Radiation self-synchronization using stimulated Raman scattering of light in an external cavity

O. P. Zaskal'ko and V. S. Starunov
P. M. Lebedev Physics Institute, USSR Academy of Sciences

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This paper reports the first observation of radiation self-synchronization and generation of a periodic sequence of short light pulses using stimulated Raman scattering (SRS) in an external transverse cavity.

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1. The stimulated scattering was excited by a 100-MW, 30-nsec, single-mode pulse of a ruby laser. A 20-cm-long carbon disulfide cell was placed inside a cavity with an optical length L of either 45 cm or 75 cm, formed by spherical mirrors with a 1-m radius and a reflection coefficient of about 98% at a wavelength of 0.69 μm. The excitation light, polarized perpendicularly to the scattering plane, was focused inside the cell by a cylindrical lens ($f = 6$ cm) whose generatrix was directed along the cavity axis. The scattered-light spectrum was analyzed by a prism spectrograph. The time characteristics of the radiation were investigated by means of a coaxial photocell that was connected to an I2-7 oscilloscope. The time resolution of the system was at least 0.5 nsec.

2. Under the described experimental conditions with a pumping power of about 30 MW, we observed stimulated Mandelshtam-Brillouin scattering (SMBS) radiation and three Stokes components of the SRS in the scattered-light spectrum (Fig. 1a). Although the pumping pulse had a smooth, bell-shaped form, a regular spike structure (Fig. 1b) was observed during the time scan of the SRS; the spike structure had a period $T = 2L/c$, where c is the velocity of light. An increase in the optical length of the cavity led to a corresponding increase of the SRS pulse interval in the time structure of the scattered light (Fig. 1c). Two single SRS pulses, one of which had a much larger amplitude, were observed in an axial period at the beginning of lasing, (Fig. 1d). The rapid increase in amplitude of the second pulse was accompanied by a slight decrease in amplitude of the pulse which was initially more intense. Subsequently, a third, barely resolvable maximum appeared 15 to 20 nsec after the onset of lasing. Since the maximum number of spikes in an axial period always corresponded to the number of successively excited spectral components of the SRS, we can assume that each spike corresponds to its own SRS spectral component. This is confirmed by the fact that a removal (after detection) of the first SRS Stokes component by a filter decreased the number of spikes in an axial period (Fig. 1e). As the pump power increased to 50–60 MW, a radiation, which was not modulated in time and had a smooth, bell-shaped form, appeared in the time scan of the scattered light 8–10 nsec after the onset of lasing. This radiation, which supplemented the short SRS pulses, increased with an increase in the pumping.

3. We assumed that the experimental results presented indicate that the cavity

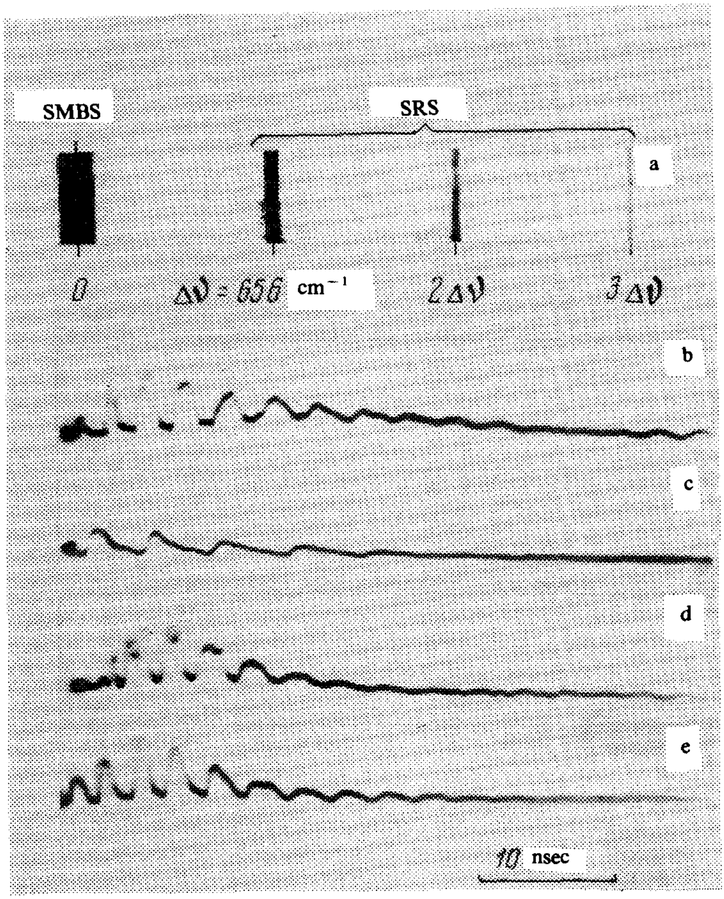

FIG. 1. (a) Spectrum and (b–e) oscillograms of SRS in carbon disulfide in an external cavity with an optical length $L = 45$ cm (b,d,e,) and $L = 75$ cm (c).

modes are self-synchronized within the limits of the amplification bandwidth of the first three SRS Stokes components excited in carbon disulfide in an external transverse cavity. The fact that the effect occurs in a medium with a large Kerr nonlinear susceptibility plays an important role in the synchronization process. In this case the mechanism for SRS synchronization should be similar to the synchronization mechanism for stimulated scattering of light in the wing of the Rayleigh line where the quadratic Kerr effect plays the main role.[1]

It should be noted that the generation of short SRS pulses in an external transverse cavity occurs at much lower pumping intensities (a factor of two to three) than those for stimulated Rayleigh scattering; this can have a great practical importance in the use of stimulated scattering effects for production of short light pulses.

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[1] O. N. Zaskal'ko, M. R. Malikov, V. E. Postovalov, V. S. Starunov, and A. L. Fabelinskiĭ, Pis'ma Zh. Eksp. Teor. Fiz. **31**, 483 (1980) [JETP Lett. **31**, 453 (1980)].