OPTICAL ABSORPTION SENSITIVITY BETTER THAN 1×10^{-12}

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Improved physical understanding of the REAL sensitivity-limiting processes, along with better technical solutions for cavity-enhanced optical heterodyne spectroscopy recently have allowed remarkable sensitivity improvements, presently at the absorption level of 5.2 x10^{-13} for a 1 s integration [a]. Here we review the several problems which led to this NICE-OHMS solution, and report recent progress with active control of the Residual Amplitude Modulation produced by the Electro-Optic Modulator.

Also, saturated absorption spectra near 1064 nm for HCCD, HCCH, and CO_2 are presented. The two additional lines are $^{12}C_2H_2$ ($2\nu_1 + \nu_2 + \nu_5$) R(12) [b] and $^{12}C^{16}O_2$ ($2\nu_1 + 3\nu_3$) R(6) [c], with their respective transition dipole moments of 50 μDebye and 6 μDebye. They are both weaker than our usual C_2HD($\nu_2 + 3\ \nu_3$) P(5) transition, which has a transition dipole moment of 70 μDebye, but all are recovered with excellent signal-to-noise ratios. The absolute resonance center frequencies of all three transitions have been measured (+/- 25 kHz) using as reference a Nd:YAG laser locked via frequency doubling on the a_{10} hyperfine-structure component of the R(56) 32-0 I_2 transition. The C_2H_2 resonance is about 4-fold weaker than that of C_2HD, while the pressure broadening rate of 34(1) MHz/Torr (FWHM) is similar. For the CO_2 transition, however, the saturated absorption signal is much weaker, by more than a factor of 350, and shows an elegant and unexpected lineshape which is believed to result from nearly overlapping one- and two-photon transitions.

[a] Jun Ye, Long-Sheng Ma, and John L. Hall, J. Opt. Soc. Am. B15, 6 (Jan 1998).
[b] K. Nakagawa, T. Katsuda, M. de Labachelerie, and M. Ohtsu, Opt. Comm. 107, 369 (1994).
[c] P. Fritschel and R. Weiss, Appl. Opt. 31,1910 (1994).