SCATTERING OF LIGHT BY A TURBULENT LIQUID

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The correlation functions and spectra obtained as a result of an investigation of the scattering of light by a stationary liquid in the process of relaxation of a single disturbance indicate the presence of long-lived low-frequency eddies.

In [1] it was shown that turbulence in a flow of water leads to the appearance of fluctuations in the intensity of the scattered light, whose characteristics are related with the character of the flow. This paper presents the results of an investigation of the scattering of light by a stationary liquid into which a single perturbation is introduced by means of a falling body.

The beam of a helium-neon laser was directed into a vessel measuring 200 × 600 × 350 mm^3 containing distilled water and absorbed by a Wood horn mounted in the wall of the vessel. The radiation scattered forward at an angle of 10° to the beam axis from a volume of the order of 1 × 1 × 0.5 mm^3 was recorded by means of a FEU-51 photomultiplier and a MPO-2 loop oscillograph.

The disturbance was introduced by means of an aluminum disk 80 mm in diameter and 5 mm thick falling freely along a guide from the surface of the liquid to the bottom of the vessel (200 mm).

Oscillograms 1, ..., 5 of the intensity of the scattered radiation recorded are presented in Fig. 1 for times 2.5, 7, 14, 24, and 38 min after the introduction of the disturbance. It is clear from these oscillo-

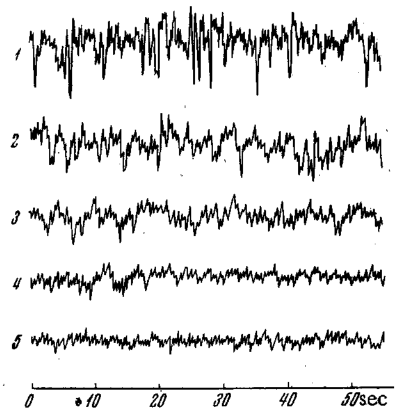

Fig. 1

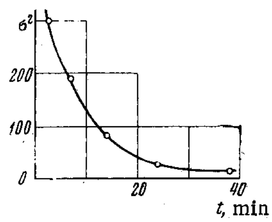

Fig. 2

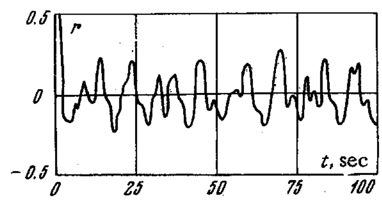

Fig. 3

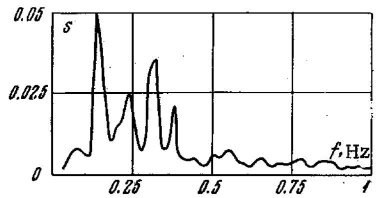

Fig. 4

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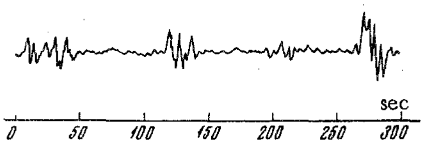

Fig. 5

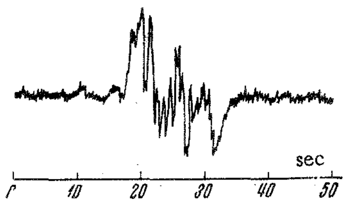

Fig. 6

grams that the amplitude of the intensity fluctuations decreases with time. Figure 2 shows the variation with time for the mean-square values of the intensity fluctuations of the scattered radiation in relative units for one of the experiments. The dependence is almost exponential.

In order to find the spectrum $s(f)$ of the intensity fluctuations we calculated the autocorrelation function [2]

$$r(t)=\frac{1}{(T-t)\sigma^2}\int_0^{T-t} I(t+\tau)\,I(\tau)\,d\tau \,. \tag{1}$$

Here I(t) is the variable component of the scattered light intensity, σ^2 its variance, and T the duration of the investigated interval of the realization.

The spectrum $s(f)$ was calculated from the equation

$$s(f_n)=\frac{2}{T'}\int_0^{T'} r(t)\cos(2\pi f_n t)\,dt \quad \left(T'<T,\quad f_n=\frac{n}{T'}\right). \tag{2}$$

Here f_n is the frequency of the n-th harmonic.

The value of T was taken equal to 160 sec, the value of T' to 100 sec. The integration was carried out on a computer with a step of 0.2 sec. A typical autocorrelation function is presented in Fig. 3, its spectrum in Fig. 4.

These graphs indicate a slow decrease in the value of the autocorrelation function, which suggests the presence of slowly damping low-frequency components, and a nonsmooth spectrum. This is apparently attributable to the existence, together with small-scale eddies, of long-period motions of the liquid. In fact, Fig. 5 shows part of an oscillogram registering the multiple passage through the region investigated of the same eddy formation at approximately equal intervals of time (in this case of the order of 75 sec).

An oscillogram showing the passage of the eddy formation to an enlarged time scale is presented in Fig. 6.

LITERATURE CITED

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2. V. S. Pugachev, Introduction to Probability Theory [in Russian], Nauka, Moscow, 1968.