In conclusion, the authors thank I.G. Mikhailov for collaboration and V.I. Smushkov for supplying the CsI samples.

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RADIATION OF A BIELECTRON (BI-HOLE) IN A BiI_3 CRYSTAL AT LOW TEMPERATURES

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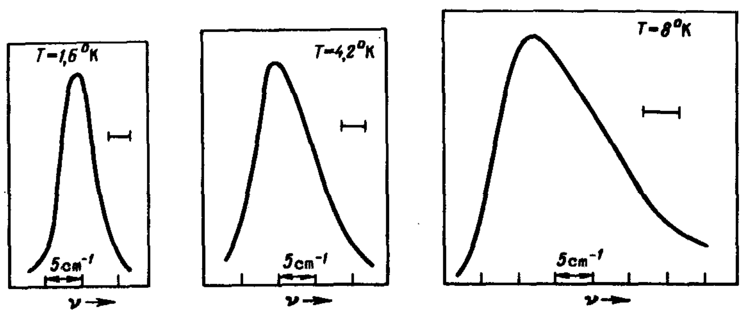
We have investigated the radiation spectrum of the inverse hydrogen-like line series of BiI_3 crystals in the temperature interval 1.6 - 10°K, using a large-dispersion (1.9 Å/mm) diffraction spectrograph. The luminescence was excited by a DRSh-500 mercury lamp through an optical filter. The luminescence was recorded photographically.

The emission spectrum of BiI_3 crystals at low temperatures is complex and has not yet been uniquely interpreted [1, 2]. We have studied in greater detail the bright n = 6 resonant emission line and its first phonon replica with frequency 112 cm^{-1}, which falls in a spectral region free of other emission lines. The use of a large-dispersion spectral instrument has revealed, in our opinion, a new interesting fact.

It is seen already at 4.2°K that the phonon replicas are broader than the resonant emission lines and have an asymmetrical shape, with a wing on the high-energy side. When the temperature is raised to 8°K, the widths of the phonon replica lines and their asymmetries increase even more. Preliminary results show that the phonon replica lines broaden linearly with rising temperature (see the figure). The resonant emission line also broaden somewhat, but their shape remains unchanged. It is seen from the figure that when the crystal is cooled to T = 1.6°K the phonon line becomes narrow and almost symmetrical. This "symmetrization" of the phonon replica shows that its asymmetric shape is not due to superposition of other emission lines.

The phonon replicas are observed against a continuous emission background that starts with the resonant emission lines n = 5 and n = 6 and stretches,



Micrograms of phonon replica (ν_6 - ω_2) emission lines of a BiI_3 crystal at 1.6, 4.2, and 8°K. The half-widths of the n = 6 resonant emission line at the same temperatures are shown for comparison.

weakening gradually, into the long-wave side (see Fig. 1a of [2]). We have observed this background up to $\lambda = 6800$ Å). This uniform continuous emission background is practically independent of the temperature. The intensities of the resonant emission lines n = 3 and n = 4 are very low, and no continuous emission background was observed in this region.

The inverse hydrogen-like series of lines of the BiI_3 crystal was interpreted by us earlier [2, 3] as a direct band-band transition between two electron or two hole bands, accompanied under certain conditions by formation of a bound state of two electrons (a bielectron) or two holes (bi-hole) in analogy with the formation of an exciton in ordinary transitions between the valence and conduction bands.[1)]

A bielectron or a bi-hole, like an exciton, can be free or bound to an impurity. The free bielectron has a kinetic energy, which in the case of parabolic bands is connected with its wave vector K and with the carrier effective masses m_1 and m_2 by the relation

$$E_{\text{kin}} = \frac{\hbar^2 K^2}{2(m_1 - m_2)}. \tag{1}$$

Unlike the exciton, the mass sum $m_1 + m_2$ is replaced here by the difference $m_1 - m_2$ (under the condition[2)] $m_1 > m_2$), since the formation of a bielectron or a bi-hole is possible only in a transition between electron or hole bands with curvatures of opposite sign [2, 3].

The kinetic energy of a free bielectron can become manifest by its radiative decay, just as the kinetic energy of a free exciton is manifest by the exciton luminescence spectrum [5].

