hydrodynamic condition $\delta\oint dl/H < 0$, which is used to find the so-called "minimum-H configurations." A detailed investigation of the trapped-particle instability in a toroidal discharge of the Tokomak type was made by the author jointly with O. P. Pogutse.

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PROPAGATION OF A LIGHT PULSE IN A NONLINEARLY AMPLIFYING AND ABSORBING MEDIUM

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Submitted 3 May 1966
ZhETF Pis'ma 4, No. 1, 19-22, 1 July 1966

1. In our paper [1] we reported an investigation of the propagation of a pulse of coherent light in a medium with nonlinear gain. It was also noted there that when a light pulse propagates in a medium with nonlinear gain and nonlinear absorption, unlike a medium with nonlinear acceleration, the duration will become shorter regardless of the shape of the initial pulse, provided absorption saturation sets in much earlier than amplification saturation. In this letter we report on successful experiments in this direction, and show that to obtain compression of a propagating light pulse it is necessary to eliminate the structure connected with the transverse development of the pulse emitted by a Q-switched laser [2,3].

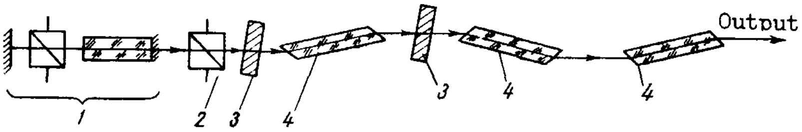

Fig. 1. Experimental setup

2. The setup of the experiment on the propagation of a high-power light pulse in a two-component nonlinear medium is shown in Fig. 1. The pulse was applied to the input of the medium from a Q-switched ruby laser (1) by means of a Kerr shutter (2). The amplifying component consisted of three ruby crystals (4) (each 24 cm long and 1.6 in diameter) with overall initial gain up to 10^4. The absorbing component consisted of two cuvettes (3) filled with a solution of vanadium phthalocyanine in toluene and placed before and after the first crystal;

the over-all initial and final transmission coefficients were 4×10^{-2} and 0.5 respectively.

The initial attempt to obtain compression of a pulse fed directly from the laser and propagating in the two-component medium was unsuccessful. The absence of pulse compression is attributed to the fact that the input pulse from the generator has a so-called transverse structure, because the development of the pulse generation in the peripheral parts of the crystal is delayed by a time of the order of the pulse duration. When a pulse with such a transverse structure propagates in a nonlinear medium, the duration at any point of the cross section is shortened, but the total pulse duration cannot be shorter than the time of transverse development of the generation. The transverse structure of the input pulse can be eliminated with the aid of an additional Kerr shutter that cuts off the leading front of the generator pulse. Owing to the depolarization of the light in the laser crystal, the initial transmission of the Kerr shutter is 3%. This initial transmission limits the maximum compression of the pulse when it propagates only in an amplifying medium.

The ratio of the over-all final and initial transmissions of the absorbing component and of the Kerr shutter should satisfy the condition $\eta_k/\eta_0 \gtrsim 2 \ln(k\mathcal{E}_0/\mathcal{E}_s)$, where k is the total initial gain of the ruby crystals, $\mathcal{E}_0$ the initial pulse energy, and $\mathcal{E}_s \simeq 4$ J/cm^2 is the energy of ruby gain saturation at 300°K. In the opposite case premature gain saturation by the leading front of the light pulse sets in.

3. When the light pulse propagated in the two-component medium, we observed a marked change in the pulse shape. The light pulse had a duration of 11 nsec at half-maximum (Fig. 2a) and an approximate energy 0.5 J past the Kerr shutter and the first absorbing cuvette, 5.7 nsec (Fig. 2b) and about 10 J past the second crystal, and 2 nsec (Fig. 2c) and about 15 J past the third. The output light-pulse power was 7 - 8 GW or about 3 GW/cm^2.

