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A COMBINED RAMAN LIDAR FOR LOW TROPOSPHERIC STUDIES

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One of the main goals of laser sensing of the atmosphere that was aimed at from the very beginning was the development of techniques and facilities for remote determination of the atmospheric meteorological and optical parameters[1].

Of the lidar techniques known at present the Raman-lidar technique occupies, in a certain sense, some specific place. Really, on the one hand Raman lidar returns due to scattering on different molecular species are very simple for interpretation and for extracting the information on the atmospheric parameters sought, but, on the other hand, the performance of these techniques in a lidar facility is overburdened with some serious technical difficulties due to extremely low cross sections of Raman effect. As a consequence, Raman lidars are not yet widely used in the atmospheric studies, although the advantages of such lidars have already been clearly demonstrated in many experimental works.

During the last decade some efforts have been undertaken at the Institute of Atmospheric Optics, Tomsk, USSR, to develop Raman lidar techniques for remote determination of the atmospheric temperature and optical parameters profiles based on the use of pure rotational Raman spectra of molecular oxygen and nitrogen as well as of the aerosol light scattering[2,3].

The present paper presents some results of further investigations into this problem, which enabled us to construct a combined Raman lidar capable of acquiring simultaneously the profiles of atmospheric temperature, humidity and some optical characteristics in the ground atmospheric layer up to 1 km height. Basic parameters of the lidar have been described earlier in [2] and [3].

Raman spectra of atmospheric species are excited in this lidar with the radiation of a copper-vapor laser emitting the beam of about 6 W mean power at a PRF of 7 kHz at $\lambda = 510.6$ nm. The use of an unstable resonator in this laser provides for obtaining a 1 minute angular wide beam with no additional beam expansion at the laser output.

The spectroscopic problem of isolating simultaneously two portions of pure rotational Raman spectra of N_2 and O_2 and vibrational Raman line of H_2O vapor is solved with the use of a specialized double grating monochromator, in which the vibrational Raman line of H_2O vapor ($\lambda = 627.4$ nm) is isolated at the exit of the first monochromator. The spurious signal due to Mie Rayleigh scattering in the "humidity" cha-

