an ytterbium-ion optical frequency standard

Increasing accuracies of the atomic clocks have wide range of applications in various fields ranging from sophisticated technologies to precision experiments. Now-a-days the state-of-the-art atomic clocks based on the optical transitions with ultra-narrow natural linewidth has achieved an accuracy of ~$10^{-18}$, which means 1 s lead or lag over the age of the universe.

In India, we have started developing an optical frequency standard using Ytterbium-ion which will operate at the $|^2\!S_{1/2}; F=0, m_F=0\rangle - |^2\!F_{7/2}; F=3, m_F=0\rangle$ electric octupole transition at wavelength 467 nm. The $^2\!F_{7/2}$-state of the Ytterbium-ion has highest sensitivity among all other optical frequency standards for measuring temporal constancy of the fine structure constant. We will use an electrodynamical (Paul) trap of end-cap geometry for trapping a single ion which will be laser cooled for performing precision frequency measurements. We have fabricated a prototype of the trap using the design parameters that we have opted through numerical simulations. We have also estimated systematic uncertainties that are expected in our experiment. As of now, we have designed the ion trap, the ultra-high vacuum chamber and optics associated to the laser cooling. Some essential sub-components of the experiment such as electromagnetically shielded helical resonator for delivering the radio frequency to the trapping electrodes, atomic oven for producing nearly collimated ytterbium atomic beam and various electronic modules have been fabricated. Current status of the experiment and future plans will be discussed.