linear even in the voltage region where there were no glowing spots. Therefore practically the entire voltage is concentrated at first at the cathode (since the crystals were of the n-type), and it is there that the strong-field region, in which all the processes in question begin, is produced. The contacts and the crystals themselves were not quite homogeneous over the surface. Therefore the concentration of the field may proceed at a faster rate in a small part of the region next to the cathode. It is in this part that the glowing spot is produced and then begins to move towards the anode. The spot may decrease in diameter as a result of edge effects. Some spots may become extinguished without reaching the anode, as was frequently observed in the experiment.

An independent check on the theory may be an estimate of the effective cross section of the donors S. It can be obtained if one knows the velocity of the moving spot, the current density in the spot, and the thickness of the layer outside the strong-field region in which impact ionization of the donors takes place. S was found to equal 3×10^{-14} cm^2. All the quantities needed for this estimate were found either from experiment or theoretically, but without any a priori assumptions concerning the parameters of the donors. Taking into account the accuracy with which these quantities were estimated, the obtained value of the donor-impact-ionization effective cross section can be regarded as perfectly reasonable.

Thus, the appearance and motion of glowing spots in Na_2ZnGeO_4:Mn crystals is connected with one more type of electric instability, characteristic of strongly compensated broad-band semiconductors with large concentration of deep donors. This instability can be called of the ionization type in view of the mechanism whereby it is produced.

[1] K.A. Verkhovskaya et al. Fiz. Tverd. Tela 10, 1906 (1968) [Sov. Phys.-Solid State 10, 1504 (1968)].
[2] G.E. Arkhangel'skii, E.Yu. L'vova, and M.V. Fok, Zh. prikl. spektr. 14, 97 (1971).

PROPAGATION OF MAGNETOPLASMA WAVES IN Bi ALLOYED WITH Te

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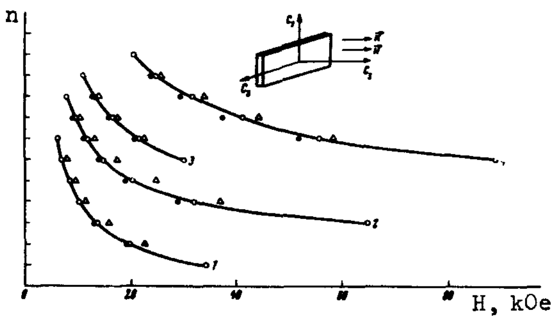
Among the various types of magnetoplasma waves propagating in a solid-state plasma (SSP), one distinguishes usually between Alfven waves, whose phase velocity v is proportional to the magnetic field H, and helicons, in which $v \sim \sqrt{H}$. The Alfven waves are observed at $\Delta N/N_{\pm} << \omega/\Omega_{\pm}$, and helicons at $\Delta N/N_{\pm} >> \omega/\Omega_{\pm}$, where $N_{\pm}$ is the concentration of the carriers of opposite sign in the medium, $\Delta N = |N_{+} - N_{-}|$, $\Omega_{\pm} = e_{\pm}H/m_{\pm}c$ is the cyclotron frequency, and ω is the wave propagation frequency. However, as indicated in [1], there should exist waves of an intermediate type propagating in the SSP under the condition $\Delta N/N_{\pm} \sim \omega/\Omega_{\pm}$.

For an experimental observation of the intermediate-type waves we used in the present investigation Bi samples doped with small amounts of Te. Te, being a donor impurity, gives up electrons, by the same token violating the condition $\Delta N = 0$, which is characteristic of pure Bi.

The experiments were performed at helium temperatures in constant magnetic fields of intensity up to 100 kOe [2]. The frequency of the incident wave was $f = 2.07 \times 10^{10}$ Hz. The samples were plane-parallel plates of thickness d = 0.6 - 1 mm with concentration 0.0006 and 0.0012 at.% Te. For comparison, we



Comparison of calculation with the experimentally obtained positions of the maxima of transmitted power: o - experiment, • - calculation in accordance with the formula nH = const, Δ - calculation in accordance with the formula $n\sqrt{H}$ = const. Curve 1 - pure Bi, curve 2 - Bi-Sb (0.5 at.% Sb), 3 - Bi-Te (0.0006 at.% Te), 4 - Bi-Te (0.0012 at.% Te). Curves 1 - 4 are shifted vertically relative to one another in an arbitrary manner.

tested also a pure Bi sample and a sample of Bi-Sb 0.5 at.%. The propagation of the magnetoplasma wave in the SSP was registered by determining the maxima of the power passing through a plane-parallel sample located across the waveguide. The condition for the maximum was the relation kd = πn, where k is the wave number and n is an integer. At first the value of n for each maximum was calculated from the position of the first and last of the observed maxima for each sample, starting from the relations nH = const and $n\sqrt{H}$ = const, which are valid for the pure Alfven and the pure helicon spectra, respectively. The results of such a calculation are shown in the figure. In the case of pure Bi, the experimental points agree sufficiently well with the calculation for the Alfven spectrum. With increasing Te concentration, the experimental points deviate from the Alfven spectrum and approach the helicon spectrum. This confirms the assumption that an intermediate type of waves, between the Alfven and the helicon waves, propagates in Bi alloyed with Te.

