EXPERIMENTAL INVESTIGATIONS INTO THE PASSAGE OF LIGHT THROUGH A TURBULENT FLUID

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Causes for the divergence of theoretic estimates and observable effects on the attenuation of a laser beam in a pure turbulent fluid obtained using a complex of devices at the Institute of Theoretical Physics, Siberian Division, Academy of Sciences of the USSR, are analyzed.

Similitude criteria relating the attenuation of a laser beam in a pure turbulent medium to its thermodynamic parameters has been treated in [1]. The ratio between the kinematic viscosity coefficient and the thermal diffusivity coefficient of the fluid [2] must be added to these criteria under nonsimilitude scattering of the heat from turbulent friction. Several of the best devices with which the passage of light through a disturbed fluid has been studied have been described [3, 4]. The experimental conditions were such that flow was assumed to be isothermic to the extent that turbulent fluctuations were low. Distilled water and doubly distilled water were used in those experiments using water. The observed effects in a number of cases were substantially above the possible theoretic estimates and substantially diverged in different types of devices with comparable parameters.

A complex of experimental hydrooptical devices has been built at the Institute of Theoretical Physics, Siberian Division, Academy of Sciences of the USSR, in which previous experimental schemes [3, 4] have been repeated. An external reference beam was introduced into a device together with the passage of a laser beam along the axis of a pipe filled with a fluid flow. The intensity of the beam passing through the fluid was continuously compared to the intensity of the reference beam. Both light beams were formed by separation of the radiation from a single laser and the error due to the instability of the radiation source was excluded in comparing the measurements. The pressure in the continuous-flow and discontinuous-flow tanks in the device with an interferometer were equated either through a small connective passage to the middle of the channels, or in terms of the indices of the pressure gauges connected to each of the independent tanks.

Experiments with an interferometer revealed a small broadening and blurring of the interference fringes similar to that observed in experiments with the passage of a laser beam through a turbulent atmosphere. No shift in the fringes, which had been observed [4] under a described experimental scheme, occurred within the measurement precision.

Attenuation of the beam in devices with passage of a laser beam through a fluid travelling through a pipe depended both on the dimensions of the device and on the method of fluid delivery. Total optical purity of water, even after taking careful measures to clean the device and the water, nevertheless could not be obtained, but the observed effects were significantly lower than in [4]. The passage of both bubbles, apparently of cavitations origin, and of solid microscopic particles could be observed here in the transparent channel.

Let us illustrate these observations by several results obtained by passing light through a slit between coaxial disks. A disturbance was created by rotating one of the disks. The device was a copy of that described in [3]. Disturbances were introduced every 3, 10, and 60 sec. An increase in the intensity

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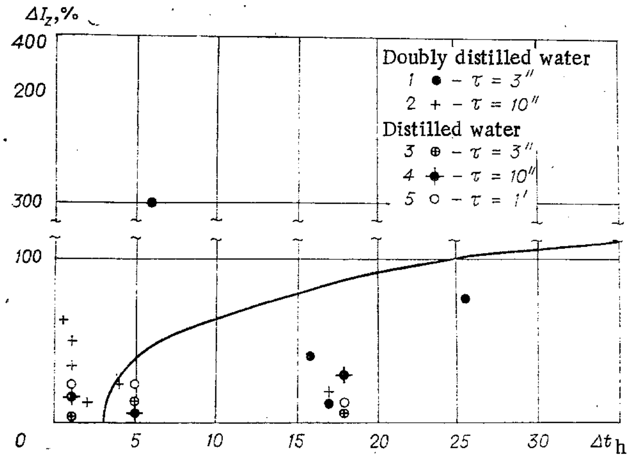

Fig. 1

of scattered light for any fluid clarification times was observed in our experiments. This increase reached 35-55% for doubly distilled water and 5-25% for distilled water. In [3] scattered light began to increase only after 3-4 h of clarification.

Results are given in Fig. 1 of our experiments and of experiments described in [3] on the dependence of the scattering intensity of a laser beam on time following the disturbance of a fluid by a rotating disk [ΔI_z is the variation in the photoelectric current during the disturbance (in percentage of the initial current), Δt_h is fluid clarification time (in h), and τ is the time at which the disturbance was introduced].

We may assume that the divergences in these experiments are explained by the influence of solid particles of various dimensions. It is highly probable that coarser particles, that practically did not undergo Brownian motion, settled relatively easily in the quiescent water, and were rapidly mixed during hydrodynamic disturbances, appeared in our experiments. A significant number of particles that underwent Brownian motion were apparently present in other experiments [3].

This is probably more the case in that the characteristic Reynolds number of the flow was less than the critical in experiments with a rotating disk.

A long-term program of hydrooptical investigations using a complex of testing units is currently underway at the Institute of Theoretical Physics, Siberian Division, Academy of Sciences of the USSR and at the Georgian Polytechnic Institute.

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