apparently due to the decrease in the Raman-scattering probability with decreasing radiation frequency. On this basis, we can hardly expect a noticeable photon fraction in components -5 and -6 at the presently attainable laser intensity. The radiation energy in the +2 component, which is not shown in Fig. 2, is approximately 2.5 times as small as in the +1 component.

The curves of Fig. 2 give, apart from constants, the photon distribution among the components as a function of the number of photons in the laser pulse. Using these data we can readily calculate what fraction of the primary photons emerges from the nitrogen forward. This is shown by the dashed curve of Fig. 2. As seen from this curve, in a wide range of laser power, approximately half the photons emerge forward. The photons in the anti-Stokes components were disregarded in the calculations, but it is clear that no significant changes will occur when they are taken accurately into account.

No anti-Stokes components were observed in the backward radiation. At an input energy larger than 2 J, the backward radiation is approximately double the forward radiation; in the -4 component, the forward radiation is several times larger than the backward one.

The foregoing results make it obvious that the theory of stepwise SRS is not valid, at least at large excitation intensities. There exists a strictly defined threshold, beyond which practically all the laser emission is transformed into the Stokes region. An insignificant fraction of the photons goes into the anti-Stokes region. When the intensity of the laser emission is increased, the photons are redistributed among the Stokes components. The higher the laser intensity, the farther it is possible to go into the Stokes region. If the intensity is high enough, we can expect transfer of the photons to the extreme Stokes components. This uncovers the possibility of obtaining powerful laser emission in the far infrared.

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* Raman scattering of light of frequency ν can occur if $\vec{\nu} > \vec{\nu}'$. Therefore the number of possible Stokes components is equal to the integer part of $\vec{\nu}_0/\vec{\nu}'$.

EFFECT OF COMPENSATION IN THE HYPERFINE SPLITTING OF THE EPR SPECTRUM OF PHOSPHORUS IN STRONGLY DOPED n-SILICON

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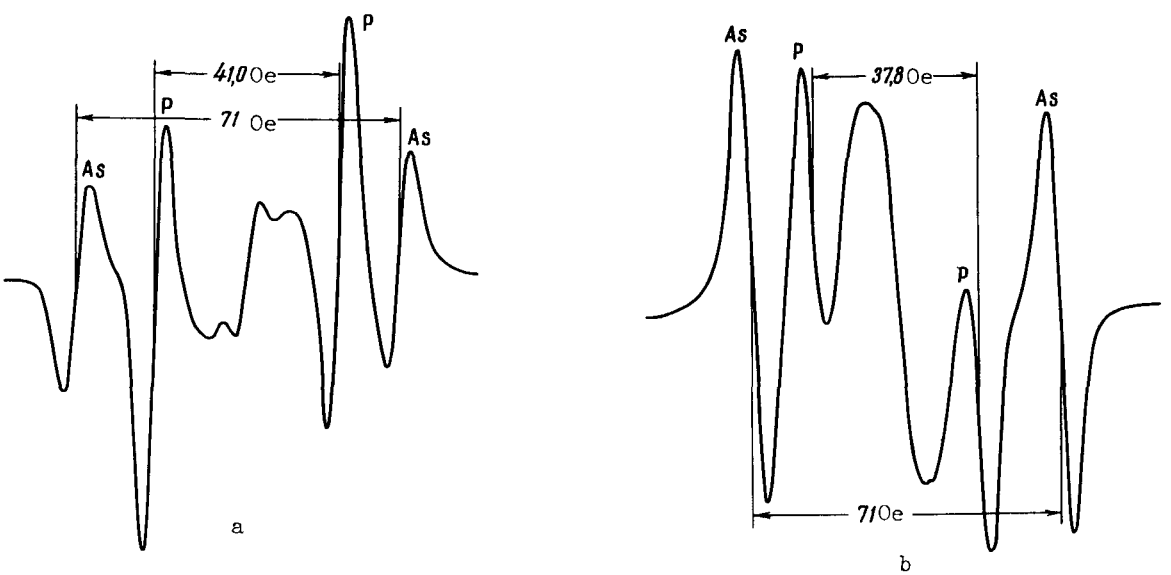
A decrease of the hyperfine splitting A was observed by us in an investigation of the EPR of phosphorus in n-Si samples with donor concentration $N_D \gtrsim 2 \times 10^{17}$ cm^{-3} and with a degree of compensation $K = N_A/N_D > 0.5$ (the compensation was effected by introducing boron as an acceptor into the melt during the growing of the ingots). For isolated phosphorus impurity

