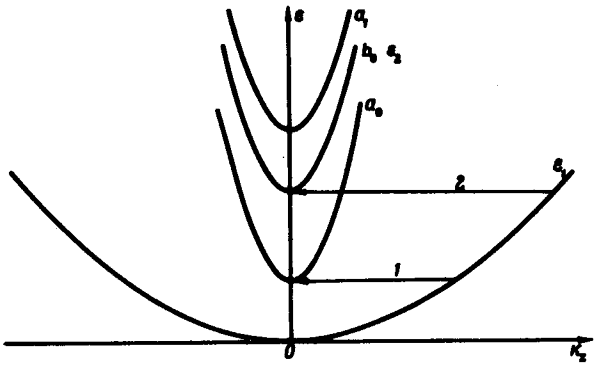

Fig. 3. Transitions in the valence band of InSb in a magnetic field that is quantizing for the light holes.

In other words, a strong enhancement of the interband scattering of the heavy holes is observed whenever the Fermi level coincides with the bottom of the Landau light-hole subband. To determine the theoretical positions of the maxima of the longitudinal magnetoresistance, the Landau levels were determined at $k_z = 0$ for the light holes in InSb. The interaction between the conduction and the valence bands was considered exactly, and the influence of the more remote bands was taken into account by perturbation theory. The InSb valence-band parameters, in Luttinger's notation [4], were assigned the values obtained by Pidgeon and Brown from magneto-absorption data [3] and satisfying the cyclotron-resonance data for the heavy holes [5]: $P^2 = 0.403$ at. un., $\gamma_1^L = 32.5$, $\gamma_2^L = 14.3$, $\gamma_3^L = 15.4$, $k^L = 13.4$, and $\varepsilon_g = 0.2355$ eV ($T = 4.2$°K). The best agreement between the observed maxima of ρ_{zz} and the values of H corresponding to agreement of the Fermi level with the Landau levels a_n and b_n of the light holes was obtained at $\zeta = 9.5$, 19, 19.5, and 40.5 meV for samples 1, 2, 3, and 4, respectively. The theoretical values of H for given ζ are indicated in Figs. 1 and 2 by vertical lines with indices a_n and b_n. It is seen that the agteement is good. The heavy-hole concentration calculated from the value of the chemical potential for each of the samples agrees well with the data determined from the Hall coefficient in a strong field. It should be noted that owing to the smearing of the Landau levels, due in turn to the collisions, the nearby maxima of ρ_{zz}, corresponding to the neighboring levels b_n and a_{n+1}, overlap to form a single maximum in the experiment. Splitting of the maxima could be observed at $T = 1.6$°K only for the lowest Landau levels and grids a and b (Fig. 2).

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ELECTRON-CYCLOTRON HEATING IN THE TOKAMAK TM-3 INSTALLATION

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Using the Tomamak TM-3 installation [1], we investigated the possibility of additionally heating a plasma in a high-frequency (HF) field in the