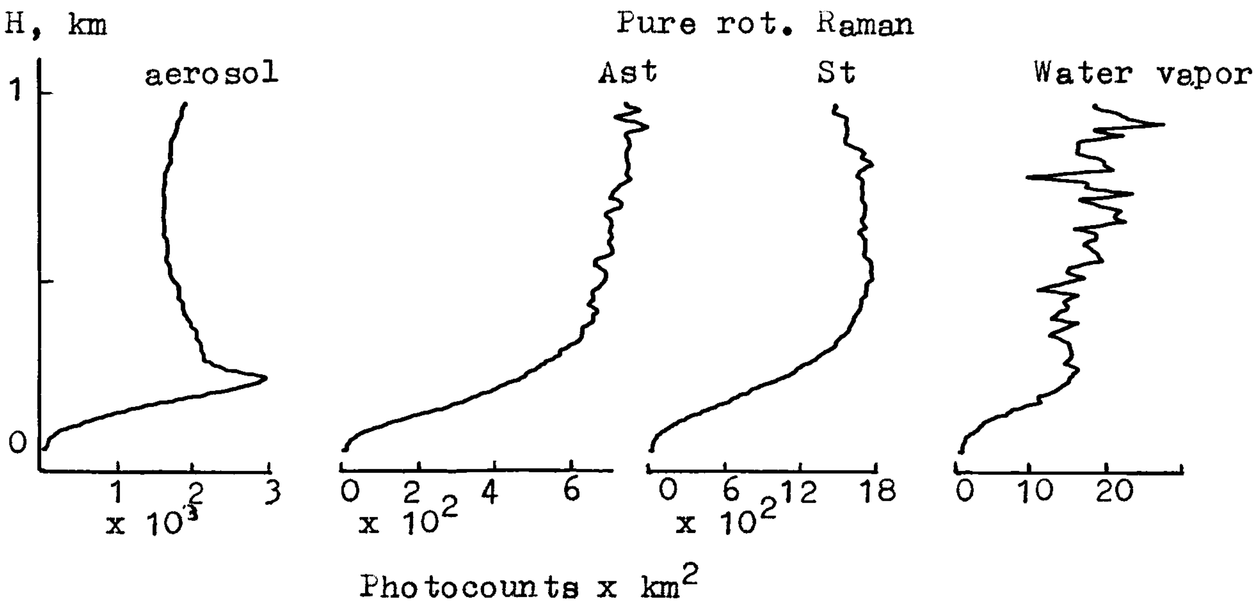

Fig. 1
Lidar returns corrected for r^2 dependence

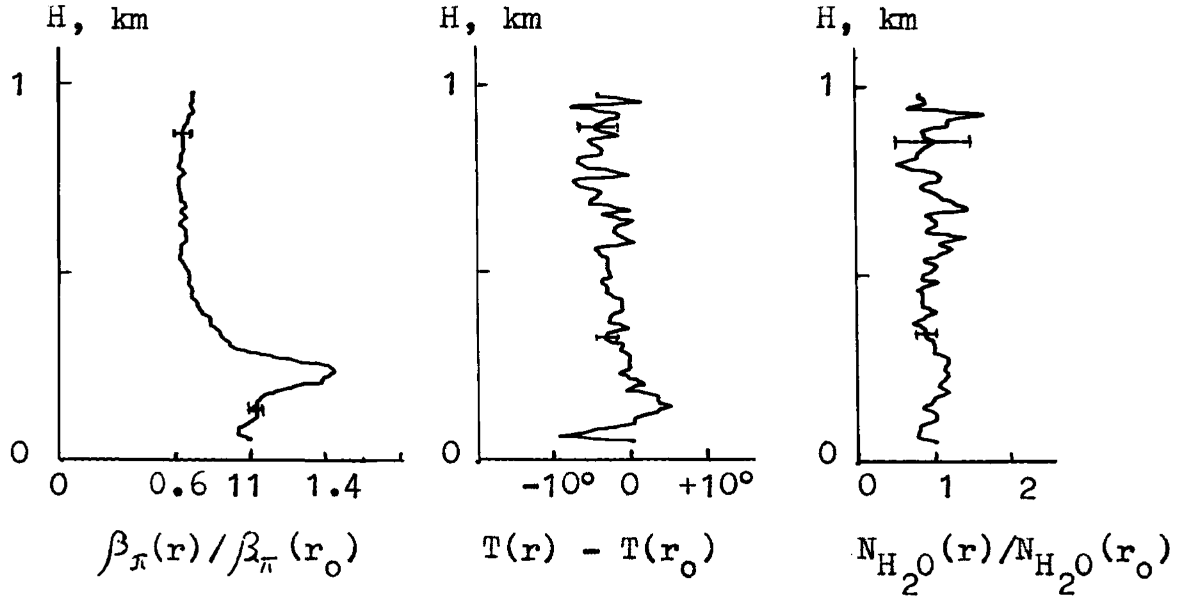

Fig. 2
Atmospheric parameters' profiles obtained from lidar returns presented in Fig. 1

nnel is suppressed by a properly chosen red-glass band filter.

The lidar data digital acquisition system used in our lidar allows four lidar returns (three Raman signals + one due to aerosol scattering) to be recorded simultaneously using the photon counting technique, up to 2 km height with the spatial resolution of 15 m. The on-line micro-computer enables one to perform the data acquisition, storage and processing in real time. The profiles of the atmospheric parameters sought can be finally plotted in the form of altitude or range functions.

Figure 1 presents the lidar returns recorded with this lidar from the ground atmospheric layer, as functions of altitude. The signals are corrected for r^2 dependence (r is the range). Figure 2 represents the profiles of atmospheric temperature, humidity and aerosol backscattering coefficient retrieved from the signals of Fig. 1. It should be noted that in the cases of humidity and aerosol backscattering the functions $\beta_\pi(r)/\beta_\pi(r_0)$ and $N_{H_2O}(r)/N_{H_2O}(r_0)$ are presented in Fig. 2, showing the vertical distribution of water vapor number density and aerosol backscatter as normalized by their values at the lowest point of the path.

In conclusion we should like to underline that the results presented in this paper only demonstrate the capabilities of the combined Raman lidar to investigate some physical processes occurring in the ground atmospheric layer, while the results of such studies are yet to be obtained in the near future. Also some technical improvements are needed in order to make this version of Raman lidar operate in the daytime.

References

1. Laser Monitoring of the Atmosphere. Ed. by Hinkley, Springer Verlag, Berlin, Heidelberg, London, New-York 1976.
2. Yu.F.Arshinov, S.M.Bobrovnikov, V.E.Zuev, and V.M.Mitev. Appl.Opt., v.22, N19, pp.2984-2990, 1983.
3. S.M.Bobrovnikov, Remote determination of optical parameters of the atmosphere using pure rotational Raman lidar, The 7-th All-Union Symposium on Laser and Acoustic Sensing of the Atmosphere. Conference Abstracts, Tomsk, USSR, 1982, pp.16-18.