Touching horizons with lasers

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High resolution spectroscopy in the infra-red is being employed for monitoring atmospheric pollutions with a variety of techniques. Our group uses two innovative forms of traditional Fourier transform spectroscopy (FTS) with broadband mid-infrared frequency combs. In dual comb spectroscopy the combination of light from two short pulse lasers with slightly different repetition rates produces interferograms without a moving mirror, yielding million times shorter measuring times than FTS, and unprecedented spectral resolution. In single comb Vernier spectroscopy implementation of cavity enhancement achieves in addition ultra-high sensitivity. We also employ narrow band diode lasers in cavity ring-down and wavelength modulation spectroscopies for the detection of methane in ambient air both in our laboratory, and over km path lengths in the atmosphere. The two mid-infrared frequency combs, based on femtosecond Erbium-doped fiber oscillators, are produced through difference frequency generation with periodically poled MgO doped lithium niobate crystals and stabilized at slightly different repetition rates around 250 MHz [1]. We performed dual frequency comb spectroscopy in the spectral range between 2900 cm-1 and 3150 cm-1 with 0.07 cm-1 resolution using a multipass cell with a path length of 580 meter. The sensitivity was about 7.6E-7 cm-1 with a data acquisition time of 80 ms. With the current setup, we measured a methane concentration of 1.9 ppmv in the ambient air in the laboratory with a minimum detection limit of 60 ppbv. In the remote sensing of greenhouse gases over long atmospheric paths carbon dioxide, methane and water vapor were the main absorbers. For these measurements a portable setup was used at the TAMU RELLIS riverside airport [2]. This research was funded by the Robert A. Welch Foundation, Grant No. A1546 and the Qatar Foundation under Grant No. NPRP 6-465-1-091.

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