By suitable choice of the frequency we could, simultaneously with the observation of χ''_{cr}, register the NMR spectrum of the ^{27}Al nuclei in the ruby lattice (to this end, the coil axis was inclined somewhat to the H_0 direction). It turned out that the gain of the χ''_{cr} signal was exactly equal to the gain in the polarization of the ^{27}Al nuclei; furthermore, the NMR and χ''_{cr} signals returned to their equilibrium values, after the microwave was turned off, at the same time constant (8 sec in Figs. 1 and 2) characterizing the nuclear spin-lattice relaxation. We note that this result seems to be the most direct experimental proof of the existence of a thermal contact between the reservoir of the electronic spin-spin interactions of the paramagnetic impurity and the Zeeman system of the lattice nuclei (cf., e.g., [6]), and it is clear that this contact remains also in the absence of a saturating field.

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NONSTATIONARY STIMULATED SCATTERING BY POLARITONS IN LITHIUM IODATE

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The increased interest in stimulated Raman scattering by polaritons is due both to the possible high-efficiency conversion of laser frequencies and to the possibility of obtaining information on the dispersion characteristics of the medium. In addition, the extraction of infrared oscillations from a crystal makes it possible to produce a tunable laser operating in the far infrared [1].

The present communication is devoted to the first experiments on SRS by polaritons under nonstationary conditions (with picosecond pumping). The scattering was investigated, in particular, in an ionic lithium-iodate crystal belonging to the point group $P6_3(C_6^6)$ with two molecules per unit cell, and has a rich spectrum of infrared-active and inactive transitions [2, 3]. However, inasmuch as the stimulated scattering develops collinearly with the pump wave the number of oscillations that can be excited without supplementary conditions (such as transverse resonators) is limited. At the same time, excitation of oscillations with the aid of a broad spectrum can create possibilities for the observation of stimulated scattering by lower modes that lie in this case in the pump-spectrum line wing.

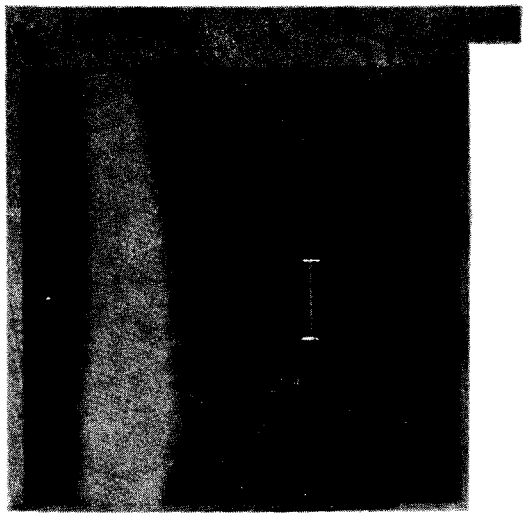

Fig. 1. SRS in $LiIO_3$ crystal cut at 45° to the y and z axes, with pump polarization along the x axis. Vertical scale - 1° outside the crystal.

Such an amplification was observed, in particular, in the spectrum of the second harmonic generated by picosecond pulses in lithium iodate[1)].

The pump wave in our experiment was the second harmonic of a neodymium-glass mode-locked laser. The frequency was doubled with a KDP crystal 25 mm long. At such a length, the group delay effects have little influence on the second-harmonic spectrum, which has a smooth envelope in this case (the quasi-static length for KDP is approximately 30 mm [4]). The second-harmonic intensity was $I_{2\omega} \approx 10^9$ W. The laser beam was focused inside the $LiIO_3$ crystal by a lens of focal length f = 192, thereby ensuring an approximate angular aperture ±1.5° inside the crystal.

We used in the experiments crystals oriented along all three axes, and also a crystal cut at 45° to the y and z axes.

When a crystal oriented along z with polarization along x was used (crystal lengths 10 and 30 mm) we observed scattering at a frequency 765 cm^{-1}, which corresponds apparently to the E_2 mode active in Raman scattering [2, 3]. The coefficient of conversion into the first Stokes component, determined from the maximum intensity, was ∿25%, and that for the second Stokes component is ∿13%. The line width at half maximum was ∿230 and ∿160 cm^{-1} for the first and second Stokes component, respectively, and the width of the unshifted line reached ∿300 cm^{-1}.

No frequency shift was observed when the crystal orientation was changed by ±10° relative to the exciting beam.

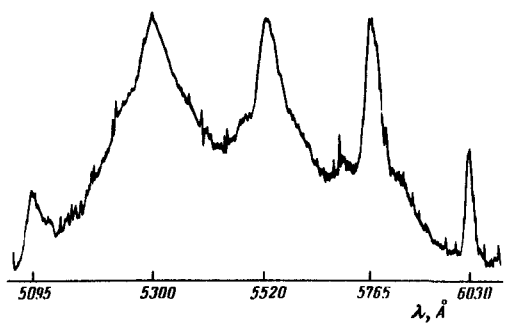

Fig. 2

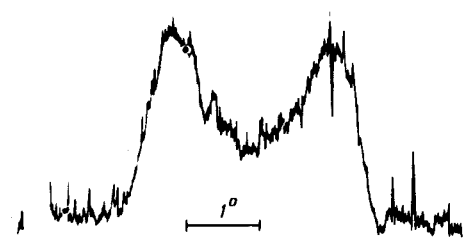

Fig. 3

Fig. 2. SRS spectrum in $LiIO_3$ (y-cut, $\vec{E} \parallel x$).

Fig. 3. Angular dependence of SRS anti-Stokes component in $LiIO_3$ (y-cut, $\vec{E} \parallel x$); angle scale - 1° inside the crystal.

