curve in the figure, the use of the Be-Al foil pair does not yield a sufficiently high measurement accuracy in the given temperature interval. This is connected with the presence of the K absorption edge for aluminum at $\lambda = 7.95$ Å, making the absorption coefficient in the aluminum foil approximately equal in the wavelength intervals 3 - 8 and 8 - 15 Å. The measurements were therefore made also with another pair of foils, Be - (Be, Ni). Such a foil combination eliminated the aforementioned shortcoming at temperatures above 100 eV, and the very strong dependence of the signal ratio in the two channels on T_e ensured sufficiently high accuracy of measurement of T_e in each "shot."

As shown by the arrangement of the experimental points in the figure, it is possible to obtain quite reliably, using the aforementioned laser parameters, plasma with $N_1 = 10^{19}$ cm^{-3}, $N_e = 5 \times 10^{19}$ cm^{-3}, and $T_e = 300$ eV $\simeq 3.5 \times 10^6$ °K. This raises hopes that thermonuclear reactions will be observed in the near future in a plasma produced with the aid of lasers.

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EXPERIMENTAL OBSERVATION OF SCATTERING OF LIGHT BY LIGHT IN A SOLID, ACCOMPANIED BY A CHANGE IN FREQUENCY

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The scattering of light by light in a solid is connected, in the phenomenological treatment, with the optical nonlinearity of the medium. In view of the far-reaching analogy between the electron-positron vacuum, on the one hand, and the electron-hole structure of the "vacuum" of a solid on the other, there exists an equally close connection, as shown in [1], between the scattering of light by light in vacuum [2] and in a solid when the latter is described at the microscopic level of the electronic processes. In this language, the process of scattering of light by light is connected with the virtual production of electron-positron or respectively electron-hole pairs by the two colliding photons, followed by their "annihilation," which is accompanied by emission of two photons. The directions and magnitudes of the quanta of all four photons are related by the energy and momentum conservation laws. In vacuum, the photon-photon scattering cross section at energies $\hbar\omega$ on the order of the electron, i.e., m_0c^2, amounts to 10^{-30} cm^2, and $\sigma \sim \omega^6$ when $m_0c^2 >> \hbar\omega$. Consequently, in the wavelength region of visible light ($\hbar\omega \sim 1$ eV) the cross section is negligibly small ($\sigma \sim 10^{-66}$ cm^2), and on the other hand, owing to the lack of sufficiently powerful gamma sources, a cross section $\sigma \sim 10^{-30}$ cm^2 turns out to be very small to be able to observe this effect in vacuum.

By virtue of the foregoing analogy we can expect the same value of the cross section for the scattering of light by light in a semiconductor ($\sigma \sim 10^{-30}$ cm^2) when $\hbar\omega \sim E_g \sim 1$ eV, inasmuch as E_g, which is the width of the forbidden band of this semiconductor, plays a role analogous to the quantity $2m_0c^2$ in vacuum. According to [1], this cross section turns out to be of the order of 10^{-28} - 10^{-27} cm^2.

We set up an experiment aimed at observing photon-photon scattering in a CdS crystal.*

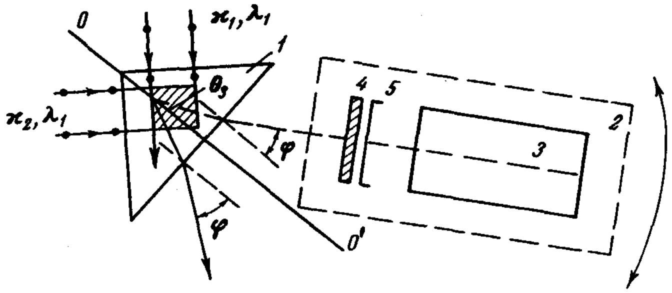

Fig. 1. Experimental setup.

The experimental setup is shown in Fig. 1.

