ponents appearing in the spectrum) [7]. The vanishing of part of the 6400 Å components, which leads to the asymmetry, can be due to Boltzmann quenching of the populations of the corresponding energy states. The latter probably explains also the peculiarities in the behavior of the zero-phonon 391 nm R_2 line of $R(F_3)$ centers in a field, namely that splitting into a poorly resolved asymmetric doublet is observed in fields $\epsilon_0 \approx 300$ kV/cm ($\delta \approx 2 \times 10^{-5}$ cm^{-1}/V/cm).[***]

The field exerts no influence on the zero-phonon 5234 Å line of N_1 centers [6]; this agrees with Pick's model [9] for these centers (an aggregate of four F centers in octahedron plane, the point group C_{2h} of F_4 center has inversion). Nor does the field act on the 3932 Å line, which belongs [6] to A → E transitions in centers of tetragonal symmetry.

[1] A. W. Overhauser and H. Ruchardt, Phys. Rev. **112**, 722 (1958).
[2] N. Bloembergen, Science **133**, 1363 (1961).
[3] W. Kaiser, S. Sugano, and D. L. Wood, Phys. Rev. Lett. **6**, 605 (1961).
[4] D. B. Fitchen, R. H. Silsbee, T. A. Fulton, and E. L. Wolt, ibid. **11**, 275 (1963).
[5] Y. Farge, G. Toulouse, and M. Lambert, J. de Phys. **27**, 287 (1966).
[6] A. E. Hughes and W. A. Runciman, Proc. Phys. Soc. **86**, 615 (1965).
[7] A. A. Kaplyanskii and V. N. Medvedev, Opt. Spektrosk. **23**, No. 5 (1967).
[8] A. A. Kaplyanskii, ibid. **16**, 602 (1964).
[9] H. Pick, Z. Physik **159**, 69 (1960).

[*] A general phenomenological calculation of the characteristics of the linear Stark effect in spectra of inversionless local centers in O_h crystals is given in [7].

[**] The calculated picture [7] of these centers agrees also - in the number, polarization, and relative positions of the components - with the experimental splitting (incompletely resolved quartet) of 6955 Å when $\epsilon_0 \parallel \langle 110 \rangle$.

[***] It must be noted that deviations unrelated to quenching were observed for the lines for which the picture of the splitting was described above as "symmetrical"; the reasons for this call for an investigation.

COHERENT EMISSION FROM ELECTRON-HOLE PLASMA OF INDIUM ANTIMONIDE IN THE ABSENCE OF A MAGNETIC FIELD

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Indium antimonide is the most complicated among the III-V compounds when it comes to generation of coherent emission by electric carrier injection [1,2].

When the coherent emission is generated with the aid of an electron-hole plasma produced in pure indium antimonide crystals [3-5], additional difficulties are caused by the pinch effect, since the contraction of the carriers into a pinch leads to a strong intrinsic absorption of the radiation in the remaining part of the crystal [6,7]. We have therefore used in [6,7] a longitudinal magnetic field to eliminate the pinch effect.

An examination of the conditions for the occurrence of the pinch effec leads to the conclusion that the pinch formation should be strongly influenced by the geometry of the cross section (form of the cross section and distance between contacts). By choosing crystals having a definite geometry, it is possible to shift the threshold of pinch formation into the region of larger currents. We report here generation of coherent emission in an electron-hole plasma of indium antimonide without a magnetic field.

Figure 1 shows the current-voltage characteristics of samples No. 41 and No. 172, made of p-type indium antimonide with hole density $p = 1.8 \times 10^{13}$ cm^{-3} at 77°K. These samples were of equal thickness (distance between contacts ≈ 0.25 mm) and equal contact area, but different shapes. Sample 172 had a square cross section, and 41 a rectangular one. The sharp rise of the resistance, observed on the current-voltage characteristics, is due to the contraction of the carrier current into a plasma pinch. It is seen that in the case of a rectangular crystal (sample 41) the plasma pinch is produced at much larger currents. This makes it possible to generate coherent emission before the plasma contracts into a pinch.

The recombination-radiation spectra of sample 41 are shown in Figs. 2a, b, c. It is seen from the figure that at a current I = 15 A (Fig. 2a) there is observed a spontaneous-emission spectrum with half-width 850 Å (3.92 eV or ≈ 10 kT). A study of the emission spectra at different injection levels has shown that when the current increases, up to I = 15 A, the maximum of the spectrum shifts towards higher quantum energies, because the conduction band becomes filled with electrons, and that starting with I > 15 A an increase in the injection level is accompanied only by a narrowing of the spectrum, the position of the maximum of the spectrum remaining the same. A current I = 20 corresponds to the threshold for the generation of coherent emission, and the modes appear in this case

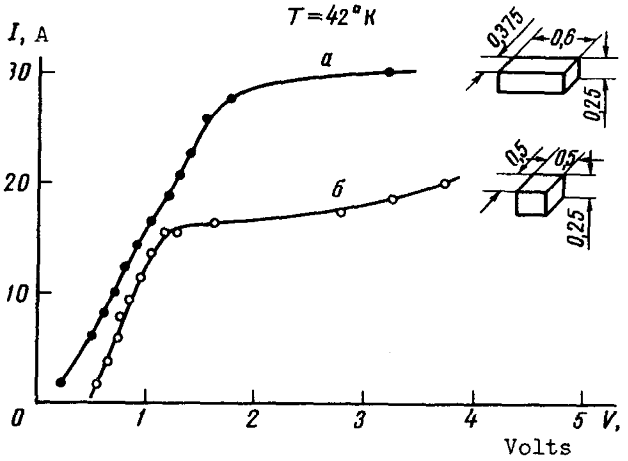

Fig. 1. Current-voltage characteristics of samples 41 (a) and 172 (b).

