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Precision measurements on the (2-0) quadrupole transitions in H₂

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The hydrogen molecule and its isotopologues has become a favorable test bench in the advancement of quantum mechanics in the molecular domain. Comparison between experiment and theory signifies a test of quantum electrodynamics in bound systems and it may be used to probe physics beyond the Standard Model (1). After the focus had been on measurement of the dissociation and ionization energies now it is shifting toward measurement of the rovibrational splittings. The long lifetime of the many (> 300) rovibrational levels in each isotopologue makes them into a benchmark testing system, in fact better than atomic hydrogen which has only one long-lived excited state. For a time it had not been possible to measure rovibrational transitions in saturation, but now that has been achieved, for the heteronuclear species HD (2,3) and HT (4).
Here we report on the next step: precision measurements of the (2-0) overtone rovibrational transitions in the H2 homonuclear species, that can only be probed via a quadrupole transition. The S(0) transition in para-H2 was measured as a narrow Lamb dip yielding an accuracy of 10 kHz. A novel problem was encountered: why only one recoil component observed when two are expected [6]? In the Q(1) line for the first time the hyperfine structure in a vibrational transition in H2 was resolved [7].

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