Polarized light from a neodymium laser (the direction of the electric vector is shown by the dots on Fig. 1), operating in the Q-switched mode with pulsed energy ~1 J and duration ~40 nsec, was split by a semitransparent mirror, and the two beams obtained in this manner, with cross section 0.28 cm^2 and wave vectors $\vec{\kappa}_1$ and $\vec{\kappa}_2$ ($|\vec{\kappa}_1| = |\vec{\kappa}_2| = 2\pi n_1/\lambda_1$, $\lambda_1 = 1.06\ \mu$) crossed in a CdS sample made in the form of a trihedral right prism (the angle between $\vec{\kappa}_1$ and $\vec{\kappa}_2$ was set to 90° with accuracy not worse than 20'.

The scattered light was recorded by photomultiplier 3 (Fig. 1), in front of which were placed filter 4 to cut off the laser light and interference filter 5. The photomultiplier with the filters was mounted on platform 2, which rotated in the plane of Fig. 1 around the sample.

In our case the spectrum of the scattered light should contain all the wavelengths from 0.635 to 3.03 μ, each wavelength corresponding to a definite angle θ_3 on both sides of 00'.

The photons produced as a result of the scattering, with wavelength λ_3, propagate at the angle θ_3 to the bisector of the angle between $\vec{\kappa}_1$ and $\vec{\kappa}_2$ (line 00' in Fig. 1) and emerge from the crystal at an angle φ to the 00' direction [$(\sin\varphi)/(\sin\theta_3) = n_3$].

The angle θ_3 is determined by the conservation laws which lead, with allowance for the frequency dispersion of the refractive index, to the expression

$$\cos\theta_3 = \frac{n_4^2}{2\sqrt{2}\,n_1 n_3}\left[4 - 2\frac{\lambda_3}{\lambda_1}\left(2 - \frac{n_1^2}{n_4^2}\right) - \frac{\lambda_1}{\lambda_3}\left(1 - \frac{n_3^2}{n_4^2}\right)\right]\ldots, \qquad (1)$$

where n_1, n_3, and n_4 are the refractive indices for the wavelengths λ_1, λ_3, and λ_4; λ_4 is the wavelength of the fourth photon participating in the process. In the derivation of (1)

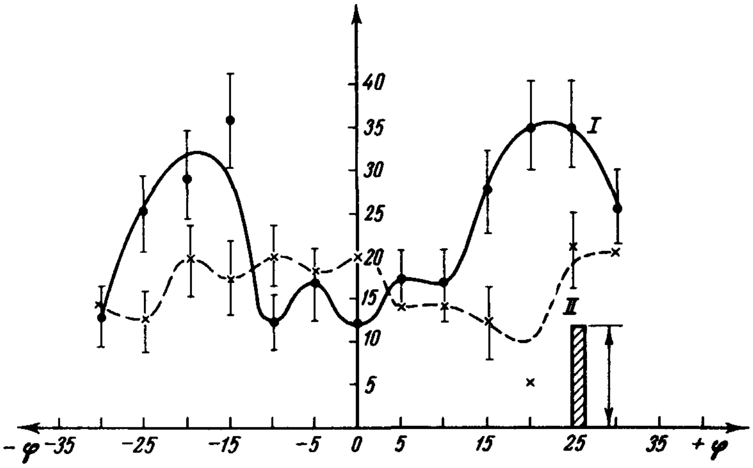

Fig. 2. Angular distribution of scattered light: Curve I - $\lambda_3' = 0.652$ μ, curve II - $\lambda_3'' = 0.628$ μ.

it was assumed that $\vec{\kappa}_1 \perp \vec{\kappa}_2$.

We measured the angular distribution of the scattered light at two wavelengths, $\lambda_3' = 0.652$ and $\lambda_3'' = 0.628$ μ. Calculation with allowance for the data on the frequency dispersion in CdS [3] shows that the radiation with wavelength $\lambda_3' = 0.652$ μ should be observed at an angle $\varphi_0 = 23°$, and the radiation with $\lambda_3'' = 0.628$ μ should not appear at all in the spectrum of the scattered light.

The results of the experiment are shown in Fig. 2. As seen from the figure, the angular distribution of the scattered light intensity has, in full agreement with the theory, two symmetrical maxima located at an angle $\varphi_0 \approx 23°$ (curve I) at $\lambda_3' = 0.652$ μ, whereas no dependence of the intensity of the scattered radiation on the angle is observed, within the limits of experimental accuracy for $\lambda_3'' = 0.628$ μ (curve II).

