4. The cross sections of the process (2), measured in many investigations, including [5], are characterized by a monotonic dependence on the ion energy. This agrees with the dependence predicted by the Firsov approximation, in which the quantity $\sin^2(\eta_g - \eta_u)$ is replaced in the calculation of the integral (1) by its mean value in a certain region of the parameter b. As seen from the figure, the curve 1 obtained by us is nonmonotonic, and the non-monotonicity exceeds the errors of the relative cross sections. These results apparently point to an oscillating character of the function $\delta = f(E)$ for the process (2).

From the electron energies of the principal levels of He_2^+ [3], we can conclude that the difference $V_g - V_u$ has no maximum, because to explain the oscillations of the cross section of the process (2) it must be assumed that the incident particle is scattered by the core of the target atom. Calculations [1] of the integral (1) for the H^+-H system reveal a weak oscillation of the cross section. There are no exact calculations of the integral (1) for the H^+-H system, but it follows from the theory that the oscillation of the cross section should increase with increasing atomic number of the particles.

In the He^+-He case, resonant charge exchange is connected between the odd and the adiabatic even terms. Resonant charge exchange with transition between the odd and adiabatic even terms is also possible. In both cases, oscillation of the cross section is possible and is due to scattering by the core, but in the latter case the conditions for the oscillation are more favorable because of the smallness of $V_g - V_u$ at $R = 0$ and the slo decrease of this difference with increasing R. According to Smith [1], the oscillating component of the charge-exchange cross section can be represented approximately in the form $Av^{1/4}\cos(\beta v^{-1} + \delta)$, ($\beta$ is the frequency and δ the phase of the oscillation), so that the distance between the extrema in the function $\delta = f(v^{-1})$ should be constant. In our experiment it is impossible to trace this function in a wide energy interval.

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AMPLIFICATION OF HELICONS IN InSb BY AN ELECTRON BEAM

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It is known that various magnetoplasma waves, particularly slow helical waves (helicons), can propagate in a magnetized electron plasma of semiconductors or metals. Whereas earlier principal attention was paid to the nature of these waves, at present greater interest is evinced in their amplification and in the development of microwave amplifiers and generators.

Bok and Nozieres [1] and one of the authors [2] have noted that helicons can be amplified by carrier drift. One method of amplification, based on the surface interaction of helicons propagating in two contiguous semiconducting layers, with carrier drift established in one of them, was proposed by Barraf and Buchsbaum [3], but could not be realized to date for a number of reasons.

Helicons propagating in a bounded semiconductor can also be amplified by interaction with an electron beam passing near the surface of the semiconductor. Such a mechanism of helicon amplification was considered, in particular, in [4], where the authors reached the rather pessimistic conclusion that an electron beam cannot interact with helicons in an n-type semiconductor. In spite of this, helicon interaction with an electron beam in n-InSb was observed experimentally in [5]. We describe here an experiment in which we not only observed interaction between an electron beam and helicons in n-InSb, but also obtained an appreciable amplification of the helicons at 10 GHz.

The experimental setup is shown in Fig. 1. The InSb sample was a cylinder 10 mm in diameter and 15 mm long, and was made of single-crystal n-InSb with electron mobility 5×10^5 cm^2/V-sec and density 5×10^{14} cm^{-3} at T = 78°K. A hole of 3.2 mm diameter was drilled through along the sample axis, and an electron beam focused by an axial magnetic field was passed through the hole. The helicons were excited and received through two coupling loops installed near the ends of the sample. The sample temperature could be varied from 80 to 300 °K. A special electronic circuit ensured smooth variation of the beam accelerating voltage.

To increase the sensitivity of the setup, the electron beam was meander-modulated at 1 kHz, and a synchronous detector separated only the signal component modulated by the interaction with the beam. The unmodulated component of the microwave poser could be compensated for by a microwave bridge circuit connected to the receiver input, thereby greatly improving the signal to noise ratio.

