I. V. Aleksandrov and Z. V. Nesterova. *Competition of nonlinear processes of transformation of the eneregy of picosecond pulses in optical fibers.* A distinctive feature of the nonlinear transformation of the energy of light pulses of picosecond duration in fiber light pipes is the manifestation of a competitive nature of the development of various nonlinear processes determined by the real and imaginary parts of the complex cubic nonlinear susceptibility of the material of the core of the fiber light pipe. The preferential development of one nonlinear process or another in a fiber light pipe depends on the diameter of the core, the length of the fiber light pipe, the level of linear loss and the profile of the refractive index in the core, and also on the parameters of the light pulses at the input of the fiber light pipe.

Previously we were able to observe the regime of multiwave conversion of the energy of intense picosecond light pulses in the process of stimulated Raman scattering by the oscillations of the quartz core of the fiber light pipe; this regime is characterized by generation of a series of anti-Stokes components and an anomalous distribution of the intensity in the Stokes components of stimulated Raman scattering.[1] An analysis carried out of the distribution of the intensity, and direct measurements of the duration of the pulses of the components of stimulated Raman scattering, have permitted the suggestion that the distribution recorded for the intensity of the light pulses of the stimulated Raman scattering components is due to a parametric mechanism of excitation of stimulated Raman scattering (SRS) in the fiber light pipe. The "nonlinear" synchronism of the wave vectors in parametric SRS in the fiber light pipe determines the agreement of the velocities of the light waves of the pump and of the SRS components, as a consequence of which a high efficiency of SRS conversion is achieved in the extended medium of the fiber light pipe. In the course of further experiments on the spatial distribution of the pumping radiation and the SRS components in multimode fiber light pipes it has been established that the observed parametric regime of SRS in fiber light pipes is accompanied by a significant redistribution of the energy over the modes of the fiber light pipe. Mixing of the modes of a fiber light pipe in the linear regime, as is well known, is most effective in the lowest modes with practically coincident group velocities of the light waves. For intense picosecond light pulses of the second-harmonic radiation of the YAG:Nd^{3+} laser, which were used by us as pumping radiation, the regime of nonlinear mixing of the higher modes is more probable.[2] The change in the refractive index of the core material of the fiber light pipe, produced by the light field, leads to distortion of the path of the optical rays, which to a high degree appears just in the higher modes, for which relatively large values of the optical pathlengths in the core of the light pipe are characteristic.[3] Thus, in a fiber light pipe of quartz glass, which has a low Raman enhancement, for pico-second pulses of high intensity one apparently obtains primarily a regime of nonlinear mixing of modes with increase of the density of optical radiation in the paraxial zone of the fiber light pipe, where as a consequence of the relatively small linear loss stimulated Raman scattering takes place with nonlinear synchronism of the wave vectors.

For stimulated Raman scattering in a fiber light pipe the inertia of the nonlinear response and of the Raman enhancement take on special significance. In order to work with a system modeling the development and competition of various nonlinear processes in fiber light pipes, we have undertaken detailed studies of the conditions of nonstationary stimulated Raman scattering in capillary fiber light pipes

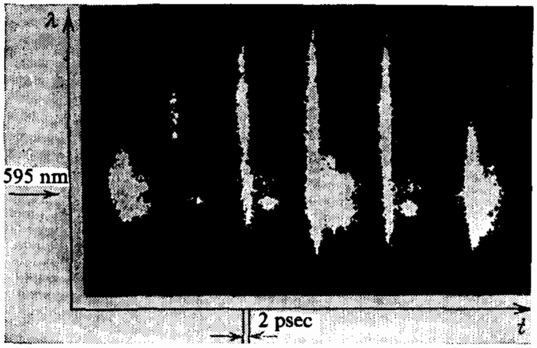

FIG. 1 Photograph of pulse-height as a function of time of the shock-wave envelope of the pulses of a train of the second Stokes component of stimulated Raman scattering by the vibration of the C-C molecule bond of liquid C_6D_6 in a capillary fiber light pipe, taken from the screen of the Agat chamber with spectral decomposition of the nonlinearly converted radiation at the entrance slit of the chamber. $\lambda_{SRS} = 595$ nm, $P_R \sim 2$ kW. The length and diameter of the capillary fiber light pipe are 1.7 m and 50 μm respectively.

filled with liquid organic compounds. It turned out that, with use of electron-optical image amplifiers of the Agat type with picosecond time resolution for direct detection of pulses from the fiber-light-pipe output, it is possible to determine the fundamental spectroscopic constants of molecules in the liquid phase—the dephasing time of the oscillations T_2, where the large length of capillary fiber light pipes in comparison with ordinary, nonwaveguide cells permits working at low intensities of the pumping radiation, which excludes the infuence of possible effects of saturation and multiphoton absorption.

In capillary fiber light pipes filled with liquid organic compounds the spectral broadening of intense light pulses is due exclusively to the self-modulation of the phases of the light waves. In development of the process of self-modulation of the phases in fiber light pipes with liquid CCl_4 and C_6D_6 we observed formation of shock waves of the envelopes of picosecond light pulses.[4] The relationship between the dispersion and nonlinearity of the material of the light-conducting core of the fiber light pipe necessary for stabilization of the shock-wave-envelope regime was achieved by tuning the pump radiation frequency in the stimulated Raman scattering process. In Fig. 1 we have shown a photograph of the pulse-height-versus-time pattern of a train of pulses of the second Stokes component of SRS by the vibration of the C-C bond of C_6D_6 molecules in a capillary fiber light pipe, obtained from the screeen of an Agat image converter with spectral decomposition of the nonlinearly converted radiation at the input slit of the image amplifier. At low power and in the absence of self-modulation of the phases the SRS pulses have a Gaussian shape. In the regime of shock-wave envelopes there is a significant distortion of the shape of the envelope with appearance at the leading edge of each pulse of a distinct zone of concentration of luminous energy which corresponds to the radiation of a broad-band light continuum. Consequently shock-wave envelopes of light pulses arise in liquid media with substantially different relaxation and dispersion characteristics under the condition of appropriate choice of the length and diameter of the capillary fiber light pipe and provision of the necessary parameters of the light pulses: wavelength, duration, and intensity of the pulses at the input of the fiber light pipe, which agrees with the results of the theoretical analysis by Ostrovskiĭ[5] and with the results of numerical calculations of the shock-wave envelope regime.[6] The experimentally observed mechanism of time self-compression of ultrashort light pulses in the form of a shock-wave envelope can be used as a means of shaping intense light pulses of subpicosecond and femtosecond duration.

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