FORMATION OF ULTRASHORT LASER PULSES WITH THE AID OF A TWO-COMPONENT MEDIUM

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It was shown in a number of experimental studies [1 - 3] that ultrashort pulses (USP) obtained with the aid of lasers with mode locking have a complicated time structure. The characteristic duration of the subpulses of such a structure correspond to the reciprocal width of the USP emission spectrum.

We have investigated the possibiiity of forming a single USP with the aid of a stable two-component medium (STCM) (amplifying medium and non-linear absorber with fast relaxation time of the saturated state) [4]. When a pulse with complicated wave form passes through such a medium, strong discrimination of the amplitudes takes place, since the medium absorbs the weak signals and amplifies the strong ones [4]. If the absorber relaxation time is sufficiently short, then one can hope to separate a single pulse from the USP of a laser with mode locking and to shortening the pulse further.

The experimental setup (Fig. 1) consisted of a USP generator, an electron-optical shutter to separate one USP from a pulse train, and a ring-type STCM. Neodymium-glass rods were the active elements in both the generator and the ring amplifier. The saturable absorber (solution of dye No. 3955 in nitrobenzene) in the STCM had an initial transmission of 14%.

To study the change of the structure and duration of the USP after the passage through the STCM, we plotted the emission spectra of the input and output signals. The result of the photometry of the spectra is shown in Fig. 2. The width of the spectrum of a train of USP from the generator is 5.4 cm^{-1}. When the USP from the generator passed through the STCM, the spectrum became considerably broader and smoother. The width of the spectrum was strongly dependent on the proximity of the amplifier regime to the threshold (at which the gain is equal to the loss for a strong signal). The width of the spectrum in the near-

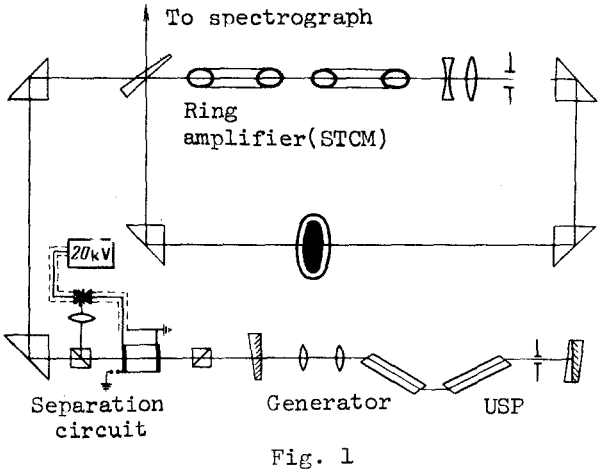

Fig. 1

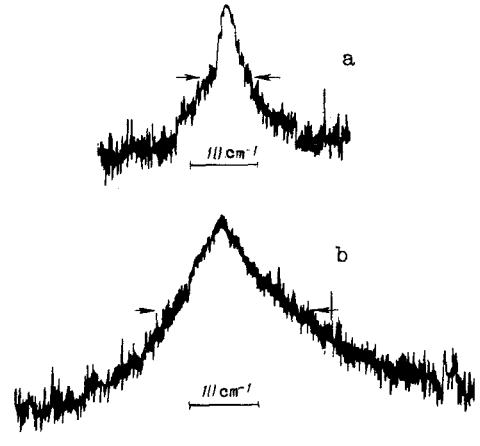

Fig. 2

Fig. 1. Diagram of experimental setup.

Fig. 2. Results of photometry of spectra: a) from the USP generator, b) past the STCM.

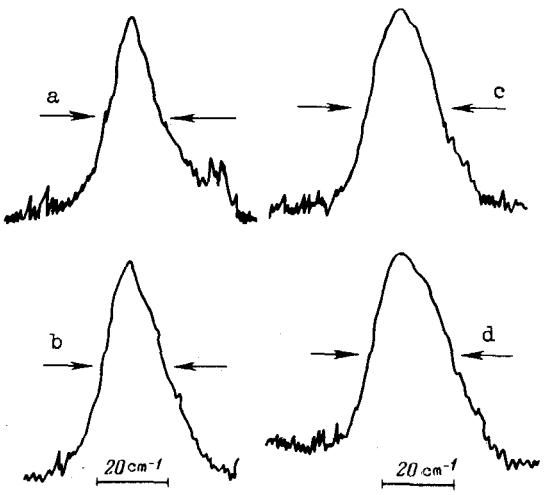

Fig. 3. Emission spectra past the STCM in different amplification regimes: a) threshold regime $\Delta\omega$ = 34 cm^{-1}, b) gain 1.5% above threshold, $\Delta\omega$ = 30 cm^{-1}, c) gain 10% above threshold, $\Delta\omega$ = 26 cm^{-1}, d) gain 15% above threshold, $\Delta\omega$ = 20 cm^{-1}.

threshold regime was maximal and reached 34 cm^{-1}. In this case a slight asymmetry of the spectrum was also observed (Figs. 3a - 3d).

