Measurement of the tensor differential polarizability between Rb clock states

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Atoms subjected to intense electric fields experience a shift in their energy levels. This shift, due to the polarizability of atomic states, enables the trapping of atoms in the focus an intense laser beam. Due to the hyperfine interaction the polarizabilities of the two hyperfine levels of ^{87}Rb differ on the 10^{-5} level, resulting in a broadening of the clock transition frequency in the highly inhomogeneous field of an optical trap. In general the atomic polarizability can be decomposed into a scalar and a traceless symmetric tensor parts, the latter being 10^{-2} that of the former. Any anisotropy of the polarizability is due to its tensor part and the shift depends on the relative angle between the electric field and the quantizing magnetic field. In our experiment we trapped ^{87}Rb atoms in an intense quasi-electrostatic field of a, linearly polarized, focused CO_2 laser beam and measured the shift in the microwave clock transition frequency using Ramsey spectroscopy. By changing the angle between the electric field of the laser and the magnetic field providing a quantization axis, we were able to isolate the 1 Hz fractional shift caused by the, previously unmeasured, tensor polarizability. The exact knowledge of the scalar and tensor parts of the polarizability are important in order to determine the black body shift of Rb clocks; an important secondary time standard; and can be compared with state-of-the-art atomic structure calculations.