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ENERGY ATTENUATION OF ULTRASHORT OPTICAL PULSES BY SCATTERING MEDIA

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We report preliminary results of direct measurements of one of the main characteristics of a scattering medium (the attenuation coefficient) interacting with an ultrashort pulse of optical radiation. Experiment revealed a decrease in the attenuation of an ultrashort pulse compared with the case of continuous illumination.

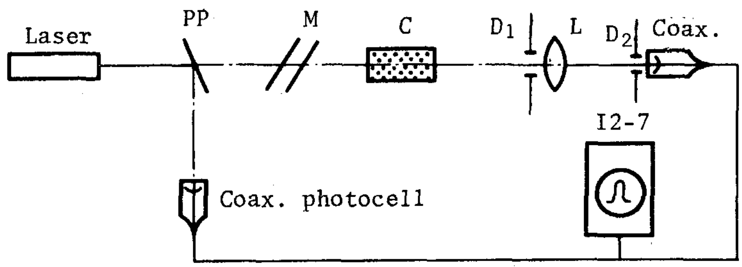
To describe the transport of optical radiation in scattering media, it is necessary to know their optical characteristics. These are pretty well known by now for the stationary scattering process, both from the theory of scattering of a plane monochromatic wave by a particle (the Love-Mie theory [1, 2]) and from experiment [3]. There are no such data, however, for nonstationary conditions, when an important role is assumed by the finite character of time of interaction between the photon flux and the scatterer.

The purpose of the present paper is to report preliminary results of direct measurements of one of the main characteristics of a scattering medium, the attenuation coefficient, in interaction with an ultrashort pulse of optical radiation.

The measurement setup is shown in the figure. A laser system generated an optical pulse of duration 50 μsec at a wavelength 0.69 μ [4]. The laser beam passing through the scattering medium was collimated with a long-focus lens (f = 1000 mm) and registered with a coaxial photocell FEK-15 and an oscilloscope I2-7. To prevent back-scattered laser light from entering the recording system, we placed at the focus of the lens a diaphragm D_2 with a diameter corresponding to the divergence of the incident laser radiation (0.003 rad). Part of the entering laser radiation was diverted with a beam-splitting plate to another FEK-15 photocell, the signal from which was also registered with the I2-7 oscilloscope. Such a scheme made it possible to compare the laser pulse passing through the scattering medium with a reference laser pulse in each measurement. To calibrate both channels, the scattering medium was replaced by dielectric mirrors that attenuated the beam in the investigated channel in such a way that when the mirrors were replaced by the scattering medium the amplitudes of the registered laser pulses were approximately the same in the two channels. This made it possible to extend the dynamic range of the recording system and to measure the attenuation coefficients of rather dense media.

The transmission of continuous illumination through a scattering layer was measured by a similar optical system. The light source was an incandescent lamp (KIM-75) in conjunction with an interference filter with a transmission bandwidth 20 Å at a wavelength 0.69 μ. The radiation passing through the scattering medium was registered with an FEU-28 photomultiplier.

The concentration of the scatterers in the investigated media did not exceed 10^8 cm^{-3} for small particles and 10^5 cm^{-3} for large ones (as a result, the distance between scatterers was not less than ten scatterer diameters). This excluded a possible influence of interference



PP - plane-parallel plate, M - attenuating mirror system, C - cell with scattering medium, D_1, D_2 - diaphragms blocking the laterally scattered radiation, L - lens.

effects in scattering of partially coherent radiation [5].

The optical thickness of the scattering medium, for both continuous and pulsed radiation, was determined from the relation $\tau = \ln(I_0/I)$, where I_0 is the signal recorded when the radiation passes through a cell without scatterer and I is the signal with a scatterer in the cell.

The table lists the measured optical thicknesses of suspensions of polystyrene latexes with different values of the parameter $\rho = 2\pi a/\lambda$ (a is the particle radius and λ the wavelength of the incident radiation) and of lycopodium spores.

Scattering medium	ρ	τ_{cont}	τ_{pul}	τ_{cont}/τ_{pul}
Polystyrene latexes	3.6	2.8	1.9	1.5
	4.3	3.0	2.2	1.4
	6.5	2.8	2.0	1.4
Lycopodium	135	4.6	3.5	1.3

The values of τ_{pul} in this table are the results of averaging 4 - 5 individual measurements, with an absolute-value scatter not larger than 0.2. The maximum absolute error for τ_{cont} does not exceed 0.05. The results show that the attenuation of pulsed radiation in the investigated scattering media is systematically lower than the attenuation of continuous radiation in the same section of the spectrum. The obtained differences in the measured optical thicknesses τ_{pul} and τ_{cont} greatly exceed the possible maximum errors in the measurements and in the data reduction.

An analysis of the experimental conditions shows that the observed "transparentization" of the medium in the case of a short laser pulse, by more than three times compared with radiation that is constant in time, is not connected with such effects as the thermal action on the properties of the medium, the spectroscopic saturation effect, and self-focusing [3].

We note in conclusion that to explain the nature of the observed effect we need further experimental and theoretical studies. However, even the obtained data show that the interaction of an ultrashort radiation pulse with a scattering medium is described by optical characteristics that differ from those in the case of continuous radiation.

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GENERATION OF POWERFUL ELECTROMAGNETIC RADIATION PULSES BY A BEAM OF RELATIVISTIC ELECTRONS

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The results are described of an experimental study of induced Cerenkov excitation of electromagnetic radiation in the centimeter band by a beam of relativistic electrons from a strong-current electron accelerator. The conversion coefficient of electron energy into electromagnetic radiation is 12 - 15%.

The power of an electromagnetic-radiation source based on the interaction of electromagnetic waves with electron beams can be increased appreciably only through a matched increase of the electron energy and of the electron-beam intensity. It is quite tempting to use for this purpose strong-current pulsed accelerators with electron energies $\sim$1 - 10 MeV and currents 0.01 - 1 mA [1 - 3].

Some variants of devices based on induced Cerenkov radiation, transition radiation, or