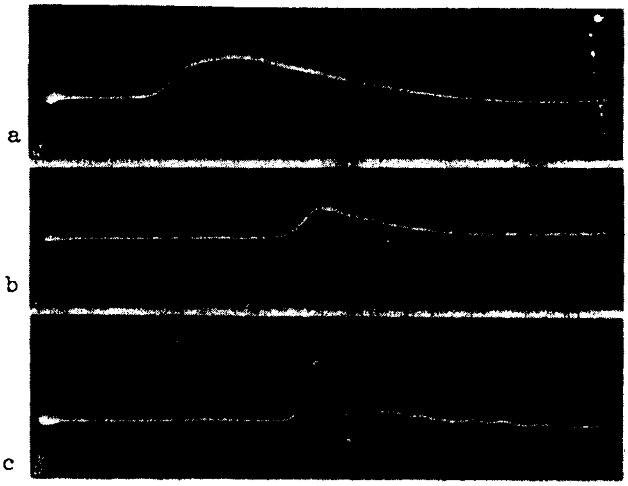

Fig. 2. Oscillograms of light pulse propagating in a two-component medium: a - ahead of the first ruby crystal, b - past the second, c - past the third. Sweep = 30 nsec.

The pulse power obtained is much higher than the power causing damage in ruby crystals by pulses of 10^{-8} second (1 GW/cm^2 [4]). This indicates that the threshold of internal self-damage of ruby crystals is determined by the pulse energy.

4. It must be noted that when the light-pulse duration is shorter than 10^{-9} sec one can expect an increase in the energy threshold of self-damage, owing to the infinite time of development of the acoustic wave under induced Mandel'shtam-Brillouin scattering. However, even if the self-damage energy $\mathcal{E}_d$ remains constant as the pulse duration is decreased, damage to the medium is not an obstacle to generation of powerful light pulses shorter than 10^{-9} sec,

since $\mathcal{E}_d$ exceeds the gain saturation energy $\mathcal{E}_s$ necessary to compress the pulse. For ruby at 300°K, $\mathcal{E}_d \simeq 10$ J/cm^2 [4] and $\mathcal{E}_s \simeq 4$ J/cm^2. This ratio is especially favorable if the ruby crystals are cooled, when $\mathcal{E}_s < 1$ J/cm^2.

5. To obtain extremely short pulses of light, effective two-component media are those in which the absorbing component has a saturation energy much lower and a homogeneous line width much larger than the amplifying medium. A light pulse propagating in such a medium can be compressed to the limiting duration determined by the reciprocal line width of the amplifying component. The duration of the leading front is determined by the absorbing component and can be much shorter than the duration of the entire pulse. When such a "limiting" pulse passes through the medium, the absorbing component is bleached, and the atoms of the amplifying component are inverted.

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GENERATION OF COHERENT RADIATION IN THE INFRARED BAND BY NONLINEAR-OPTICS METHODS

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ZhETF Pis'ma 4, No. 1, 22-26, 1 July 1966

We report in this letter experimental results offering evidence that sufficiently intense sources of coherent infrared radiation, at least in the 2 - 5 μ range, can be produced by using the effect of optical mixing in nonlinear media. We have realized in our experiments for the first time effective synchronous mixing of radiation from a Q-switched ruby laser (λ_l = 6943 Å) with radiation of the first Stokes component of stimulated Raman scattering (SRS) in cyclohexane (λ_c = 8657 Å) and n-heptane (λ_c = 8677 Å) in an $LiNbO_3$ crystal. This produced at the output of the nonlinear crystal radiation pulses with wavelength λ_p = 3.5 μ (ν_p = 2853 cm^{-1}) and λ_p = 3.47 μ (ν_p = 2878 cm^{-1}) respectively, with power not lower than 1 - 10 W. We recall that mixing with an output signal in the infrared band entails appreciable difficulties. Most important among them are: need for choosing a crystal that supports the presence of accumulating interactions (synchronism directions), difficulty of recording short pulses of infrared radiation, and much more stringent demands with regards to spatial coherence of the interacting beams (compared with the optical band) (see, e.g., [1]).

To overcome the foregoing difficulties, we chose as the nonlinear crystal $LiNbO_3$ [2], which is transparent in the 0.4 - 5 μ band and has, as shown by calculation, sufficient birefringence for realization of accumulating interactions in its optical transparency range 1).