As shown by calculation, the form of the maxima on curve I is determined by the form of the transmission band of the employed interference filter ($\Delta\lambda = 150$ Å). If it is assumed in first approximation that the distribution of the intensity over the beam is uniform, then the measured scattering cross section is $\sim 10^{-28}$ cm^2.

It should be noted that the measurements have shown that it is necessary to decrease greatly the power flux of the laser pulse (to approximately 1.5 MW/cm^2) in order to observe the effect, for higher light intensity incident on the sample surface produces strong parasitic radiation, due apparently to surface breakdown [4]. The absolute magnitude of the effect observed by us therefore turned out to be small, up to 10^3 quanta (the photomultiplier pulses corresponded to 2 - 10 photoelectrons knocked out of the photocathode, and consequently fluctuated greatly). This made it necessary to average a large number of measurements. The shaded strip of Fig. 2 corresponds to the signal from one photoelectron. The points through which the curves of Fig. 2 were drawn correspond to the mean values of the ordinates of 10 measurements. As seen from curve I, a certain deviation from the background level is observed at angles $\varphi \approx \pm 5°$, possibly connected with the interaction of the ordinary and extraordinary rays produced by the birefringence in CdS.

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[*] The nature of the considered effect differs greatly from that described in [5], where apparently the incident beam was essentially reflected specularly from the region of matter where the refractive index was changed by the powerful laser light, and there was no change of frequency of the scattered light.

SELF-SYNCHRONIZATION OF MODES IN A GaAs SEMICONDUCTOR INJECTION LASER

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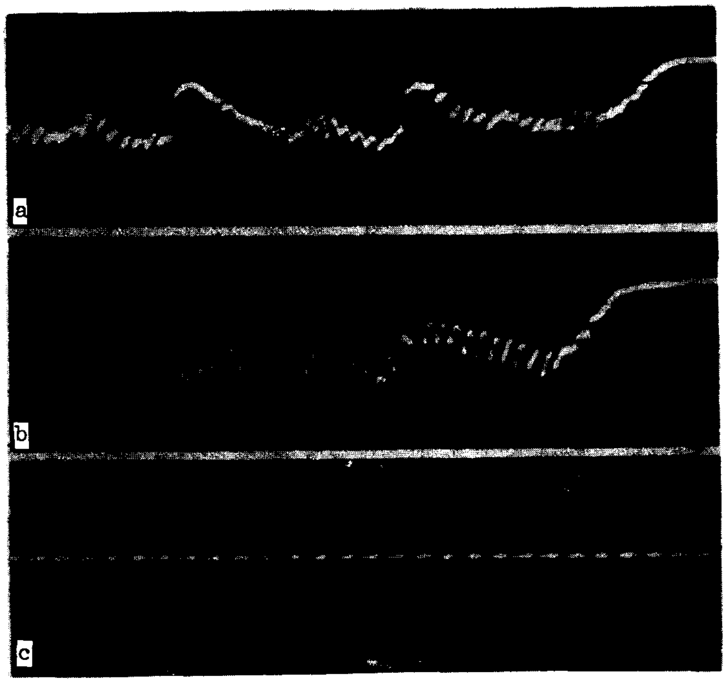
The purpose of the present note is to report observation of self-synchronization of axial modes in a laser diode with external mirror. The mode capture effect was manifest in the occurrence, as a result of the nonlinearity of the active medium*, of a series of coherent modes, equally spaced in frequency, and the summary field due to the interference between them was a sequence of pulses spaced 2L/c apart and with duration 2L/Kc, where L is the optical length of the resonator, c the speed of light, and K the number of synchronized coherent modes. This phenomenon is of interest in connection with the possibility of obtaining ultrashort periodic pulses of coherent light. The self-synchronization of the modes was investi-



Oscillograms of emission of an injection laser diode with external mirror: a - unifrom excitation, pump power 2.7 A, threshold 2.4 A; b - non-unifrom excitation, pump current 5A, threshold 4.6 A; c - 10^{-8} sec timing markers.