which, in my opinion, still lies in the framework of the known astrophysics and elementary-particle physics).

Fortunately, the theoretical scheme that can lead to such a sorry state for observational neutrino astronomy, is esthetically unattractive, and one can hope that it is not realized in nature.

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NONLINEAR EFFECTS IN THE PROPAGATION OF HYPERSONIC WAVES IN INDIUM ANTIMONIDE

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We report here observation of nonlinear effects in the amplification of hypersonic waves of frequency 1 - 2 GHz in indium-antimonide crystals with $n = 4 \times 10^{14}$ cm^{-3}, $\mu = 6 \times 10^{5}$ cm^{2}/V-sec at T = 77°K, under conditions when the parameter $q\ell = 5 - 10$, where q is the wave vector of the sound wave and ℓ is the electron mean free path. As noted in [1 - 4], under these conditions one can expect the appearance of a new type of nonlinear effects, characteristic of the case $q\ell > 1$ and due to distortion of the electron momentum distribution function as a result of the electron interaction with the strong sound wave.

According to estimates, this type of nonlinearity is expected to set in at sound-flux intensities $10^{-2} - 10^{-1}$ W/cm^{2}.

The excitation and registration of the sound in the InSb crystals were carried out by a well-known pulsed method using a CdS epitaxial electroacoustic converter. The double-conversion losses did not exceed 40 - 50 dB. In the

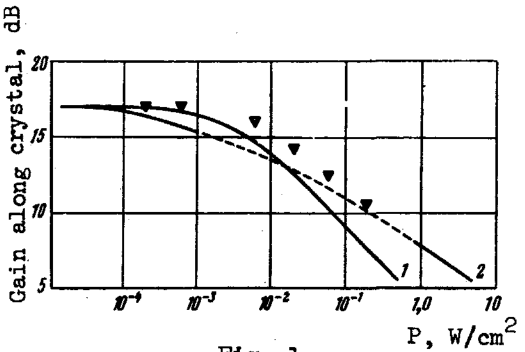

Fig. 1

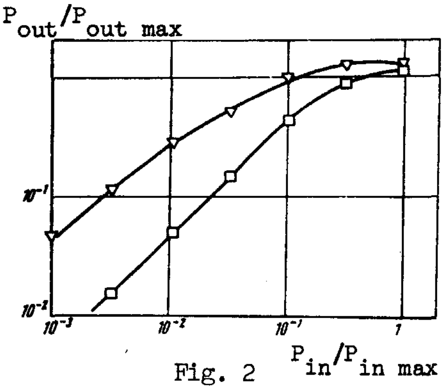

Fig. 2

Fig. 1. Electronic amplification of hypersound vs. the power of the sound flux introduced into the crystal: ▼ - experimental points. Curve 1 - calculation in accord with [4], curve 2 - calculation in accord with [3], the dashed part of the curve corresponds to extrapolation from the regions of small and large sound-flux powers. $f = 1.9$ GHz, $v_d = 20\ v_s$.

Fig. 2. Sound-flux power at crystal output, P_{out}, vs. input power P_{in}, $f = 1.9$ GHz.

absence of supersonic electron drift to cause the amplification, no nonlinear effects were observed experimentally when sound passed through the crystal and following the electroacoustic conversion.

The experimental dependence of the electronic amplification on the intensity of the sound flux introduced into the crystal at a fixed value of the drift velocity v_d is shown in Fig. 1. With increasing sound intensity in the crystal, a noticeable decrease of the electronic amplification is observed. A similar behavior is shown by the dependence of the electronic amplification on the sound power at other frequencies, and the higher the frequency, the lower sound intensity at which the nonlinearity appears; this agrees with [3, 4]. This is a very important circumstance, since it makes it possible to separate qualitatively this effect from the concentration nonlinearity, characterized by an increase of the threshold power with increasing frequency. We note also that the onset of a concentration nonlinearity is expected at much higher powers, $\sim 10 - 10^2$ W/cm^2.

