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Precision Experiments with Single Particles in Ion Traps for Tests of Fundamental Interactions

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Ion trap technology has made it possible to store, cool and observe single ions or ensembles of few ions under well controlled experimental conditions and at very low temperatures [1]. Single particles in traps allow for clean investigations of basic interactions and also for the determination of fundamental constants. This has been demonstrated by investigations of Quantum Electrodynamics (QED) with respect to the g-factor of the free electron [2] and of the electron bound in hydrogen-like carbon and oxygen [3], which form the most precise determinations of the fine-structure constant and of the mass of the electron, respectively. A precision test of CPT invariance has been performed in a proton-antiproton mass comparison with single particles in a Penning trap [4]. Optical quantum jump spectroscopy with single laser-cooled ions in rf traps has paved the way for optical frequency standards and for the investigation of a possible variation of fundamental constants. With the novel technique of deceleration, trapping and cooling, even high-accuracy experiments with highly charged ions up to uranium U91+ will be possible at the HITRAP facility at GSI Darmstadt [5].

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