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Optical Clocks with Trapped Ions

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The techniques of trapping and laser cooling of ions have allowed to perform laser spectroscopy of forbidden transitions with a resolution of a few hertz. These systems will be used as optical atomic clocks that offer higher stability and greater accuracy than the best primary cesium clocks available today. At PTB we have built an optical clock based on a single trapped ytterbium ion and have shown that the frequencies realized in two independent ion traps agree to within a few parts in 10ˆ16 . An interesting question from fundamental physics that can be investigated with optical clocks of this precision is the search for possible temporal variations of fundamental constants, based on comparisons between different transition frequencies over time. Presently, we can infer an upper limit for the relative change of the fine structure constant of 4*10ˆ-16 per year. We are also investigating the concept of a nuclear optical clock that will be based on a low-energy isomeric state in Th-229. Such a system promises further advances in accuracy and may open a new field at the borderline between atomic and nuclear physics.

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