Chirped-laser Dispersion Spectroscopy for Large-area Methane Detection

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Abstract: This work presents an overview of Chirped Laser Dispersion Spectroscopy (CLaDS) implementations to large area methane monitoring and recent developments in sensitivity enhancement techniques.
OCIS codes: (300.6360) Spectroscopy, laser; (260.2030) Dispersion; (300.6310) Spectroscopy, heterodyne;

Energy production from natural gas has been increasing significantly in the recent years, which promises a cleaner alternative to other fossil fuels. However methane, the major component (~95%) of natural gas, is a potent greenhouse gas and any leaks resulting from production, transport and distribution must be kept below 1% of the total production in order to obtain net climatic improvements over existing fossil fuel energy sources. Therefore there is pressing need for new methane leak detection, quantification, and long-term monitoring targeting especially the large areal transport and distribution networks and natural gas production facilities.

Methane leak detection has applications ranging from pipeline/fracking-site leak-detection, to safety monitoring in mining industries. Given the safety hazards many methane-monitoring applications require passive technologies that don't introduce any additional explosive risks. Laser spectroscopy based on low power semiconductor sources offers all-optical (i.e. passive) sensing configurations that efficiently and accurately quantify the atmospheric methane concentration. In this work Chirped Laser Dispersion Spectroscopy (CLaDS) is utilized to perform methane detection [1, 2]. In contrast to conventional absorption-based spectroscopic techniques CLaDS probes optical dispersion in the vicinity of molecular transitions, which provides unique measurement capabilities and enables new applications in chemical detection [3-5].

In this paper an overview of CLaDS implementations to large area methane monitoring in an open-path remote sensing configuration [6, 7], as well as passive distributed sensing systems based on optical fiber platforms[8] will be presented. Recent developments in CLaDS measurement techniques provide effective suppression of atmospheric turbulence/scattering-induced phase noise, while enabling improved signal-to-noise ratios via heterodyne enhancement provided by a strong optical local oscillator. Both theoretical modeling as well as experimental validations of the CLaDS methane sensing technologies will be discussed. Several prototype instruments operating in the near-infrared will be presented.

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