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Optical clocks based on multi-ion systems

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Abstract

The most successful implementations of the optical clock are single-ion clocks and optical lattice clocks. In contrast to the large signal to noise ratio with many atoms in the latter that of the former is limited by single ion. However, in most of the ion clocks a single ion in a Paul trap has been used. In this presentation we discuss our experimental studies to overcome inhomogeneous frequency shifts of the ions, which hinder extension to multi-ion systems. The one of the major shifts is the electric quadrupole shift associated with the electric field. In the first strategy we use ion species with null electric quadrupole moment. 115In+ ions in a linear trap realize the extension to a multi-ion clock. The second strategy is to engineer the trapping potential to suppress the quadrupole shift inhomogeneity. We have found that 40Ca+ ions in the ‘iso-spacing potential’ implemented with planar surface traps can be extended to the multi-ion clock. The last strategy uses the macroscopic coherence of Ca+ ions prepared in the iso-spacing potential. We found that coherent radiation by superradiance might be observed when more than 1000 Ca+ ions with the suppressed quadrupole-shift inhomogeneity are coupled to an optical cavity.