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Search for Temporal Variations in Alpha Using a Yb^+ Optical Frequency Standard

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Optical frequency standards based on forbidden transitions of trapped and laser-cooled ions have now achieved significantly higher stability and also greater accuracy than primary cesium clocks. At PTB we investigate an optical clock based on the electric quadrupole transition $S_{1/2} - D_{3/2}$ at 688 THz in the $^{171}Yb^+$ ion and have shown that the frequencies realized in two independent ion traps agree to within a few parts in 10^{16}. Results from a sequence of precise measurements of the absolute transition frequency are now available that cover a period of seven years. Combined with data obtained at NIST on the quadrupole transition in Hg^+, this allows to derive a model-independent limit for a temporal drift of the fine structure constant alpha. We prepare to observe the electric-octupole transition $S_{1/2} - F_{7/2}$ of Yb^+ at 642 THz with sub-hertz resolution. This narrow-linewidth reference transition promises a reduced quantum-noise limited instability of the single-ion optical clock. The ratio of the 688 THz and 642 THz reference frequencies can be measured as a dimensionless number with a femtosecond laser frequency comb, independent from the realization of the SI second with cesium clocks. Repeated measurements of this quantity permit to search for temporal variations of alpha with increased sensitivity.