Noise-Immune Cavity-Enhanced Optical Heterodyne Molecular Spectrometry Modeling under Saturated Absorption

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The Noise-Immune Cavity-Enhanced Optical Heterodyne Molecular Spectrometry (NICE-OHMS) is a modern technique renowned for its ultimate sensitivity, because it combines long equivalent absorption length provided by a high finesse cavity, and a detection theoretically limited by the sole photon-shot-noise. One fallout of the high finesse is the possibility to accumulating strong intracavity electromagnetic fields (EMF). Under this condition, molecular transitions can be easy saturated giving rise to the usual Lamb dips (or hole burning). However, the unusual shape of the basically trichromatic EMF (due to the RF lateral sidebands) induces nonlinear couplings, i.e., new crossover transitions. An analytical methodology will be presented to calculate spectra provided by NICE-OHMS experiments. It is based on the solutions of the equations of motion of an open two-blocked-level system performed in the frequency-domain (optically thin medium). Knowing the transition dipole moment, the NICE-OHMS signals (“absorption-like” and “dispersion-like”) can be simulated by integration over the Doppler shifts and by paying attention to the molecular Zeeman sublevels and to the EMF polarization[1]. The approach has been validated by discussion experimental data obtained on two transitions of C_2H_2 in the near-infrared under moderated saturation[2]. One of the applications of the saturated absorption is to be able to simultaneously determine the transition intensity and the density number while only one these 2 quantities can only be assessed in nonlinear absorption.

References
[1]Opt. Soc. Am. B 32, 838 (2015)
[2]Optics Express 16, 14689 (2008)