Application of Raman and Brillouin lidar to measurement of air and water temperature profiles*

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In this paper we discuss the measurements of the vertical temperature profiles in the sea and in the atmosphere [1] using backscatter-frequency doubled YAG:Nd^{3+} pulsed laser radiation.

Atmospherical experimental lidar system is shown in Fig. 1.

Theory: The use of the ideal gas law in the form

$$P(h) = \varrho(h)T(h)R/M$$

where: h — altitude, P — pressure, ϱ — density, R — universal gas constant, M — molecular weight, leads to:

$$\Delta P(h)/P(h) = [\Delta\varrho(h)/\varrho(h)] + [\Delta T(h)/T(h)].$$

For a fixed altitude h, where the pressure during the measurement can be usually taken as constant

$$\Delta\varrho(h)/\varrho(h) = -\Delta T(h)/T(h).$$

For constant pressure (altitude), the signal received by a lidar system measuring Raman signal backscattered from nitrogen would indicate

$$\Delta S_{N_2}(h)/S_{N_2}(h) = -\Delta T(h)/T(h)$$

where $S_{N_2}(h)$ is the backscattered Raman signal, proportional to $\varrho_{N_2}(h)$. Thus, at any altitude, where the partial pressure of nitrogen is approximately constant, the Raman backscatter gives a direct indication of temperature fluctuations [2]. The results of experiments are shown in the Table.

Brillouin-Raman system for monitoring vertical water temperature profiles is presented in Fig. 2.

Measurements of the temperature are to be carried out by using the Raman effect. In the Raman effect, unlike the Brillouin effect, the wavelength of the

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backscattered light is altered considerably by the interaction of the light with energy levels of the salt and water molecules. Since the population of these levels is temperature dependent, the characteristics of the Raman spectrum dep-
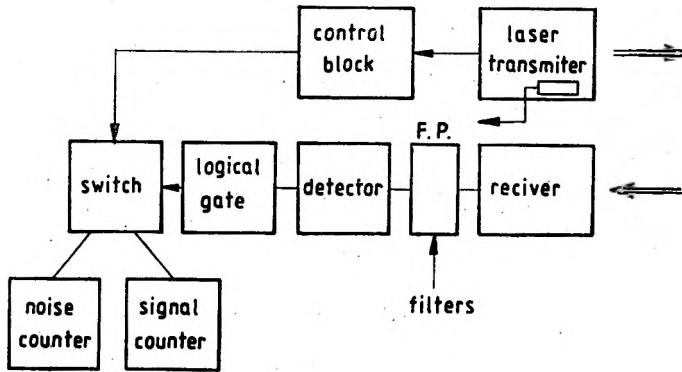

Fig. 1. Block diagram of lidar system

end on the water temperature. It turns out that both the wavelength and the polarization of the Raman light are temperature dependent. A recent study by Chang and Young has shown that if the laser light is circularly polarized, the Raman scattered light will show depolarization which is temperature dependent. This dependence is different from that of the Brillouin effect mentioned above [3–5].
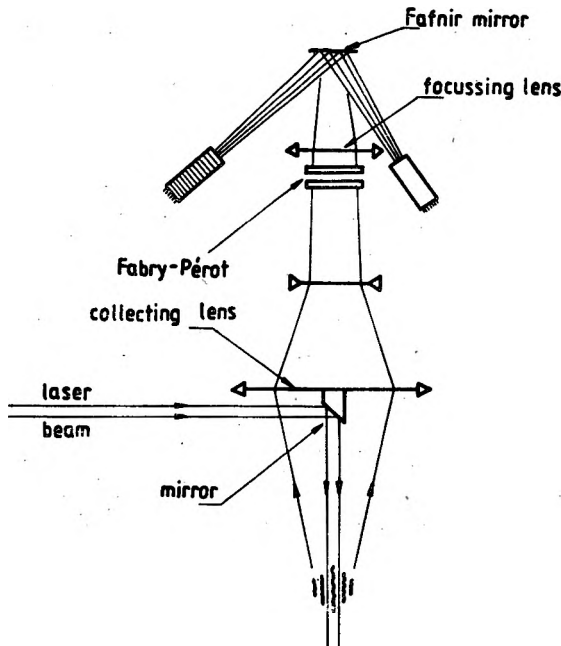

Fig. 2. Fabry-Pérot system

We have designed an important experiment to test a new method, using backscattered radiation from a laser beam to measure a temperature, Brillouin and Raman scattering all are utilized to evaluate the parameters [6].

h (km)	$(\mathrm{var}\ T)^{1/2}/\bar{T}$	S (photon counts)
0	0	0
0.5	2.47×10^{-3}	2.90×10^5
1.0	4.05×10^{-3}	1.20×10^5
5.0	1.70×10^{-2}	6.70×10^3
10.0	2.90×10^{-2}	2.30×10^3

To obtain the information the beam of frequency doubled YAG : Nd$^+$ pulse laser should be used together with a Fabry-Pérot interferometer and interference filters. The results will be checked by direct measurement.

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