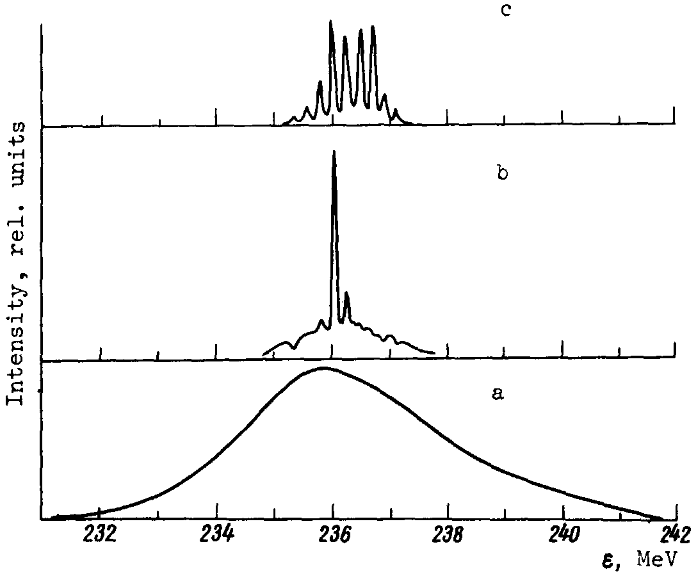

Fig. 2. Emission spectra of sample No. 41 at different injection currents, a) I = 15 A, b) I = 20 A, c) I = 25 A.

at quantum energies corresponding to the maximum in the spontaneous-emission spectrum. At currents much higher than threshold (I = 25 A), multimode generation is observed (Fig. 2c). From the distance between modes we calculated the quantity $n - \lambda(dn/d\lambda)$, which was found to be equal to 5.2, in full agreement with the value 5.2 obtained by others [2].

Thus, by using a suitable crystal geometry, it is possible to generate coherent emission in an electron-hole plasma of indium antimonide without a magnetic field.

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[1] R. J. Phelan, A. R. Calawa, R. H. Rediker, R. J. Keyes, and B. Lax, Appl. Phys. Lett. 3, 143 (1963).
[2] C. Benoit a la Guillaume and P. Lavallard, Solid State Communication 1, 148 (1963).
[3] J. Melngailis, R. J. Phelan, and R. H. Rediker, Appl. Phys. Lett. 5, 99 (1964).
[4] A. P. Shotov, S. P. Grishechkina, and R. A. Muminov, Fiz. Tverd. Tela 8, 2496 (1966) [Sov. Phys.-Solid State 8, 1998 (1967)].
[5] A. P. Shotov, S. P. Grishechkina, B. D. Kopylovskii, and R. A. Muminov, ibid. 8, 1083 (1966) [8, 865 (1966)].
[6] A. P. Shotov, S. P. Grishechkina, and R. A. Muminov, Zh. Eksp. Teor. Fiz. 50, 1525 (1966) [Sov. Phys.-JETP 23, 1071 (1966)].
[7] A. P. Shotov, S. P. Grishechkina, and R. A. Muminov, ibid. 52, 71 (1967) [25, 45 (1967)].

ANGULAR ANISOTROPY OF GAMMA QUANTA AND KINETIC ENERGY OF FISSION FRAGMENTS

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According to the existing theoretical notions developed by Strutinskii [1], the angular anisotropy of the emitted prompt fission γ quanta, $A = W(0°)/W(90°) - 1 \sim 10 - 15\%$ is caused by the fact that the fragments have an angular momentum $j \sim 10\hbar$ which is correlated with the direction of fragment emission. The appearance of a rather large angular momentum is related in [1] to the instability of the fragments to rotation, under the influence of the transverse component of the Coulomb repulsion of the stubs produced as a result of scission. On the basis of this mechanism, it can be assumed that the angular anisotropy of the γ-quantum emission is highly sensitive to the configuration of the fissioning nucleus at the critical instant of scission. In particular, an appreciable change of A is expected when the kinetic energy E_k and the fragment mass ratio m_1/m_2 change. This problem is treated in the literature in only one paper [2], where data are reported on the variation of A with m_1/m_2, i.e., for fission methods characterized by a fixed fragment mass-ratio range, but for all possible values of E_k at a given m_1/m_2.

We studied the dependence of A on both E_k and m_1/m_2 in the fission of U^{235} by thermal neutrons. A study of the dependence of A on E_k seems to be more attractive, since the variation of E_k is connected with the simplest changes in the configurations of the fissioning nucleus at the instant of scissions; these changes can be interpreted in first approximation as the results of the fluctuations of the effective distance between the produced fragments. Furthermore, it is precisely for this dependence that Hoffman [3] made a concrete prediction. According to [3], a considerable increase of A with increasing E_k is expected (j doubles when