TIME CHARACTERISTICS OF ACOUSTIC SIGNAL GENERATED BY A SMALL VOLUME OF LIQUID UNDER THE ACTION OF HIGH–POWER LIGHT FIELD

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In this paper we present some results of physical experiment on generation of acoustic echo from water droplet aerosol irradiated with high–power laser radiation. It is shown in the paper that in the case of short laser pulse and small volume of interaction the duration of acoustic signal is determined by the energy absorbed.

When excitation of acoustic waves with laser radiation is studied, two limiting cases of acoustic pulse formation are considered: when $t_p c/L > 1$ (t_p is the duration of the exciting laser pulse, L is the size of interaction zone, and c is the sound speed in the irradiated medium), then an acoustic pulse copies the shape of exciting laser pulse; when $t_p c/L < 1$ the acoustic pulse duration $t_{a.p.}$ is determined by the time of sound propagation through the interaction volume.[1,2]

These approximations are sufficient when the action of laser radiation does not result in induced phase transitions in the irradiated substance. If the result of interaction between radiation and substance is its evaporation or explosion, then the situations are possible where duration of the processes t_{pr} is longer than the time of sound propagation through the interaction zone and duration of the exciting laser pulse ($t_{pr} > L/c$ and t_p). In this case the duration and shape of the excited acoustic pulse are determined by duration of processes initiated by the radiation. It is possible to separate out the following processes resulting in variation of the medium density during the explosion: explosive evaporation, i.e., phase transition of liquid to vapor during explosion; evaporation of hot fragments formed after explosive destruction of superheated liquid; and, heating of ambient air due to heat exchange with vapor and heated liquid.

In the previous papers[3,4] an acoustic signal was examined, which was generated by an area of interaction between powerful light field and aerosol, presenting an acoustic response to all the processes listed here. In this case the condition $t_p c/L < 1$ was fulfilled. The duration of acoustic pulse was determined by experimental geometry, corresponded to duration of sound propagation through a cross section of interaction volume, and was independent of radiant energy density.

In the present experiment the area of interaction of laser radiation with liquid presented a thin disk of dimensions: less than 10^{-3} m in section perpendicular to direction of acoustic signal reception and 10^{-5} m in longitudinal section. A TsTS–19 piezoceramic detecting element with a transmission band of 2.5 MHz was used as a receiver of acoustic signal. An exciting radiation pulse of duration $t_p = 3$ μs was generated with a CO_2 laser. Thus, the condition $t_p c/L > 1$ is fulfilled, under which the acoustic pulse duration is determined by duration of radiation action. However, as shown in Refs. 5 and 6, variations of phase state and heat exchange do not always fit in the interaction time. The conditions of explosive boiling–up can be attained during the entire exciting pulse including the end of it. The explosion itself, i.e., egress and divergence of vapor condensate lasts for a period much longer than that of the initiating laser pulse. Evaporation of hot fragments continues without action of radiation at the expense of particle heat accumulation.

Depicted in Figure 1 is duration of acoustic pulse positive phase $t_{a.p.}$ *vs* density of exciting radiant energy E (curve *1*). A specific bend in the plot obtained is related to the explosive boiling–up threshold.

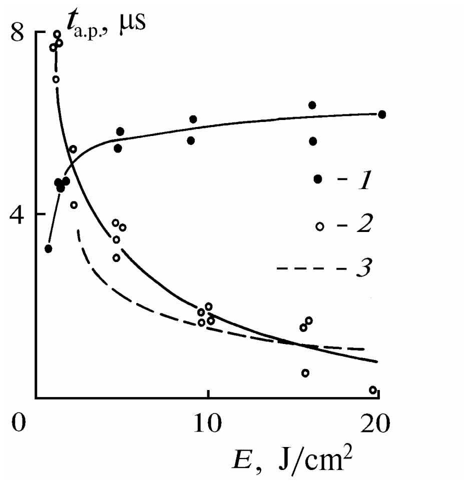

FIG. 1.

The time delay between the start of acoustic wave formation and the start of laser pulse excitation is presented with curve *2*. The time delays of destruction of superheated liquid found from acoustic measurements are in good agreement with the results previously obtained by the optical method (curve *3*).[5]

Thus, it is shown in the paper that under the action of a 3 μs laser pulse on a liquid layer with thickness of $L < ct_{pr}$ the temporal characteristics of an acoustic response depend on exciting radiant energy density. They are determined by characteristic durations of phase transitions of liquid in a light field.

A detailed estimate of additive contribution of the aforementioned processes to acoustic signal formation

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requires further investigations. Such investigations, provided that the volume of interaction is small, when a shape of acoustic pulse is determined by the shape of exciting wave and the dynamics of the process, enable one to find the relation between the excitation parameters and the dynamics of explosion and evaporation.

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