OPTICAL ABSORPTION SENSITIVITY BETTER THAN $1 \times 10^{-12}$

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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 $5.2 \times 10^{-13}$ 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$_2$H$_2$ ($2\nu_1 + \nu_2 + \nu_5$) R(12) $^b$ and $^{12}$C$^{16}$O$_2$ ($2\nu_1 + 3\nu_2$) R(6) $^c$, with their respective transition dipole moments of 50 $\mu$Debye and 6 $\mu$Debye. They are both weaker than our usual C$_2$HD ($\nu_2 + 3\nu_2$) P(5) transition, which has a transition dipole moment of 70 $\mu$Debye, 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$_2$H$_2$ resonance is about 4-fold weaker than that of C$_2$HD, 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.

