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Doppler-free two-photon spectroscopy of trapped HD+ ions

High-precision spectroscopy using resonance-enhanced multi-photon dissociation (REMPD) of the (v,L): (0,2) –(8,3) overtone of trapped, laser-cooled HD^+ molecular ions has been demonstrated with an unprecedented resolution of 0.8 ppb [1]. The resolution achieved is largely limited by Doppler broadening. To overcome this we are now implementing Doppler-free two-photon spectroscopy for HD^+ ion in the Lamb-Dicke regime. For this purpose, we have chosen the nearly degenerate (v,L): (0,3) –(4,2) and (4,2) –(9,3) rovibrational transitions of the molecule at 1.44 μm. We have performed realistic simulations of the spectroscopic signal taking into account saturation effects, ion trajectories, laser frequency noise, and redistribution of population by blackbody radiation. From these simulations sub-Doppler lines with a width in the 100-Hz range seem well feasible, allowing a relative uncertainty of the order of 10^{-14} for the two-photon transition [2]. A comparison of experimental results at that level with state-of-the-art HD^+ level structure calculations may lead to the most stringent test of molecular QED at the level of 4×10^{-11} [3]. Moreover, it will provide a new value of the proton-electron mass ratio with a relative uncertainty of ~10^{-10}, and enable searches for possible fifth forces ensuing from rolled-up higher dimensions with improved sensitivity [4].

References:

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