UPGRADED RAMAN LIDAR WITH ULTRASPECTRAL RESOLUTION

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Upgraded Raman Lidar with spectral resolution of $d\lambda/\lambda \leq 10^{-3}$ have been design and elaborated for the aerosearch of leaks on the main gas pipelines. The sensing is carried out by 7ns - pulses of DPSS laser with energy of 10 mJ at 300Hz frequency and wavelength of 261.7 nm. Polycromator have been implemented on base of the concave grating (N=1200 mm) and operates in 4th diffraction order. Lidar measures the leaks of CH4 with concentration of 2 ppm and above. Scanning in angles of ±30o and at frequency of 20 Hz allows to carry out measurements on inclined courses.

Lidar studies make it possible to discriminate substances of technogenic and natural origin and their dispersion and absorption in the entire earth's biosphere and to carry out efficient remote determination of local concentrations of harmful and explosive condensed and gaseous impurities in the atmosphere and on the land and water surface, including the detection of leaks from oil and gas pipelines. Modern Raman lidars can be made with very small size and mass. This is entirely done by using compact solid-state lasers with diode pumping and lightened optics. As is well known, the improvement of the instrumental accuracy and the mass-and-size characteristics in optoelectronic complexes is associated with the reduction of the wavelength of the radiation. The use of UV illumination and reception facilities in lidars makes it possible to qualitatively increase the sensitivity and accuracy of the detection of chemical substances and physical objects. Traditional means of increasing the sensitivity and selectivity of detector systems as a rule are associated with increasing the speed of the entrance optics and decreasing the spectral width of the signals. In lidar complexes, such an approach is often accompanied by the need to increase the power of the probe radiation, and this may pose a hazard to the safety of the eyes of people who enter its region of activity. Therefore, to satisfy the enumerated requirements on the measurement accuracy, methods and devices must be developed that are capable of significantly reducing the background illumination and increasing the noise immunity and the SNR.

Even though molecular vibrations have a spectral line width no greater than 1 cm^{-1}, the Raman scattering spectra of actual molecules, especially in the short-wavelength region, can lie close to each other. For example, the wave numbers of the vibrational transitions in nitrogen and methane are not much different. Therefore, the use of the Raman method to select a wide array of atmospheric impurities requires ultrahigh spectral resolution, which makes it possible to eliminate overlap of the SRS spectral lines when the concentration difference of the corresponding molecules is substantial.

The differential Raman scattering cross sections of the vibrational transitions of molecules increase with decreasing wavelength. The SRS method therefore has the greatest sensitivity and response rate in the UV region. When $\lambda < 250$ nm, there is an appreciable effect from the extinction of the atmosphere, and the level of background illumination sharply increases in the region $\lambda > 320$ nm, especially in the daytime. In the UV region, the main absorbing components in the atmosphere are molecules of ozone O3 and oxygen O2. However, ozone has an extremely low concentration in the troposphere, while oxygen absorbs in the range 180-220 nm. Therefore, λ = 250-320 nm is the most suitable range for operation in the near-earth layer of the atmosphere. [1]

Our staff has developed a unique set of laser-optic components and the latest technology of UV high-precision and high-dispersion optics, has created and introduced series of compact solid-state lasers with diode pumping at various enterprises, and is using the latest achievements in the area of photodetector devices, baseline models, and automatic means of recording and processing signals in the gigahertz range of frequencies. In test measurements at a flight height from 100 to 450 m, data were established on the sensitivity of the lidar to methane (6 ppm) and hydrogen sulfide (2 ppm). [2]

Aviation lidar with ultraspectral resolution can find wide application not only in the efficient monitoring of the state of the near-earth atmosphere and the ecological safety of the environment, but also for carrying out a wide range of studies in the physics and chemistry of the atmosphere, geophysics, and geology.

[1] Alimov ; S. V. Kascheev ; D. V. Kosachev ; S. B. Petrov ; A. P. Zhevlakov «Multifunctional lidar for needs of oil-and-gas pipes» Proc. SPIE 6610, 66100B (2007).

[2] S. Alimov, D. Kosachev, O. Danilov, A. Zhevlakov, S. Kashcheev, A. Mak, S. Petrov, and V. Ustyugov, "Aviation Raman lidar with ultraspectral resolution," J. Opt. Technol. 76, 199-207 (2009).