When the exciting radiation propagated along the x axis of the crystal as an ordinary ray, a variation of the SRS frequency was observed. We were unable to trace the dependence of the frequency shift on the crystal rotation angle by using the Stokes component. The lower spectral width of the anti-Stokes component makes it easier to trace the dependence of the shift on the rotational angle, which is shown in Fig. 4.

When the exciting radiation propagated in the x-direction as an extraordinary ray, an additional spectral band was observed between the first and second anti-Stokes components, and its frequency was shifted 1050 to 1300 cm^{-1} away from the exciting frequency. A plot of this band is shown in Fig. 5. No analogous line was observed in the Stokes region. This band can therefore not be interpreted as a four-photon parametric decay, but can apparently be interpreted as the exciting radiation superimposed on the continuous infrared radiation due to the heating of the crystal by absorption.

Depending on the crystal orientation, synchronism of such an interaction should be obtained at various frequencies. This mechanism is also favored by the fact that the radiation has a diffuse character.

The efficiency of conversion into this tunable frequency was of the order of 1% of the second-harmonic intensity at a crystal length 23 mm.

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DISTRIBUTION OF FLUX OF CHARGE-EXCHANGE ATOMS FROM A PLASMA OVER THE CROSS SECTION OF THE PLASMA FILAMENT IN THE TOKAMAK-4 APPARATUS

M.P. Petrov
A.F. Ioffe Physico-technical Institute, USSR Academy of Sciences
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An energy analysis of the flux of charge-exchange atoms from a plasma is widely used at present to measure the ion temperature in Tokamak installations. It was shown in [1] that if the atom flux is analyzed in the equatorial plane of the toroid in the direction of the major radius R, then the maximum values of the ion temperature in the central region of the plasma filament can be determined from the Maxwellian "tails" of the energy distribution of the atoms. An attempt was made to measure the distribution of the ion temperature over the cross section of the plasma filament in the Tokamak-4 by tilting the axis of the atom analyzer up and down relative to the equatorial plane of the toroidal chamber. A five-channel atomic-particle analyzer was used in these experiments and yielded simultaneously the values of the atom flux at five different energies. The distributions obtained in this manner for the flux of deuterium atoms with different energies E over the cross section of the plasma filament are shown in

Fig. 1. It is seen from the figure that the distributions are axially symmetrical in a range of ±5 cm along the minor radius r of the toroid, and that the higher the energy of the atoms, the steeper the fall-off of their fluxes towards the periphery. The symmetry is upset by the fact that when the analyzer axis is tilted upwards 10 cm from the equatorial plane, the flux of the atoms with energy E > 1.3 keV again increases noticeably. An analogous asymmetry was observed in a more pronounced form earlier in the Tokamak T-3 and TM-3 installations [2, 3].

We recall that atomic-particle analyzer register atoms whose velocity vectors make small angles, 20 - 30', with the plane of the plasma loop cross section, i.e., of atoms that appear in charge exchange of trapped ions.

Trapped ions are taken to be, first, toroidal trapped ions that drift along "banana" trajectories, and second, locally trapped ions captured in local mirror traps between the coils of the longitudinal magnetic field of the Tokamak, where they drift toroidally. The existence of both groups of trapped ions in the plasma of the Tokamak-4 may be, as shown below, the reason why an asymmetry in the distribution of the charge-exchange atom flux is observed in these experiments. We consider first, from this point of view, the toroidally trapped ions. Figure 2 shows the projection of a typical trajectory of such ions, with energy ∿1 keV, on the plane of the plasma-filament cross section. The figure shows also the relative concentration of the hydrogen atoms over the cross section of the plasma filament, measured by a spectroscopic method [4] in the Tokamak-3A, whose geometry and physical parameters are quite close to those of Tokamak-4. The maximum deviation of the trapped ions from the magnetic surface is of the order of $\Delta r \sim \rho_i q\sqrt{R/r}$ [5], where ρ_i is the Larmor radius of the ions and q is the stability margin of the plasma filament. For the conditions in question (longitudinal magnetic field intensity 27 kOe, r = 10 cm, R = 100 cm), q = 2/Δr is

