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Cold Molecule Spectroscopy for Constraining the Evolution of the Fine Structure Constant

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Current theories that attempt to unify gravity with the other fundamental forces predict spatial and temporal variations in the fundamental constants, including the fine structure constant, α. Measurements of the variation of α by observation of multiple absorption lines from distant quasars are currently not in agreement. Due to the use of spatially diverse absorbers, these measurements are sensitive to relative Doppler shifts. Therefore an independent confirmation of the variation of α is important. Recently, there has been considerable interest in using spectroscopy of hydroxyl radical (OH) megamasers in interstellar space to constrain the evolution of fundamental constants. To aid in this work, we have performed precise laboratory-based measurements of ground-state, λ-doublet, microwave transitions in OH. Utilizing slow, cold molecules produced by a Stark decelerator, we have improved over the precision of the previous best measurement by twenty-five-fold for the $F' = 2 \rightarrow F = 2$ transition and by ten-fold for the $F' = 1 \rightarrow F = 1$ transition. Comparing these laboratory frequencies to those from OH megamasers in interstellar space will allow a sensitivity of 1 ppm for $\Delta\alpha/\alpha$ over 10^{10} years.