

ULTRAHIGH FINESSE CAVITY-ENHANCED SPECTROSCOPY OF DEUTERIUM MOLECULE FOR QED TESTS

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Molecular hydrogen, in the view of its simplicity, is well suited for testing quantum electrodynamics (QED) for molecules as well as for searching for new physics beyond the standard model such as new forces or extra dimensions. Furthermore, molecular hydrogen possesses a wide structure of ultranarrow rovibrational transitions with different sensitivities to the proton charge radius and proton-to-electron mass ratio. Therefore, the recent large progress in both theoretical and experimental determinations of the rovibrational splitting in different isotopologues of molecular hydrogen makes it a promising system for determination of some physical constants.

We present the most accurate measurement of the position of the weak quadrupole S(2) 2–0 line in molecular deuterium. We have collected the spectra with a frequency-stabilized cavity ring-down spectrometer (FS-CRDS) with an ultrahigh finesse optical cavity ($F = 637\,000$), optical frequency comb and operating in the frequency-agile, rapid scanning spectroscopy (FARS) mode. To reduce the systematic errors in line position determination, we analyzed our spectra with one of the most physically justified line-shape model describing the collisional effects, the speed-dependent billiard-ball profile (SDBBP), parameters of which are derived from *ab initio* quantum-scattering calculations.

Despite working in the Doppler-limited regime, we reached 40 kHz of statistical uncertainty and 161 kHz of absolute accuracy. The accuracy of our measurement corresponds to the fifth significant digit of the leading term in QED correction. We were also able to test two other higher-order QED terms. We observed 2.3σ discrepancy with the recent theoretical value.