Intraresonator generation of stimulated Raman emission in mode self-locking

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We demonstrate the feasibility of effective generation of single ultrashort pulses of stimulated emission when a nonlinear medium is excited by a laser operating in the mode self-locking regime.

Considerable attention is being paid of late to generators of stimulated Raman emission (SRE). Greatest interest attaches to the study of SRE and SRS in field of ultrashort pulses[1,2] and the possibility of using the SRE phenomenon for the generation of ultrashort pulses.[3]

We report here experimental investigations of intraresonator generation of SRE in self mode-locking of a laser.

The investigated laser is illustrated in Fig. 1. The SRE laser is a resonator with an optical delay line (ODL), inside of which is placed a ruby crystal, a saturable filter (solution of phthalocyanine in nitrobenzene), and a cell with benzene (or toluene in a number of experiments). The resonator and ODL mirrors had high reflectances ($r > 99\%$) at the ruby generation wavelength $\lambda = 6943$ Å and at the first Stokes component. The effective resonator length was 830 cm, which made it possible to obtain a well reproducible regime of mode self-locking for the ruby laser.[4] The ruby was excited with two IFP-800 lamps at a pumping energy up to 1600 J. The length of the cell with the benzene was varied during the experiment between 30 and 170 mm. The radiation was registered simultaneously at two wavelengths, 6943 and 7455 Å. The bandwidth of the recording apparatus exceeded 100 MHz.

Without the cell with the benzene, the laser generated a train of ultrashort pulses at intervals of 56 nsec; the half-width of the envelope was ~800 nsec. When the cell with benzene was placed in the resonator, the character of the lasing changed radically. The most appreciable changes occurred when the cell was placed at the neck of the caustic of the laser generator. In this case the train of radiation at 6943 Å was greatly decreased: the duration of the envelope (at half-width) decreased to 100–150 nsec, and the SRE consisted in practice of one rather intense ultrashort radiation pulse. The intensities of the neighboring radiation pulses at 7455 Å were smaller by one order of magnitude. The SRE pulse duration was much shorter (by a factor ~10) than the duration of the pulses at the wavelength 6943 Å (see Fig. 2a). It should be noted that the SRE pulse was delayed relative to the start of the exciting pulse of the ruby laser by an amount on the order of 6 nsec.

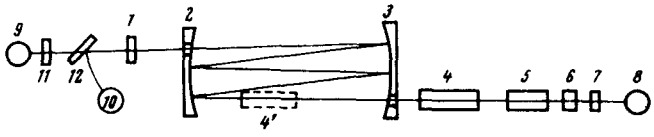

FIG. 1. Experimental setup: 1 and 7—resonator mirrors, 2 and 3—mirrors of optical delay line, 4 and 4′—cell with benzene, 5—ruby crystal, 6—saturable filter, 8—photoreceiver for the registration of the ruby radiation and the first Stokes component, 11—IKS-2 light filter, 12—beam-splitting plate.

When the cell with benzene was placed inside the ODL in a region where the caustic of the resonator had a maximum value, the duration of the ruby-laser pulse train was reduced by a relatively smaller amount, and each ruby-laser pulse was accompanied by an SRE pulse (see Fig. 2b). The intensity of the SRE pulses was in this case much lower, but their duration, just as in the first case, was much lower than the duration of the pulses with $\lambda = 6943$ Å.

The apparent reason for the decrease of the number of pulses in the radiation train is the self-focusing of the radiation inside the cell with the benzene, accompanied by an effective transfer of the ruby-radiation energy to the Stokes radiation. This assumption is favored by the fact that when the cell length was decreased or when the cell was placed in the region where the caustic had the maximum cross section, no appreciable decrease took place in the duration of the radiation train, and the SRE intensity was decreased.

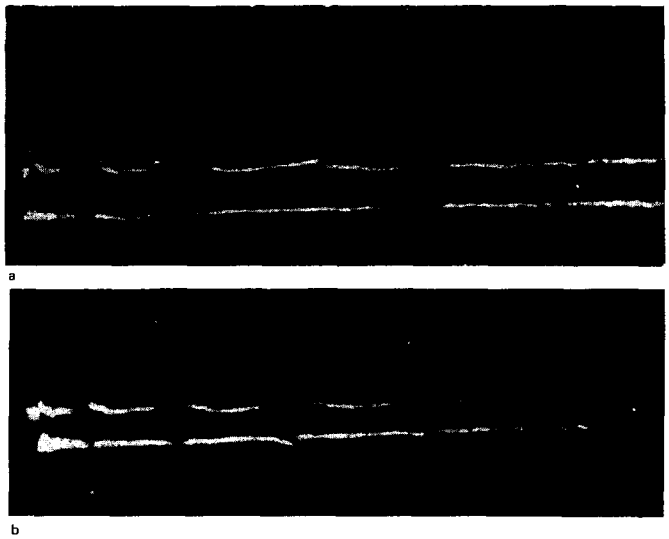

FIG. 2. Oscillograms of emission pulses (total sweep duration 300 nsec). Upper sweep – ruby-laser radiation, lower – SRE radiation.

Thus, our investigations have demonstrated the feasibility of effective generation of ultrashort SRE pulses in the case of intraresonator generation in the mode self-locking regime.

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