[1] F.P. Bundy, J. Chem. Phys. 38, 3, 618 (1963).
[2] N.S. Fateeva, L.F. Vereshchagin, and V.S. Kolotygin, Dokl. Akad. Nauk SSSR 152, 317 and 88 (1963) [Sov. Phys. Dokl. 8, 904 and 893 (1964)].
[3] L.F. Vereshchagin and N.S. Fateeva, Zh. Eksp. Teor. Fiz. 55, 1145 (1968) [Sov. Phys.-JETP 28, 597 (1969)].
[4] N.S. Fateeva and L.F. Vereshchagin, PTE, No. 3, 222 (1970).

INTERACTION OF AN ULTRASHORT NEODYMIUM-LASER PULSE WITH GaAs

T.L. Gvardzhaladze, A.Z. Grasyuk, I.G. Zubarev, P.G. Kruykov, and O.B. Shashberashvili
P.N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 6 January 1971
ZhETF Pis. Red. 13, No. 3, 159 - 161 (5 February 1971)

1. In a GaAs sample at 77°K, we observed a decrease in the velocity of propagation of single pulses from a neodymium laser in the picosecond band, to a value (2 - 4) times 10^8 cm/sec as compared with the expected value $c/n \approx 9 \times 10^9$ cm/sec (n = 3.3 is the refractive index for light with wavelength $\lambda \approx 1.06\ \mu$).

The GaAs sample was irradiated with pulses separated from a train emitted by a mode-locked neodymium laser [1]. The number of pulses in the axial period and their relative amplitudes varied from flash to flash. The pulse duration τ was not measured. We attempted to satisfy all the conditions necessary for the operation of a laser in the mode-locking regime, in which τ amounts to $(10^{-11} - 10^{-12})$ sec [2]. The laser pulses were registered with a coaxial photocell FEK15 and an oscilloscope I2-7; the time constant of the apparatus was approximately 1 nanosecond.

The oscilloscope sweep was calibrated and made it possible to measure the time intervals between the maximum of the pulses with accuracy up to 0.5 nsec. The experimental setup is shown in Fig. 1. In Fig. 2a are shown oscillograms of light pulses in the absence of a sample. The first pair (1 and 2) of pulses corresponds to passage of light along the path AB, and the second (3 and 4) along ACB.

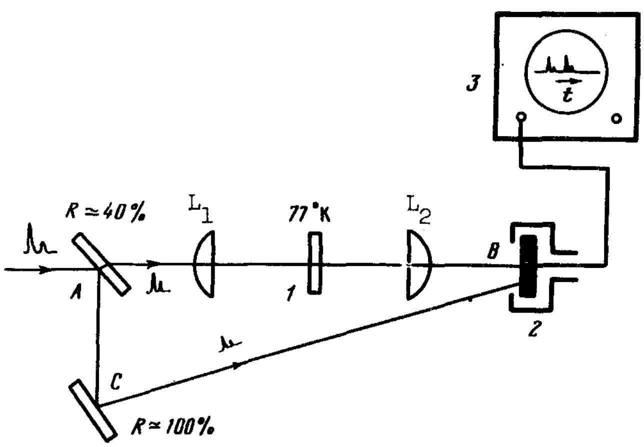

Fig. 1. Experimental setup: 1 - GaAs sample, 2 - coaxial photocell, 3 - oscilloscope, L_1 and L_2 - cylindrical lenses with focal lengths $f_1 = 16.5$ cm and $f_2 = 15.5$ cm respectively.

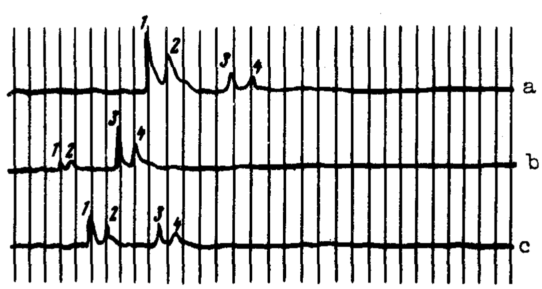

Fig. 2. Oscilloscope sweep 100 nsec. The parallel lines are drawn every three nsec with allowance for the nonlinearity of the sweep and correspond to the period of the sinusoidal signal with frequency 330 MHz, which was fed to the input of the I2-7 oscilloscope.

Figure 2b pertains to a GaAs sample of thickness $\ell \simeq 0.8$ cm placed in the path AB, the energy density of the light pulse incident on the sample being $(1 - 3) \times 10^{-1}$ J/cm^2. Figure 2c corresponds to $\ell \simeq 0.2$ cm at the same energy density.

When a GaAs sample is placed in the path AB, we noted in some cases a shortening of the time interval δt between the maxima of the pulses 1 and 3 (also 2 and 4), compared with the corresponding intervals in Fig. 2a. For example, in Fig. 2b this reduction (delay of the signal passing through the sample) δt is 2 nsec, and in Fig. 2c it equals 1 nsec.

The velocity v of propagation of light in the sample can be estimated from the formula

$$v = c\left(1 + c\frac{\delta t}{\ell}\right)^{-1},$$

where c is the velocity of light in vacuum.

For a GaAs sample of thickness $\ell \simeq 0.8$ cm, v turns out to equal 4×10^8 cm/sec, and for $\ell \simeq 0.2$ cm we have $v = 2 \times 10^8$ cm/sec.

2. For the employed exciting-light intensities, the observed values of the two-photon absorption coefficient are much smaller than for the case of nanosecond pulses.

The calculated coefficient of two-photon interband absorption of the radiation of a neodymium laser for GaAs is $K^{(2)} = 2.5$ I cm^{-1}, where I is measured in MW/cm^2, and is in good agreement with experiment at a pulse duration $\tau \sim (20 - 30)$ nsec and up to incident-light intensities $I \sim 25$ M/cm^2 [3]. The comparison was not made for larger intensities, because the GaAs sample was then damaged.

If we assume in accordance with [1, 2] that the pulse duration does not exceed 10^{-11} sec, then the oscillograms shown in Fig. 2 correspond to the case when the intensity of the incident light $I \simeq (10 - 30)$ GW/cm^2, and $K^{(2)}$ is smaller than the calculated value by three orders of magnitude.

The observed large transparency of GaAs and the delay of the light in it give grounds for assuming that coherent interaction of ultrashort radiation of the neodymium laser with the two-photon absorbing medium GaAs takes place [4 - 6].

The authors are grateful to A.V. Dudenkova for supplying the GaAs samples.

[1] A.J. De Maria, D.A. Statser, and H.A. Heynau, Appl. Phys. Lett. 8, 174 (1966).
[2] N.G. Basov, P.G. Kryukov, Yu.V. Senatskii, and S.V. Chekalin, Zh. Eksp. Teor. Fiz. 57, 1175 (1969) [Sov. Phys.-JETP 30, 641 (1970)].
[3] N.G. Basov, A.Z. Grasyuk, I.G. Zubarev, V.A. Katulin, and O.N. Krokhin, ibid. 50, 551 (1966) [23, 366 (1966)].
[4] E.M. Belenov and I.A. Poluektov, ibid. 56, 1407 (1968) [29, 754 (1968)].
[5] S.E. McCall and E.L. Hahn, Phys. Rev. 183, 457 (1969).
[6] I.A. Poluektov and Yu.M. Popov, ZhETF Pis. Red. 9, 542 (1969) [JETP Lett. 9, 330 (1969)].