The instrument for lidar infrared remote measurement of industrial pollution

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Remote monitoring of industrial emissions into the atmosphere, the hazardous gases near landfills and incinerators, monitoring the presence of gas leaks in manufactures today play a huge role for human being. And this role will increase in the near future, because of aggravated ecological problems, business interests etc.

We present an instrument concept for lidar monitoring of industrial atmospheric pollution, based on the commonly used technique for tunable diode laser spectroscopy (TDLS), termed wavelength modulation spectroscopy (WMS). This instrument is being developed to determine the presence of technogenic pollution of atmospheric air in concentrations that pose a danger to nature, as well as human life and health. At the first stage, methane was chosen as the object of interest.

For remote measurement of atmospheric impurities, we propose to use a near-infrared diode laser (DL) operating in continuous mode with sinusoidal modulation of the injection current with a frequency of ~100 kHz. In the absence of molecules absorbing laser radiation, the photodetector detects radiation only at the modulation frequency \( f \). In the presence of absorbing molecules, a signal appears at higher harmonics (2\( f \), 3\( f \)). If the laser radiation is tuned to the center of the absorption line and modulated in the vicinity of this value, then the received signal at the first harmonic 1\( f \) is proportional to the total intensity of the detected radiation, and the 2\( f \) signal is proportional to the intensity absorbed by the molecules of the measured gas. Thus, the amplitude ratio of 2\( f \) signal and 1\( f \) signal characterizes the absorption of the measured gas and allows calculating of this gas concentration. Furthermore in remote measurements of laser radiation scattered from the surface, the total intensity of the detected radiation can vary by an order of magnitude, therefore, normalization of the 2\( f \) signal to the 1\( f \) signal is necessary.

The correct operation of this technique require that the radiation frequency of the DL should be stabilized at the center of the absorbing line with high accuracy: ~1% of the absorption line width, which at atmospheric pressure is \( \sim { 10 }^{- 3} \text{ cm}^{-1} \). Such high stability of the laser radiation frequency is achievable using the 3\( f \) signal, which passes through zero in the center of the line.

During the implementation of the project a compact and lightweight instrument, that can be
installed on the unmanned aerial vehicles (UAVs) to control the emission of harmful gases at industrial sites, landfills, will be created. Currently, such instrument using other operation algorithms have a mass of 10-20 kg and are usually installed on manned helicopters. The installation of such instrument on the UAV will greatly simplify and reduce the cost of industrial pollution monitoring. First tests of our instrument are planned on the second half of 2020.

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