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Advanced Broadband DIAL Sounder of Methane

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Methane is a powerful greenhouse biogas that plays a key role in several atmospheric environmental domains affecting the current enhancement of the greenhouse effect. It has been the cause of about 20% of the increased trapping of atmospheric infrared radiation during the past 200 years. In addition, it affects the oxidizing capacity of the atmosphere and, therefore, the lifetimes of other strong greenhouse gases. The trends of growing emissions from industrial zones and the rapidly melting permafrost of Northern America, Europe and Asia nowadays raise great concern. The development of remote sensors of methane, especially over facilities of peak concentrations, such as sewage treatment and biogas production plants is highly demanded.

The optical remote sensing has the advantage of obtaining selective analytical information unaffected by systematic external influence, e.g., disturbing electric fields, moisture, heat, multi- component gas mixtures, etc. We advanced pioneering studies in this research area to realize an effective differential absorption lidar (DIAL), which operates with broadband lasers thus replacing their narrowband counterparts [1-3]. DIAL is also advantageous in retrieving range-resolved data about the atmospheric content of methane unattainable by in-situ analysers.

The DIAL technique developed in our study utilizes the spectral properties of powerful broadband laser diodes matching the strong molecular vibration-rotational absorption bands of methane around 1.65 μm. The conventional scheme of differential absorption on dual wavelengths "On" and "Off" an absorption line is replaced with the ratio of confined segments of the integral absorption spectrum. The detected signal is a function of the absorption line strengths instead of the amplitude of the separate line subjected to pressure-broadening. Since the absorption spectra of methane are generally mixed with interfering spectra of water vapor, an optimal approach to DIAL measurement is needed that is insensitive to atmospheric humidity.

A solution based on multiplexation of the radiation of a single powerful laser diode in complementary spectral channels is proposed equalizing the absorption by water vapor in the range of the broad laser line. The high-resolution spectra of methane and water vapor are derived from HITRAN database of molecular absorption. Such lidar of compact design, reliable operation, low energy consumption and great dynamic range of sensitive measurement is promising for uses in mobile and airborne ecological surveillance of methane emissions, particularly over hardly-accessible regions, as well as, for gas pipeline control and reconnaissance of energy resources.

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