"Rapid" change of polarizability upon excitation of stimulated Raman scattering in hydrogen

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We have experimentally observed a rapid variation of the polarizability of the medium in the course of stimulated Raman scattering in compressed hydrogen following excitation of the latter by a mode-locked ruby laser.

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Several recent theoretical papers are devoted to self-action of light in matter under stimulated Raman scattering (SRS).[1–3] This subject is of interest because the study of self-action can yield additional information on the parameters of the investigated substance. In addition, this investigation is also of practical interest, since self-action may exert a significant influence on the characteristics of Raman lasers.

One of the mechanisms of self-action in a gaseous medium, the appearance of a SRS lens, was experimentally investigated in[4].

In this paper we report experimental observation of one other effect of self-action of a light beam, which comes into play only at the instant when Raman radiation is generated.

The experimental setup is shown in Fig. 1. The master generator was a mode-locked ruby laser with optical delay line (ODL) inside the resonator. Such a laser emits a sequence of short pulses, the repetition frequency of which can be varied by varying the effective length of the ODL. The light of this laser was focused by lens 10 into a cell with compressed hydrogen. To register the self-action we used a shadow procedure,[5] and the probing signal was either part of the radiation flux from the master laser, or the emission of an auxiliary laser 20 operating in a smooth-pulse regime (in the latter case, the rotating mirror 9 was removed). The auxiliary laser 20 could operate at a wavelength 0.69 μ (ruby) as well as at 1.06 μ (Nd^{3+} glass). The mirror system 8 and 9 made it possible to vary the delay of the probing voltage relative to the instants of the onset of SRS.

The intensity of the probing pulses was chosen to be low enough to preclude the possible production of SRS by the probing radiation. The registration system could record simultaneously the radiation of the master laser, the Stokes radiation, and the scattering of the probing radiation due to the onset of the SRS.

Stimulated Raman scattering excited by a long train of pulses appears first at the start of the train, then stops, and a "silence zone" reappears. Our investigations have made it possible to register not only the onset of the SRS lens, due to the difference of the polarizabilities of the ground and excited states of the hydrogen molecules, but also to observe the self-action of the light beam which appears, unlike the SRS lens, only at the instant when the Raman radiation is generated. Typical oscillograms are shown in Fig. 2. From the result it follows that at the instant when the Raman scattering is generated there appears in the focus of the lens a region with rapidly time-varying refractive index, which scatters the sounding radiation pulses. The lifetime of this region does not exceed the duration of the Raman pulse. If the probing pulses are delayed relative to the radiation pulses of the master generator by an amount larger than the duration of an individual pulse, then this type of scattering disappears.

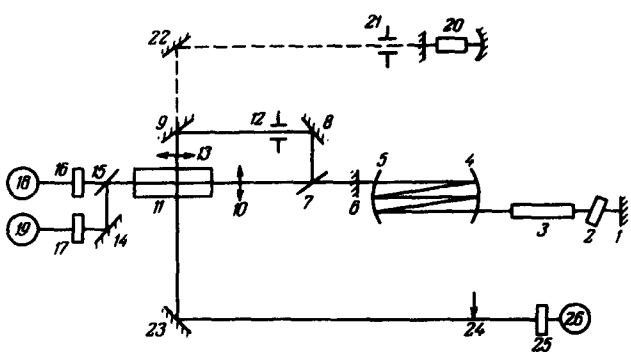

FIG. 1. Experimental setup: 1 and 6—laser mirrors, 2—saturable filter, 3—active element (ruby), 4, 5—ODL mirrors, 7 and 15—beam-splitting plates, 8, 9, 14, 22, and 23—rotating mirrors, 10 and 13—lenses, 11—cell with compressed hydrogen, 16, 17, and 25—optical filters, 12 and 21—slits, 20—auxiliary laser, 18, 19, and 26 (coaxial photocells (FÉK-09), 25—"knife."

FIG. 2. Emission oscillograms: a—emission of master laser; b—simulated Raman emission; c—scattered radiation. The delay of the scattered radiation relative to the Raman radiation is due to the registration circuit. The interval between spikes is 60 nsec.

If the probing radiation is produced by an auxiliary laser (ruby or glass), then the oscillogram of the scattered radiation is similar to that shown in Fig. 2c, in spite of the fact that the auxiliary laser operates in the smooth-pulse regime.

Thus, we have observed in the present study a rapid variation of the polarizability of the medium during the course of stimulated Raman emission (the relaxation time of the polarization of the medium is $\tau_\rho \leq 2$ nsec).

Additional investigations are being carried out to explain the detailed mechanism of the onset of this polarizability.

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