[1)] To be published in Izv. Akad. Nauk Arm.SSR (R.N. Gyuzalyan, K.V. Karmenyan, and Yu.S. Chiligaryan).

Using a crystal cut at 45° (crystal length 10 mm) to the axes y and z, with the exciting radiation polarized along x, we obtained the spectrum shown in Fig. 1. As seen from the figure, oscillations with frequencies ∿760 and ∿625 cm^{-1} are excited at such a crystal geometry. The measurement errors in all experiments do not exceed ±5 cm^{-1}.

The spectrograph slit was placed at the focus of the lens, so that the obtained image gives the spectral distribution of the Raman scattering in the crystal as a function of the angle.

It is difficult to interpret uniquely the obtained frequency shifts, particularly in view of the disparity in the interpretation of the lines obtained from the spontaneous Raman scattering spectra [3, 4], in which the 824 cm^{-1} mode is regarded as belonging to different symmetry types. It is more probable, however, that this is a mixed A + E_1 mode [4], for otherwise this line should appear also in the case of z-orientation of the crystal.

When the exciting radiation polarization is oriented along the x axis, SRS by polaritons of the 795 cm^{-1} IR-active A mode [5] was excited at a frequency ∿755 cm^{-1}, owing to the dispersion characteristics of the medium.

We registered up to three Stokes and two anti-Stokes SRS components. Figure 2 shows clearly the saturation of the first and second Stokes components.

The anti-Stokes components were generated in cones for which the momentum conservation laws for the four-photon interaction were satisfied. Figure 3 shows the angular distribution of the first anti-Stokes component. The angle inside the crystal between the pump beam axis and the cone generator was ∿1°10' in our case, whereas calculations based on the dispersion curves of lithium iodate [6] yield 1°25', thus seemingly indicating that the refractive index changes in the interaction region. Favoring this is also the line broadening, a possible mechanism of which is the phase self-modulation which is due to the change of the refractive index and which should lead to a large broadening of the unshifted component [7]. The variation of the type-A mode of the polariton frequency in the range 755 - 790 cm^{-1} is easier to trace with the aid of the anti-Stokes component.

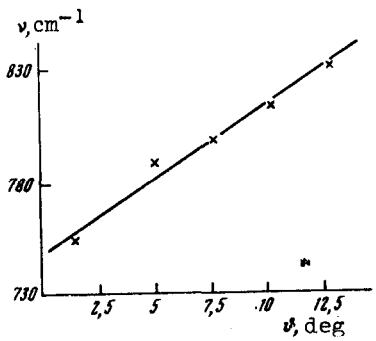

Fig. 4

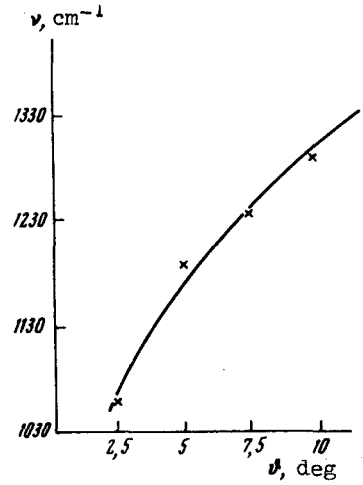

Fig. 5

Fig. 4. Anti-Stokes component frequency vs. the angle of inclination to the x axis (the angle is measured outside the crystal).

Fig. 5. Frequency of additional spectral line vs. the rotation angle (measured outside the crystal).

When the exciting radiation propagated along the x axis of the crystal as an ordinary ray, a variation of the SRS frequency was observed. We were unable to trace the dependence of the frequency shift on the crystal rotation angle by using the Stokes component. The lower spectral width of the anti-Stokes component makes it easier to trace the dependence of the shift on the rotational angle, which is shown in Fig. 4.

When the exciting radiation propagated in the x-direction as an extraordinary ray, an additional spectral band was observed between the first and second anti-Stokes components, and its frequency was shifted 1050 to 1300 cm^{-1} away from the exciting frequency. A plot of this band is shown in Fig. 5. No analogous line was observed in the Stokes region. This band can therefore not be interpreted as a four-photon parametric decay, but can apparently be interpreted as the exciting radiation superimposed on the continuous infrared radiation due to the heating of the crystal by absorption.

Depending on the crystal orientation, synchronism of such an interaction should be obtained at various frequencies. This mechanism is also favored by the fact that the radiation has a diffuse character.

The efficiency of conversion into this tunable frequency was of the order of 1% of the second-harmonic intensity at a crystal length 23 mm.

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DISTRIBUTION OF FLUX OF CHARGE-EXCHANGE ATOMS FROM A PLASMA OVER THE CROSS SECTION OF THE PLASMA FILAMENT IN THE TOKAMAK-4 APPARATUS

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An energy analysis of the flux of charge-exchange atoms from a plasma is widely used at present to measure the ion temperature in Tokamak installations. It was shown in [1] that if the atom flux is analyzed in the equatorial plane of the toroid in the direction of the major radius R, then the maximum values of the ion temperature in the central region of the plasma filament can be determined from the Maxwellian "tails" of the energy distribution of the atoms. An attempt was made to measure the distribution of the ion temperature over the cross section of the plasma filament in the Tokamak-4 by tilting the axis of the atom analyzer up and down relative to the equatorial plane of the toroidal chamber. A five-channel atomic-particle analyzer was used in these experiments and yielded simultaneously the values of the atom flux at five different energies. The distributions obtained in this manner for the flux of deuterium atoms with different energies E over the cross section of the plasma filament are shown in