Figure 1 shows also the results of a theoretical calculation of the observed effect with allowance for the lattice absorption of sound in the crystal. The theoretical curves calculated for two limiting cases of the theory, $\hbar^2 q^2 m^* < \hbar/\tau_p$ and $\hbar^2 q^2/m^* > \hbar/\tau_p$ (where m^* is the electron effective mass and τ_p the electron momentum relaxation time, coincide within the limits of applicability of the calculation and the experimental errors, with the results of the experiment, for which $\hbar^2 q^2/m^* \sim \hbar/\tau_p$.

It is of interest also to call attention to the character of the dependence of the power of the acoustic flux after the amplification (on energing from the crystal) on the introduced power (Fig. 2). A characteristic feature is the saturation at high levels of the output signal, indicating that a stationary sound-wave regime is established in the output section of the crystal.

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POSSIBILITY OF PRODUCING INVERTED POPULATION IN ATOMIC BEAMS BY CHARGE EXCHANGE OF PROTONS WITH ATOMS

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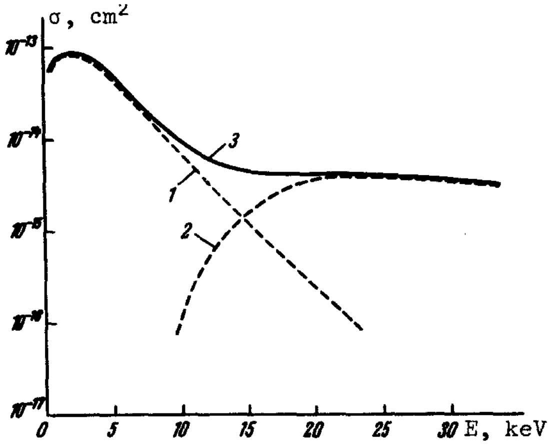
The charge exchange of protons with atoms (the reaction $p + A \rightarrow H + A^+$) is in many cases a very effective method of producing excited atoms and ions. By way of an example, the figure shows the effective cross section of charge exchange with Cs atoms. At collision energies up to 10 - 15 keV, the electron is captured with overwhelming probability in the 2p and 2s states of the hydrogen atom, and the cross section for charge exchange in the 2p state is approximately three times larger than in the 2s state. The large value of the cross section is due to the quasiresonant character of the process: the ionization potential of the Cs atom is close to the binding energy of the electron in the H atom with principal quantum number $n = 2$. The capture of the electron in the ground state of the H atom in the indicated energy region is smaller by two orders of magnitude, and charge exchange in all states with $n > 2$ has a total cross section smaller by a factor of 20 than the cross section for charge exchange in the 2p state. At collision energies higher than 20 keV, the capture of an optical electron becomes ineffective, and the principal role is assumed by charge exchange on the inner shells of the Cs atom [1]. In this case, an excited Cs^+ ion ($5p^56s$) is produced, and the H atom is predominantly in the ground state. Calculation of the charge-exchange cross section (see the figure) was carried out within the framework of the method of strong coupling of several states [2]. The result agrees with the available experimental data [3, 4]. Similar properties are possessed by the cross sections for the charge exchange of protons with K and Rb atoms.



Effective cross section for the charge exchange of protons with Cs atoms: 1 - cross section for capture of an outer electron of the Cs atom in the H-atom state with $n = 2$: $p + Cs \rightarrow H\ (n = 2) + Cs^+(5p^6)$; 2 - cross section for the capture of a 5p electron of the Cs atom: $p + Cs \rightarrow H + Cs^+ (5p^56s)$; 3 - total cross section of the charge exchange $p + Cs \rightarrow H + Cs^+$.

An inverted medium (H atoms in a state with $n = 2$) can be produced when a beam of atomic cesium is intersected by a beam of protons having an energy less than or equal to 10 keV (proton velocity $v_p \simeq 10^8$ cm/sec). At a Cs atom density on the order of 10^{16} - 10^{17} cm^{-3}, the proton beam exchanges charge over a path 10^{-2} - 10^{-3} cm. The emission of the L_α line ($\lambda = 1215.85$ Å) occurs over a path 0.2 cm. At a proton beam cross section of 1 cm^2 the working volume is 0.2 cm^3. Since the temperature in most