HIGH PRECISION 2.0 μm PHOTOACOUSTIC SPECTROMETER FOR DETERMINATION OF THE $^{13}CO_2/^{12}CO_2$ ISOTOPE RATIO

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We have developed a portable photoacoustic spectrometer for high precision measurements of the $^{13}CO_2/^{12}CO_2$ isotope ratio and the absolute molar concentration of each isotope. The spectrometer extends on our previous work at 1.57 μm [1], and now employs two separate intensity modulated distributed feedback lasers and a fiber amplifier, operating in the 2.0 μm wavelength region. Each DFB is selected to probe individual spectrally isolated ro-vibrational transitions for $^{12}CO_2$ and $^{13}CO_2$. The spectrometer is actively temperature controlled, mitigating variations in the two spectral line intensities and the temperature dependent system response.

For measurements of ambient concentrations of carbon dioxide at nominally natural abundance in dry air, we demonstrate a measurement precision of 140 ppb for $^{12}CO_2$ with a 1 s averaging time and 10 ppb for $^{13}CO_2$ with a 60 s averaging time. Precision in δ13C of better than 0.1 permil is demonstrated. The analyzer response is calibrated in terms of certified gas mixtures and compared to characterization by cavity ringdown spectroscopy. We also investigate how water vapor affects the photoacoustic signals by promoting collisional relaxation for each isotope.

[1] Z.D. Reed, B. Sperling, et al. App. Phys. B. 117, 645-657, 2014