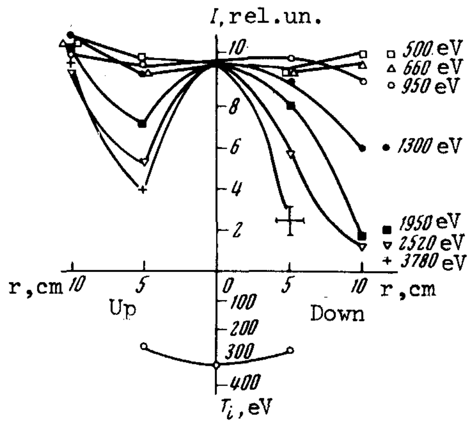

Fig. 1

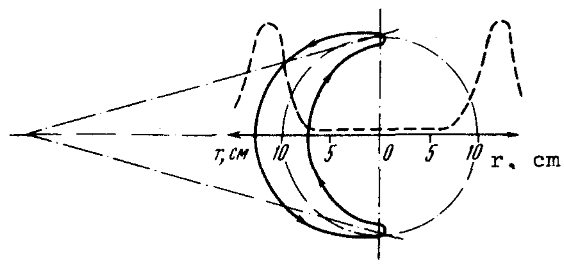

Fig. 2

Fig. 1. Distribution of the flux of charge-exchange atoms with different energies and of the ion temperature over the cross section of the plasma filament. The abscissas are the deviations of the analyzer axis from the equatorial plane at the center of the discharge. The flux distributions are normalized to the central point. Discharge conditions: H_z = 27.5 kOe, discharge current 137 kA, average electron concentration 1.75×10^{13} cm^{-3}.

Fig. 2. Distribution of atom concentration over the cross section of the plasma filament (dashed line) and projection of the trajectory of trapped ions with E = 1 keV on the plane of the plasma-filament cross section. The dash-dot lines show the extreme positions of the analyzer axis.

equal to several centimeters. It is seen from Fig. 2 that the principal drop in the atom concentration in the plasma lies between the outer and inner parts of the "banana" trajectory of the ions. The period of oscillation of the trapped ions is [5] $t_1 \approx (10Rq/v)\sqrt{R/r}$, where v is the ion velocity. Calculation shows that during the time of drift on the outer trajectory, in a region with an atom concentration $\sim 10^{11}$ cm^{-3}, the ion flux should be weakened severalfold by the resonant charge exchange before the ions reach the turning point. This may be the reason why the charge-exchange atom flux from the upper region of the plasma filament is several times larger than the flux from below. The appearance of the asymmetry only at an atom energy $E \geq 1.3$ keV can be attributed to the fact that the collision frequencies for the lower-energy ions exceed the frequencies of revolution on the banana trajectories. This mixes the trapped ions with untrapped ones. Indeed, in order for a deuteron to go over from a trapped state to an untrapped one it is necessary that its velocity vector be turned through an angle $\sim\sqrt{r/R}$ [5]. The time interval required for this purpose is $t_2 = \tau(2/\pi(\sqrt{r/R}))^2$. Here $\tau = m^2v^3/4\pi ne^4L_C$ is the time of rotation of the deuteron velocity vector in ion-ion collisions in a pure deuterium plasma through an angle 90° (m is the deuteron mass, n the plasma concentration, e the electron charge, and L_C the Coulomb logarithm). Equating t_1 to t_2, we can determine the critical deuteron velocity v_c at which the frequencies of the ion-ion collisions and the "banana" oscillations become equalized: $v_c = (10\pi^3R^{2.5}qne^4L_C/m^2r^{1.5})^{1/4}$. At $n = 1.75 \times 10^{13}$ cm^{-3} and $L_C = 10$ we obtain $v_c = 3.8 \times 10^7$ cm/sec, corresponding to a deuteron energy 1.5 keV. It is precisely at this energy that the asymmetry comes into play in the experimentally measured distribution of the charge-exchange atom flux.