The interaction between the helicons and the electron beam was observed at a sample temperature 90 - 130°K and in a magnetic field of 5 - 12 kOe. There was no interaction at room temperature, probably because of the increased helicon damping in the sample due to the decrease of $\omega_c\tau$. A typical plot of the microwave power passing through the system against the accelerating voltage is shown in Fig. 2. The presence of several maxima of interaction is due apparently to the fact that the electron beam interacted with different helicon modes of the sample, having different phase velocities [6]. The width of the region of strong inter-

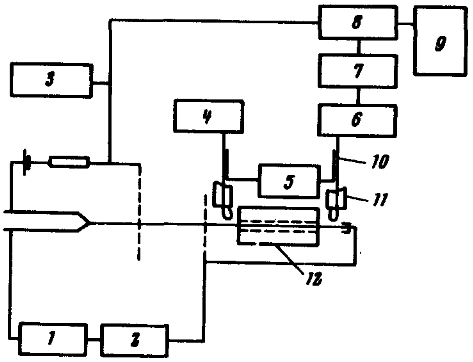

Fig. 1. Experimental setup: 1 - power supply, 2 - beam accelerating-voltage sweep block, 3 - 1-kHz generat,r 4 - 10-GHz generator, 5 - attenuator and phase shifter, 6 - microwave superheterodyne receiver, 7 - selective 1-kHz amplifier, 8 - synchronous detector, 9 - automatic recorder, 10 - directional coupler, 11 - coupling loops.

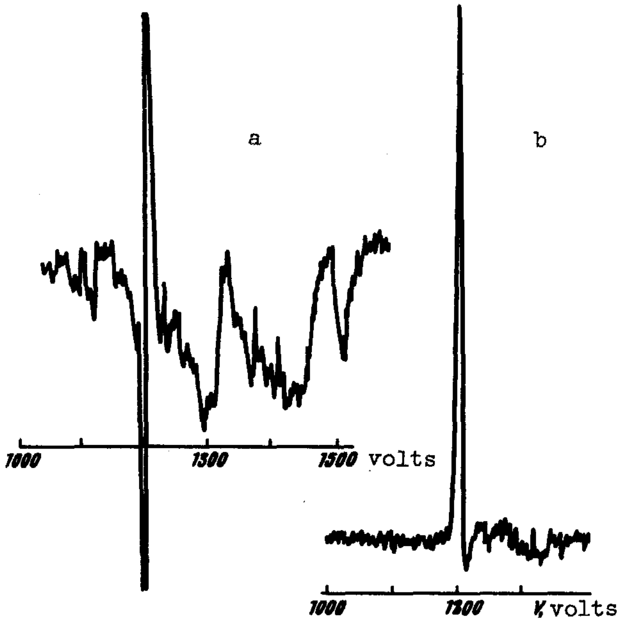

Fig. 2. Microwave power passing through the plasma-beam system as a function of the accelerating voltage of the beam; a - modulated microwave power compensated for, b - no compensation. The receiver gain has been decreased by several times.

action, in which both absorption and appreciable amplification of the signal took place, did not exceed 10 V. The largest gain obtained by us (without allowance for loss due to the mismatch between the sample and the microwave channel) was 15 dB at 10 GHz, T = 120°K, H = 11 kOe, and V = 1.2 kV.

Estimates have shown that under the given conditions the beam velocity was approximately equal to the phase velocity of the helicons, so that the synchronism condition was satisfied for the helicons and the slow wave of the space charge. This means that the electron beam interacted with the longitudinal component of the electric field of the slow electromagnetic wave produced by the helicons in the inner cavity of the sample. Such an interaction is analogous to the interaction between an electron beam and the field of the slow-wave system in an ordinary traveling-wave tube, which leads, as is well known, to the occurrence of convective instability. This apparently was indeed observed in experiment.

In conclusion, we thank D. N. Astrov for useful advice and a discussion of the results.

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THE FEASIBILITY OF AN OPTICAL PLASMOTRON AND ITS POWER REQUIREMENTS

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High-frequency plasmotrons have found important applications in physical research and in engineering. In these devices, gas is blown along a tube through a solenoid in which a stationary inductive discharge is produced. A jet of dense plasma at atmospheric pressure flows out of the tube. There exist also microwave plasmotrons. This raises the question whether a CO_2 laser can be used to produce or to maintain continuously a dense plasma.

Let us determine the minimum required light power and the plasma temperature. Assume that a plasma initially produced by an external source is situated in the path of a parallel light beam of radius R; intensity S, and power $S\pi R^2$. The light intensity is too low to