Local and Remote Measurements of Atmospheric Trace Gases

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Infrared spectroscopic detection of trace gases offers high sensitivity and specificity and therefore is broadly used in various applications, including monitoring of pollutions and greenhouse gases, analysis of respiration processes, etc. In this talk we review some of our recent advances in methods and techniques in this field, and the results on measurements of methane, acetone and acetylene are discussed. Three complimentary approaches were investigated: cavity ring-down spectroscopy (CRDS), wavelength modulation spectroscopy (WMS), and frequency comb spectroscopy (FCS) [1]. CRDS is applied for breath analysis, and the detection was optimized in the near-IR by selecting appropriate absorption peaks and varying gas pressure assuring also a high spectral resolution. The WMS technique is realized by modulating the current and therefore also the wavelength of a diode or quantum cascade laser at some frequency (f), so that the signal of the ratio of the amplitudes (2f/1f) is detected. It is highly sensitive, relatively low cost, but requires tuning the laser wavelength over the absorption lines of the species of interest. We consider local measurements with a multipass cell and also a long open-path configuration. The remote measurements were performed with retroreflectors [2] over paths exceeding 2km. The influence of the atmospheric turbulence was assessed. Further improvements of the signal-to-noise ratio of the WMS measurement is possible by using various denoising schemes and performing measurement in the mid-IR spectral region. The FCS approach can have several realizations, in particular direct FCS, Fourier transform, Vernier and dual FCS. The FCS approach and in particular that of dual FCS is more cost demanding, however being by its nature broadband, the dual FCS detection techniques allows acquiring spectra rapidly, permitting spectral acquisition in milliseconds. Efficient analysis of gas mixtures is possible by using neural network algorithms [3].

Acknowledgements: This work was supported by the Robert Welch Foundation, grant A1546.

References

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