Let us examine the possible contribution of the drift of the locally trapped ions to the observed asymmetry in the distribution of the charge-exchange atoms. The behavior of this group of ions in Tokamak plasma was analyzed in detail by Anderson and Furth [6]. The drift displacement of such ions during the time between ion-ion collisions, which causes the ions to leave the mirror trap, is of the order of $\Delta r \sim v_g\tau(2\sqrt{\varepsilon}/\pi)^2$, where v_g is the ion drift velocity and ε is the relative attenuation of the field intensity between the Tokamak coils. In Tokamak-4, ε = 3 - 4% on the periphery of the plasma filament. Under these conditions, the drift displacement of the locally trapped deuterons with energy $E \geq$ 1.5 keV can reach several centimeters. The drift flux of deuterons with such energies can penetrate into the peripheral regions of a plasma with an increased atom concentration, thus increasing the flux of charge-exchange atoms from these regions. We note that the polarity of the observed asymmetry coincides with the drift direction of the toroidally- and locally-trapped ions.

Thus, the observed deviation from axial symmetry in the distribution of the atom flux in the upper part of the plasma filament is obviously connected with the drift of the trapped ions into a region with high atom concentration on the periphery of the plasma filament. The symmetrical character of the distributions in the atom flux from the internal zone of a plasma filament of 10 cm diameter, in conjunction with the fact that the energy distributions of the atoms emitted from this zone have a Maxwellian character, indicate apparently that the ion temperature has an axially-symmetrical distribution. The values of the ion temperature for this zone are shown by the lower curve of Fig. 1. We see that the ion temperature varies little in the near-axis part of a plasma filament of 10 cm diameter. The described experiments show thus that an analysis of the flux of the charge exchange atoms from different regions of the plasma filament in a Tokamak can yield information on the ion-temperature distribution, at any rate in the interior regions of the plasma. These regions can be larger the farther the sheath of high-concentration of neutral atoms from the discharge axis. It is precisely the presence of this sheath in the presence of a drift of trapped ions which prevents measurements of the ion-temperature distribution by this method on the periphery of the plasma filament.

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FEASIBILITY OF NONPHONON MECHANISM OF SUPERCONDUCTIVITY IN THE ALLOY Nb_3Sn

A.I. Golovashkin and G.P. Motulevich
P.N. Lebedev Physics Institute, USSR Academy of Sciences
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A number of superconducting alloys with a lattice of the A-15 type and having critical temperatures $T_c \sim 17 - 21°K$ much higher than T_c of pure metals have been discovered in the last few years [1]. To check on a possible connection between such high values of T_c and the nonphonon superconductivity mechanism, Hopfield [2] proposed to determine the sign of the effective Coulomb pseudopotential μ^*, using the Macmillan formula [3]

$$T_c = \frac{\Theta}{1{,}45} \exp\left\{ - \frac{1{,}04(1+\lambda)}{\lambda - \mu^*(1 + 0{,}62\lambda)} \right\} \tag{1}$$

and the value of the electron-phonon interaction constant λ obtained from optical measurements in the infrared region of the spectrum (Θ is the Debye temperature).

The electron-phonon interaction constant can be expressed in terms of the electron-phonon collision frequency ν_{ep} [2, 4]

$$\lambda = \frac{\hbar}{2\pi} \frac{\nu_{ep}}{kT} . \tag{2}$$

The frequency ν_{ep} should be determined here at temperatures $T \sim \Theta$, when ν_{ep} is proportional to T; k is Boltzmann's constant. ν_{ep} can be obtained in turn from optical measurements in the infrared [5]. In the presence of noticeable scattering of the electrons by impurities or defects, to determine ν_{ep} it is necessary to perform, besides the optical measurements, also measurements of the ratio of the residual resistance of the sample to the resistance at the temperature T, i.e., R_{res}/R. Owing to the presence of effects connected with the quantum character of the electron-photon interaction [6], the electron-phonon collision frequency ν_{ep}^{opt} obtained by the optical method is always larger than ν_{ep}.