atoms in silicon, the value of A is 42 Oe [1]. The experiments were made at 9.4 GHz and 4.2°K. The standard sample used to obtain the magnetic-field markers was n-Si doped with 6×10^{16} As atoms/cm^3 and with the hfs lines spaced 71 Oe apart. The parameters of the investigated samples and the experimental values of A are listed in the table. The figure shows the EPR spectra in the form $d\chi''/dH = f(H)$ for strongly-compensated samples with $N_D = 2 \times 10^{17}$ cm^{-3} and $N_D = 7.2 \times 10^{17}$ cm^{-3} (samples 3 and 7 of the table, respectively). The EPR spectra of weakly-compensated samples are not presented here, since they are given in [2]. It follows from the table that in all the weakly-compensated samples ($K < 0.01$) the value of A remains constant

T a b l e

Parameters of investigated samples and values of hyperfine splitting A

Sample No.	N_D, cm^{-3}	$K = N_A/N_D$	Resistivity at room temperature, ohm-cm	A, Oe
1	2×10^{17}	< 0.01	0.054	42
2	2×10^{17}	0.6	0.17	42
3	2×10^{17}	0.9	0.48	41
4	6×10^{17}	< 0.01	0.033	42
5	6×10^{17}	0.9	0.14	38.3
6	7.2×10^{17}	< 0.01	0.029	-
7	7.2×10^{17}	0.99	4.2	37.8



EPR spectra $d\chi''/dH = f(H)$ of two strongly-compensated n-Si samples: a) $N_D = 2 \times 10^{17}$ cm^{-3}, K = 0.9; b) $N_D = 7.2 \times 10^{17}$ cm^{-3}, K = 0.99. The two outermost lines on the spectra are the hfs lines of a standard n-Si sample with 6×10^{16} As atoms/cm^3.

up to a concentration $N_D = 7.2 \times 10^{17}$ cm^{-3} at which the hfs structure lines at the frequencies $\nu = \nu_0 \pm A/2$ practically disappear; the frequency ν_0 is determined from the relation $h\nu_0 = g\beta H$. The decrease of A following strong compensation is especially noticeable for $N_D \gtrsim 6 \times 10^{17}$ cm^{-3}, where strong exchange interaction exists, as is evidenced by the intense line at the frequency ν_0 [2]. The appearance of the hfs lines in a sample with $N_D = 7.2 \times 10^{17}$ cm^{-3} and K = 0.99 (sample 7 of the table) points unequivocally to the occurrence of localized states as a result of the compensation. This effect was observed for the first time in [3] and was explained theoretically in [4].

The decrease in the value of the hyperfine splitting in strongly-doped samples with strong compensation can be explained qualitatively on the basis of the theory of Takeyama et al. [5], who considered the electron states of isolated impurity pairs. Assuming that the pair interaction is strongest in the strongly doped crystals and that compensation leads to the formation of ionized pairs, we estimated the energy of the volume interaction at $N_D \gtrsim 6 \times 10^{17}$ cm^{-3} by extrapolating the data of [5] to higher concentrations. The obtained value, $\gtrsim 4 \times 10^{-3}$ eV is of the same order of magnitude as the valley-orbit splitting of phosphorus in n-Si, $E_{12} = 1.5 \times 10^{-2}$ eV [6]. In this case, according to [5], the ground states of the ionized pair become mixed with higher states that make no contribution to the hfs, thus leading to a decrease in A.

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LINEAR STARK EFFECT ON ZERO-PHONON LINES OF COLOR CENTERS IN LITHIUM FLUORIDE CRYSTALS

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If the point symmetry group of an impurity or a defect in a crystal does not contain an inversion, then the linear Stark effect is possible in their optical spectrum in an external electric field [1-3]. The first attempts to observe this effect in the spectra of complex color centers in alkali-halide crystals were made by Overhauser and Ruchardt [1] for the broad bands of M and R centers in KCl and NaCl. The observation of an electron-vibrational structure in the spectra of the color centers, including narrow zero-phonon lines [4], uncovers new possibilities for observing the linear Stark effect in spectra of inversionless color centers.

We have observed in an electric field a splitting, linear in the field, of a number of zero-phonon lines in the absorption spectra of complex electronic color centers of LiF. A constant field of intensity up to $\epsilon_0 \approx 300$ kV/cm was applied at 4.2°K to single crystals of γ-ray-colored LiF along the ⟨100⟩ axis. The absorption spectra were photographed in a direc-