The lines of the radiative decay of a bielectron or a bi-hole with emission of one or several phonons should also be characterized by an asymmetrical shape with a short-wave wing that exhibits a characteristic temperature dependence. This can be regarded as a manifestation of a "bielectron" band with a quadratic dispersion law (1). If thermal equilibrium with the lattice can be established during the bielectron lifetime, then the shape of the wing can be close to Maxwellian [5, 6].

The phenomena observed by us for the phonon replica $\omega_2 = 112$ cm^{-1} of the n = 6 line of the emission series, namely the strongly pronounced short-wave asymmetry and its characteristic temperature dependence, agree with the notion of a bielectron (bi-hole) possessing a kinetic energy.

We note, however, that a difficulty arises in the model of the free beelectron (bi-hole) in connection with the interpretation of the observed narrow resonant-fluorescence lines[3)]. Indeed, in the decay of a bielectron (bi-hole), the final state has a continuous energy spectrum corresponding to the presence of free electrons (holes). This can lead to the appearance not of narrow resonant-fluorescence lines but to broad emission bands corresponding to carriers moving apart with different values of kinetic energy. These bands can apparently be "made narrower" only by assuming that the region of the quadratic dispersion in the initial band (1) is essentially limited to a small region of K localized near the point K = 0.

[1)] The bound state of an electron in a repulsion potential was considered also in [4].

[2)] The fact that the net carrier mass $m_1 - m_2$ turns out to be positive in this case is important from the point of view of the stability of the bielectron.

[3)] This difficulty was pointed out to us by E.I. Rashba.

It should be noted at the same time that the continuous emission spectrum background observed by us, which stretches into the long-wave region away from resonant emission lines (n = 5 and n = 6), is possibly a manifestation of this mechanism. This question, however, calls for a more detailed experimental and theoretical investigation.

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"LEADING" PARTICLE AND ASYMMETRY OF THE NEUTRAL ρ^0-MESON DECAY IN THE REACTION $\pi^- + A \to 2\pi^-\pi^+ + A^*$

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In our earlier study of the production of three pions ($2\pi^-\pi^+$) by π^- mesons with momentum ~3.9 GeV/c on light nuclei (C, F, Cl) [1], the interactions with the quasi-free nucleons of the nuclei were selected by fitting to the nucleon reaction. This revealed intense ρ^0-meson generation in the ($\pi^+\pi^-$) system. If no limitations are imposed on the 4-momentum transfer, then the relative amplitude of the ρ-meson signal is equal to the amplitude observed in reactions with free nucleons at the same primary energy.

The selection of events with effective masses of the ($\pi^+\pi^-$) combination in the ρ-meson band and with 4-momenta $\Delta^2 < 0.5$ (GeV/c)^2 transferred to the ($\pi^+\pi^-$) pair causes the cases of peripheral production of aligned ρ^0 mesons to be added to the selected events, as seen from Fig. 1. The asymmetry of the neutral ρ decay, which is universally known [2], is also clearly manifest in this case. The predominant forward emission of a pion having the same sign as the primary one is customarily attributed to interference between the fundamental P-wave (ρ meson) and the background S-wave. The presence of an S-wave ($\pi^+\pi^-$) resonance with a mass close to the ρ-meson mass (ε^0) is assumed.

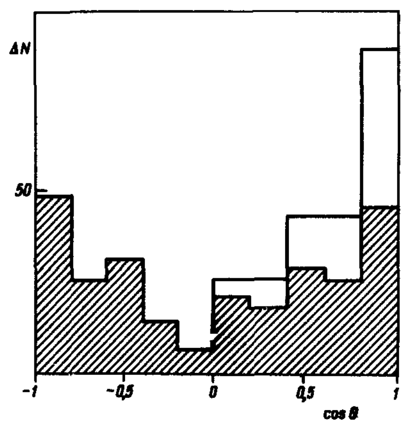

Fig. 1. Distribution with respect to the π^--meson emission angle in the ($\pi^+\pi^-$) c.m.s.; $\Delta^2 < 0.5$ (Gev/c)^2; 0.64 GeV < $M_{\pi^+\pi^-}$ < 0.88 GeV. The events outside the region 1.08 < $M_{N\pi}$ < 1.3 GeV are shown shaded.

Certain considerations can be advanced with respect to the mechanism that causes the asymmetry. It is based on the following facts.