The spectrum can broaden both as a result of the decrease in duration and as a result of effects connected with the nonlinear increment to the refractive index [5]. In the latter case the width of the spectrum increases with increasing intensity, and the spectrum itself becomes cut up [5]. Since in our case the maximum broadening was observed in the threshold regime, and the width of the spectrum decreased with increasing intensity, the spectrum broadening must be attributed to the decreased duration. The center of the luminescence line of neodymium glass does not coincide with the center of the dye absorption line. This leads to the observed asymmetry of the emission spectrum. The fact that the asymmetry is maximal in the threshold regime indicates that the dye is most effective in this case. The pulse duration corresponding to the maximum spectrum width is $\sim(1/\Delta\omega_{max}) = 10^{-12}$ sec. The change of the structure and of the duration of the USP in the STCM was investigated also by measuring the coefficient of second-harmonic conversion of the radiation, which was effected with a KDP crystal 5 mm thick. We measured in the experiment the conversion coefficient

$$K = \frac{I_{2\omega}}{[I_{\omega}]^2},$$

where I_{ω} and $I_{2\omega}$ are the USP energies at the fundamental and second harmonic, respectively. The change of K yields information on the change of the duration and the structure of the USP [6].

It was observed that after the radiation passes through the STCM the coefficient K increases on the average by two orders of magnitude. Such an increase of K cannot be attributed solely to the reduction of the pulse duration in the USP, since the maximum broadening of the spectrum and the associated reduction would increase K by only one order of magnitude. The increase of K can be explained only as being due to a simultaneous reduction of the duration of the subpulse and the decrease of the number of subpulses in the USP. No increase of K was observed at a large excess of amplifier pump over threshold. This result, together with the change of the broadening of the spectrum when the threshold is exceeded, agrees with the theory [4] according to which the reduction of the duration and the separation of a single pulse should occur most effectively under threshold conditions.

The experiments have shown that by passing USP of complicated wave form through an STCM it is possible to separate a single USP and to decrease its duration to a value on the order of one picosecond. The maximum USP duration

should be limited by the relaxation time of the employed absorber. Consequently, dye No. 3955 has a saturated-state relaxation time on the order of 10^{-12} sec.

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OSCILLATION OF THE RADIATION OF AN ELECTRON-HOLE FERMI LIQUID IN GERMANIUM IN A STRONG MAGNETIC FIELD

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When a magnetic field is applied to a solid, a number of resonant effects are produced (cyclotron resonance, the Shubnikov - de Haas effect, oscillations of magneto-absorption, and others), and these yield the most complete information concerning the band spectrum of the solid.

We have observed a new resonance effect, namely the oscillation of the recombination radiation of germanium under the phase-transition conditions when electron-hole drops are produced [1] from the gas of free excitons.

We investigated the recombination radiation of pure germanium crystals ($N_A + N_D \sim 10^{12}$ cm^{-3}) with the <100>, <110>, and <111> axes along the magnetic field direction. A cryostat especially constructed for optical measurements, on the basis of the "Solenoid" apparatus of our Institute[1)], has made it possible to employ high-transmission optics both to excite the recombination radiation (He-Ne laser) and to gather the radiation. As a result, the spectral width of the slit used when registering the emission spectra was 5×10^{-4} eV. An x-y automatic recorder was used to plot the integrated radiation intensity as a function of the magnetic field.

Just as in the case of the <100> orientation [2], we obtained a splitting of the emission line E_d of the electron-hole drops also for two other orientations of the samples, and the magnitude of the splitting Δ greatly exceeded kT in all cases (e.g., $\Delta \approx 1.5$ meV at 60 kG and H $\|$ <110>).

When registering the integrated radiation intensity, when the spectral width of the slit covered completely the E_d line with allowance for the change of its energy position, we observed oscillations of this radiation as a function

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