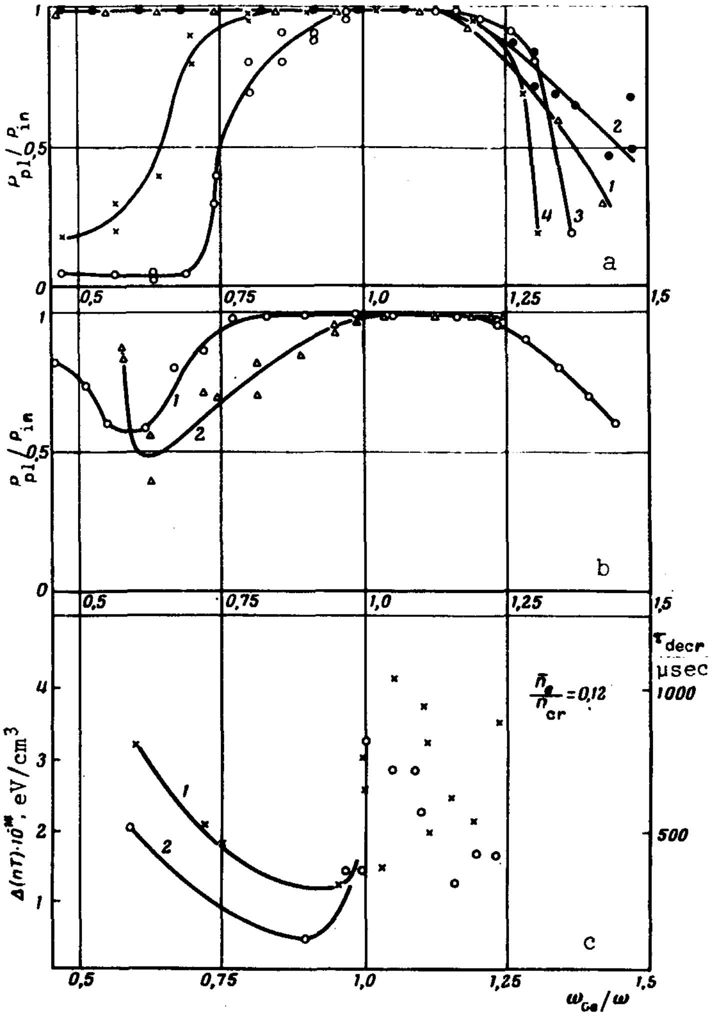

Fig. 1

frequency range of the electron-cyclotron resonance and its harmonics. In most experiments we used a generator with wavelength λ ∿ 1 cm and power ∿40 kW. The generator pulse duration was 500 µsec at an approximate TM-3 discharge-current pulse duration 10 msec. The HF power was fed through a horizontal tube along the major radius of the apparatus. The corrugated stainless-steel liner constituted a multimode resonator with Q ∿ 10^4 in the absence of plasma. The energy level of the HF field in the chamber was monitored with a horn antenna located far enough from the point of entry of the generator energy. The ratio of the signals received by such an antenna with and without the plasma is proportional to the quantity $(1 - P_{pl}/P_{in})$, where P_{pl} is the power absorbed in the plasma and P_{in} is the power input to the liner from the generator. We investigated the dependence of the degree of absorption P_{pl}/P_{in} of the change of the plasma parameters (due to the action of the HF radiation on the plasma) on the longitudinal magnetic field H_z and the plasma concentration n_e. The influence of the HF radiation was revealed by the changes of the following quantities: the plasma-column diamagnetism, the chamber circuit voltage U, and the shift of the equilibrium positions of the plasma column and of the current derivative.

Figure 1a shows plots of P_{pl}/P_{in} against ω_{ce}/ω (ω_{ce} is the electron-cyclotron frequency corresponding to the field H_{z0} on the liner axis, and ω

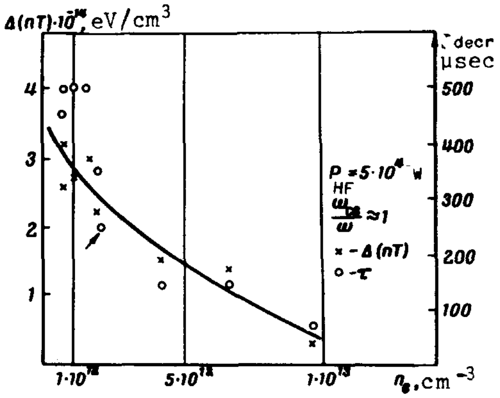

Fig. 2

is the generator frequency), obtained during the stage of discharge evolution when the electron temperature is low. Curves 1 and 2 were obtained at high plasma density, $\bar{n}_e/n_{cr} = 1.4$ and 1.14, respectively ($\bar{n}_e$ is the electron density averaged over the column cross section and obtained by interferometer measurements, and n_{cr} is the critical density corresponding to the generator frequency). Plot 1 was obtained with low power input to the chamber from the generator ($P \sim 3$ W), while curve 2 was obtained at a generator power $P \sim 10^4$ W. We see that almost total absorption is observed in the entire range $1/2 < \omega_{ce}/\omega < 1$, and the absorption decreases at $\omega_{ce}/\omega > 1$. The absorption in the cold plasma can be attributed to the linear wave transformation [2] and to damping of the plasma oscillations by the collisions, both in the presence and in the absence of a resonance zone in the liner cross section ($\omega_{ce}/\omega = 1$). It should be recognized that the variation of the magnetic field in the chamber cross section, due to the toroidal geometry, amounts to ∼25% of H_{z0}. Curves 3 and 4 were obtained at $n_e/n_{cr} = 0.07$ and 0.36, respectively. We see that when n_e decreases at small values of the magnetic field, the absorption vanishes at a certain value of ω_{ce}/ω, and that this value decreases with increasing concentration. This phenomenon can be attributed to the lack of conditions for transformation at this value of ω_{ce}/ω, since the relation $\omega^2 = \omega_{ce}^2 + \omega_{pe}^2$ is not satisfied anywhere in the plasma volume. It should be noted that in these regimes there are no singularities in the absorption at $\omega_{ce}/\omega = 1/2$.