A more accurate calculation of the spectrum was carried out by means of a formula obtained by expanding the dispersion relation

$$\frac{k^2c^2}{\omega^2} = \epsilon_0 - \Sigma \frac{4\pi Ne^2}{m\omega(\omega - \Omega)} . \tag{1}$$

Accurate to terms of order $\omega^2/\Omega_\pm^2$ we have:

$$n(Q) = \frac{\omega d}{\pi c}\sqrt{\epsilon_0 + \frac{4\pi ec}{\omega}\frac{\Delta N}{H(Q)} + 4\pi c^2 \frac{\Sigma Nm}{H^2(Q)}} \tag{2}$$

Here n(Q) is the number of half-waves subtended by the thickness of the sample, Q is the serial number of the maximum, counting from the strong-field side, and ε_0 is the dielectric constant of the lattice. It is seen from the tabulated results that ΔN increases with increasing degree of alloying. For pure Bi, the deviation of ΔN from zero, corresponding to approximately 1% of $(N_+ + N_-)$, can be attributed to experimental errors and to the inaccurate character of the expansion (2). The difference between the values of n(1) and integers is apparently due to the leakage of power past the sample.

The theoretical value of ΔN was calculated by starting from the concentration of the impurity at an effectiveness coefficient 0.7 [5]. The value of R is

$$\sqrt{\frac{\sum_{Q=1}^{Q_{max}} [n(Q) - n(1) - Q + 1]^2}{Q_{max}}}$$

Substance	Concentration, at%	ΔN exper.	ΔN theor.	ΣNm	n (1)	R
Bi	0	$6,75 \cdot 10$	0	$2,1 \cdot 10^{-11}$	2,3	0,024
Bi – Te	0,0006	$5,3 \cdot 10^{16}$	$1 \cdot 10^{17}$	$2,25 \cdot 10^{-11}$	5.1	0,013
Bi – Te	0.0012	$1,05 \cdot 10^{17}$	$2 \cdot 10^{17}$	$2,9 \cdot 10^{-11}$	4.8	0.027
Bi – Sb	0.5	$1,38 \cdot 10^{16}$	0	$1,7 \cdot 10^{-11}$	2.5	0,055

A comparison of the microwave power passing through the samples of pure and alloyed Bi shows that the attenuation increases with increasing alloy content. The same is evidenced also by the fact that with increasing alloying the distinctly resolved interference pattern shifts into the region of stronger fields (see the figure). At the same time, the depth of modulation on the Shubnikov - de Haas (SH) effect curves plotted by us is practically independent of the degree of alloying. Thus, the alloying exerts an influence on the damping of the microwave oscillations, without causing a decrease in the amplitude of the SH effect. This contradiction can be resolved by assuming that alloying gives rise in Bi to a new type of carriers, and the mobility of these carriers is small. The presence of such carriers requires that an additional conduction band be present somewhat above the Fermi level (higher by several millielectron volts), or else a valley of the band L, or else an impurity level [3]. Although the presence of such band-structure elements does not agree with the usually accepted scheme [4], their presence is also favored by a certain increase of the quantity ΣNm with increasing alloying, and also the fact that the microwaves have a small degree of damping in the alloy Bi - Sb 0.5 at.%, in which the Fermi level is lower than in pure Bi.

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[1] V.G. Veselago, M.V. Glushkov, and A.M. Prokhorov, Radiotekhnika i elektronika 12, 1220 (1967).
[2] V.G. Veselago, L.P. Maksimov, and A.M. Prokhorov, PTE No. 4, 192 (1968).
[3] L. Esaki, J. Phys. Soc. Japan 21, Suppl. 89 (1966).
[4] N.B. Brandt and S.M. Chudinov, Zh. Eksp. Teor. Fiz. 59, 1494 (1970) [Sov. Phys.-JETP 32, No. 5 (1971)].
[5] N.B. Brandt and L.G. Lyubutina, ibid. 52, 686 (1967) [25, 450 (1967)].

DIRECT PROOF OF THE EXISTENCE OF AN EXCITED NEGATIVE C^- ION AND THE DETERMINATION OF THE BINDING ENERGY OF THE ELECTRON IN IT

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The question of the possible existence of excited negative ions is of considerable interest both from the point of view of the theory (verification of approximate method of calculating the binding energy) and from the practical point of view (physics of gas discharge and of low-temperature plasma, astrophysics).

For a number of negative ions (mainly elements of groups III and IV of the periodic system), the theory admits of the possible existence of metastable excited states with the same electron configuration as the ground state of the