A $^{14}CO_2$ cavity ring-down analyzer using a frequency comb referenced and stabilized quantum cascade laser system

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The radioisotope ^{14}C is a promising tracer in biomedical applications, due to the pervasiveness of carbon both in the human body, as well as in the complex drug compounds applied in modern medicine. However, the cost or sensitivity of traditional detection techniques such as Accelerator Mass Spectrometry (AMS) or Liquid Scintillation Counting (LSC) has hindered its wide application. In recent years highly sensitive laser absorption spectroscopy, such as Cavity Ring-Down Spectroscopy (CRDS), has been developed for trace gas analysis and its viability for $^{14}CO_2$ detection near and beyond the natural abundance ratio of 10^{-12} has been demonstrated [1]. Our group has developed and applied a Mid-infrared CRDS analyzer for $^{14}CO_2$ biomedical applications [2,3]. While the system was shown to be highly competitive in both cost and performance compared to LSC, wider applicability will require further improvements in its detection limit.

For accurate determination of isotope ratios in Cavity ring-down spectroscopy a precise knowledge of the frequency axis is required. A fiber-based difference frequency generated Mid-IR frequency comb was used as a reference for frequency calibration [4]. Stabilization of the QCL beat-note to the comb was achieved using a low bandwidth feedback loop. First spectra of $^{14}CO_2$ using the comb-locked laser were demonstrated, with an assumed laser frequency accuracy below 1 MHz. To increase cavity coupling efficiency and stability of the laser, passive optical feedback from an external reflector to the QCL was attempted, resulting in increased transmission through the cavity.

References:

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