Figure 1b shows similar plots but obtained for a high electron temperature ($T_e \geq 200$ eV) at the center of the discharge-current pulse. Plot 1 was obtained at 3 W from the generator ($\bar{n}_e/n_{cr} = 0.44$), and plot 2 at a generator power 40 kW ($\bar{n}_e/n_{cr} = 0.12$). In this case, unlike in the cold plasma, absorption is observed also near the second harmonic ($\omega_{ce}/\omega = 1/2$). It should be noted that at $\omega_{ce}/\omega = 1/2$ and $\bar{n}_e/n_{cr} = 0.12$ there are no conditions for linear transformation anywhere in the plasma. The stronger HF power absorption at $\omega_{ce}/\omega \sim 1/2$ is accompanied by an increase of the plasma heating.

Figure 1c shows the increment of nT of the plasma as a function of the relative longitudinal magnetic field (curve 1). The same figure shows the time of the decrease of Δ(nT) after the HF generator is turned off vs. ω_{ce}/ω (curve 2). Attention is called to the correlation between τ_{decr} and Δ(nT). This correlation is even more pronounced in Fig. 2, where the same quantities are shown as functions of n_e. The proportionality of Δ(nT) to τ_{decr} means that the HF energy absorbed in the plasma in the investigated regimes depends little on the concentration and apparently also on H_z. The arrow in Fig. 2 marks the energy lifetime of the plasma τ_ε, calculated by the usual method for Tokamak: $\tau_\varepsilon = (3/2)nTV/IU$ (V is the plasma volume). Since no changes of the electron density were observed during the course of the HF generator pulse, the increase of nT should be due to the growth of T_e. If it is assumed that all the plasma electrons are heated, then $\Delta T_e \simeq 200 - 400$ eV, whereas the "initial" electron temperature at the instant when the generator is turned on is $T_e \simeq 250$ eV in the investigated regime. A comparison of τ_{decr} with τ_ε shows that what is heated is that fraction of the plasma column which has a "lifetime" not shorter than τ_ε. The increase of nT at a constant discharge current (the latter changes not more than 1.5% during the time of the generator pulse) should lead to an additional shift of the equilibrium position of the plasma column outward from the chamber axis. The experiments revealed satisfactory agreement between the additional shift and Δ(nT). The additional heating of the plasma electrons should, naturally, also lead to a decrease of the chamber circuit voltage. Such an effect actually takes place at sufficiently high electron concentration. In discharges with low concentration, however, the voltage increases during the course of the pulse. This fact can be attributed, in principle, to the increase of the number of trapped particles because of the increase of the transverse energy of the electrons.

We have thus registered with the TM-3 installation electron-cyclotron heating with Δ(nT) up to 4×10^{14} eV-cm^{-3}. The heating efficiency for such Δ(nT) amounts to 20 - 30%. In a hot plasma, heating can take place in the region $\omega_{ce}/\omega \simeq 1/2$.

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MEASUREMENT OF INFRALOW TEMPERATURES WITH THE AID OF THE MOSSBAUER EFFECT

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The possibility of using the Mossbauer effect to measure infralow temperatures has already been discussed a number of times [1]. Such a method is based on two assumptions: a) the populations of the nuclear levels are proportional to the Boltzmann factor, and b) the γ-quantum emission or absorption probability is proportional to the population of the initial state.

The cooled absorbers used in our experiments were samples of metallic iron. In this case we have for the ratio of the intensities of symmetrical absorption lines (e.g., corresponding to the transitions ±1/2 → ±3/2), in a thin absorber,

$$p = (N_\infty - N_+) / (N_\infty - N_-) = e^{\Delta/T} \tag{1}$$

where $N_\pm$ is the intensity of the transmitted radiation at resonance (+ corresponds to motion of the source towards the absorber), N_∞ is the intensity far from resonance, $\Delta = 2.33 \times 10^{-3}$ °K is the hyperfine splitting of the ground state of Fe^{57}, and T is the absolute temperature.

We used samples with natural Fe^{57} contents (rolled foil of carbonyl iron of thickness 0.12 mg/cm^2 in terms of Fe^{57}) and samples enriched with Fe^{57} to 89% (thicknesses 0.17 and 0.31 mg/cm^2 in terms of Fe^{57}). The enriched foils