New limits on Lorentz violation from a single trapped ytterbium ion

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In an attempt to unify all fundamental forces at the Planck scale, it is suggested that spontaneous breaking of Lorentz symmetry might occur. Such a Lorentz violation could lead to energy shifts of atomic states with non-spherical electron orbitals. We search for Lorentz violation using high-precision spectroscopy of such states in a Michelson-Morley type experiment, where the sidereal rotation of Earth probes the different directions in the universe. We directly compare the nearly orthogonally oriented substates of the highly sensitive $^2F_{7/2}$ Zeeman manifold in the $^{172}Yb^+$ ion with rf Ramsey spectroscopy and investigate the isotropy of space-time. With a robust composite pulse sequence, we suppress the influence of ambient noise and reach coherence times of more than 1s. As a result, we reach the highest sensitivity to Lorentz violation using precision spectroscopy to date and constrain the symmetry breaking coefficients at the 10^{-21} level. These results represent the most stringent test of this type of Lorentz violation in the combined electron-photon sector. The method is readily applicable to ion Coulomb crystals for future improved tests of Lorentz symmetry in the search for new physics.