VIBRATIONAL LAMB-DIP SPECTROSCOPY OF WATER ISOTOPOLOGUES: HYPERFINE STRUCTURE IN $H_2{}^{17}O$ AND PERTURBATIONS IN $HD^{16}O$

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Doppler-free saturation techniques have revolutionized the precision and resolution of molecular spectroscopy. It sets the standard for improving the accuracy of the level structure of molecules by several orders of magnitude. In our studies we employ a NICE-OHMS setup for measuring spectra of water isotopologues in vibrational excitation to the 4^{th} polyad, at a wavelength of 1.4 μm [a]. The high intra-cavity circulating laser power allows for saturating the vibrational lines producing Lamb dips at typical widths of 400 kHz.

Here we present our work on two different water isotopologues $HD^{16}O$ and $H_2{}^{17}O$, in which various physical effects significantly alter the ordinary saturated Lamb-dip. In $H_2{}^{17}O$, thanks to the spin of the ^{17}O, we resolve the hyperfine structure, which can be exploited to extract hyperfine constants from a rovibrational transition. In $HD^{16}O$, where the deuteron breaks the para/ortho symmetry, perturbed spectral line shapes are observed, in particular for lines that exhibit small K_c splittings between lines of opposite parity. It is hypothesized that AC Stark effects are the cause for breaking up the line into a multi-component structure.

[a] R. Tobias, T. Furtenbacher, I. Simko, A.G. Csaszar, M.L. Diouf, F.M.J. Cozijn, J.M.A. Staa, E.J. Salumbides, W. Ubachs, Spectroscopic-network-assisted precision spectroscopy and its application to water, Nature Comm. 11, 1708 (2020)