Experiment has shown, however, that at excitation power densities $P/S \lesssim 10$ kW/cm^2 two processes are observed in the luminescence growth kinetics $I_g(t)$. One is fast and corresponds to the intensity jumps on the oscillograms, which occur after a time $\lesssim 1.5$ nsec. The other is slower, with duration $\gtrsim 3$ nsec. The ratio of the first process to the second decreases (Figs. 2b and 2f) with increasing number of the exciting spike (and with increase in its intensity).

The observed effects can be explained by assuming that intense excitation makes possible stimulated emission of non-equilibrium ("hot") phonons. As shown in [7], for stimulated nonradiative transitions to occur it is necessary to have an inverted population and a coupling between the particles via the photon or phonon field. For the $3 \to 2$ transition the level population inversion condition is satisfied only for the first spikes. It is for these that the maximum amplitudes of the fast jumps are observed on the oscillograms of Fig. 2. Estimates show that at densities $P/S \sim (1 - 10)$ kW/cm^2 $= (2.6 - 26) \times 10^{12}$ quanta/cm^2 (at $\lambda = 530$ nm), at which the effect of stimulation of nonradiative transitions is already observed, the distance between excited centers is $\sim(0.8 - 0.4) \times 10^{-4}$ cm and is comparable with the wavelength of the exciting light. To effect a coupling between centers via the phonon field at such distances between centers, it is necessary to have a phonon lifetime $\tau_{ph} > 10^{-10}$ sec, which seems little likely to us for CaF_2.

It follows from the aggregate of presented facts and estimates that stimulated nonradiative transitions are observed in $CaF_2(Sm^{2+})$ and the coupling between centers can be realized via the field of the exciting light wave.

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ENERGY SPECTRA OF NEUTRAL COMPONENTS IN SCATTERING BY A SOLID TARGET

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The radiation emitted by an ion-bombarded solid target includes a group of fast particles, ions as well as neutral atoms, the energies of which are comparable with the energy of the incident ions. These particles are partners of one or several successive pair collisions between the ion and the target atom [1]. The angular and energy distributions of these particles carry considerable information both on the microscopic properties of the bombarded sample (its crystal structure [2], the thermal lattice vibration [3], the composition of the surface [4]) and on the potentials of the interaction between the two colliding atomic systems [1].

In many cases, for example when metals are bombarded with inert-gas ions of energy $10^3 - 10^4$ eV, most fast scattered particles are neutral, and the ions constitute only several per cent [5]. In spite of this, almost all the published data pertain to the ionic component of the scattering. There have been

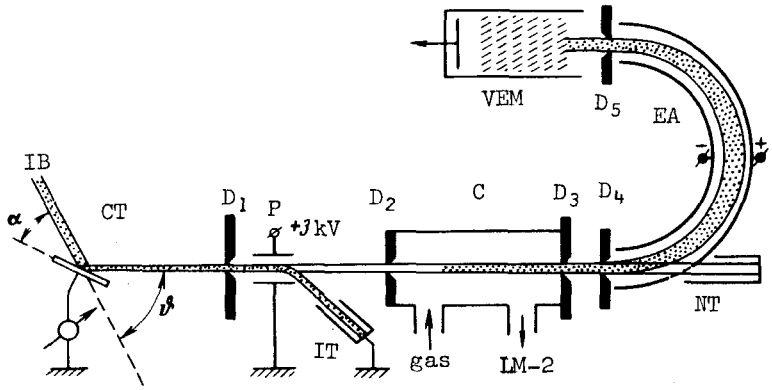

Fig. 1. Diagram of setup: CT - copper target, IB - ion beam, D_1 - D_5 - diaphragms, P - deflecting plates, C - stripping chamber, EA - electrostatic analyzer, VEM - vacuum electron multiplier, IT - trap for deflected ions, NT - trap for unstripped neutral particles.

much fewer studies of the properties of the neutral component. The energy spectra of fast neutral atoms have not been investigated at all. Yet a comparison of the neutral and ion spectra could be useful to explain the mechanism whereby secondary particles are emitted, in analogy with the case of cathode sputtering [6].

An analysis of the neutral component of the scattering is much more complicated than the corresponding analysis of the ionic component, since it calls for first ionizing the neutral atoms without distorting their rather narrow energy distribution. The use of time-of-flight methods, according to a report by Van der Weg and Bierman [7], was unsuccessful because of the superposition of spectra of different types of particles.

We have stripped fast neutral atoms in a gas target, and then analyzed them by energy in an electric field. The energy spectra of the ions and neutral atoms were obtained under identical conditions, making a comparison possible.

The experimental setup is shown in Fig. 1 (we used elements of the apparatus described in [3]). The copper target CT was bombarded with singly-charged argon ions. Diaphragm D_1, with dimensions 10 × 1 mm, separated a narrow beam of particles that experienced scattering through an angle θ. The plates P served to remove the ions from the scattered beam. The stripping chamber C was bounded by slits of adjustable width: the gas pressure in this chamber was measured with an ionization manometer. After passing through the stripping chamber, the particle beam entered the input slit of the electrostatic analyzer. The energy resolution was not worse than 1%.

We first plotted the energy spectra of the ions on the (100) face of a copper crystal and on a polycrystalline target in the absence of gas in the stripping chambers and with the plates P short circuited (dashed curves in Figs. 2 and 3). These spectra have the usual form (cf., e.g., [1, 2]).

The energy spectra of the neutral atoms (solid curves in Figs. 2 and 3) were obtained by filling the stripping chamber with hydrogen, helium, or argon at pressures from 2×10^{-5} to 2×10^{-3} Torr. A deflecting voltage was applied to the plates P. The spectra were constructed with allowance for the dependence of the stripping cross section of the energy of the fast neutral atom [8, 9].

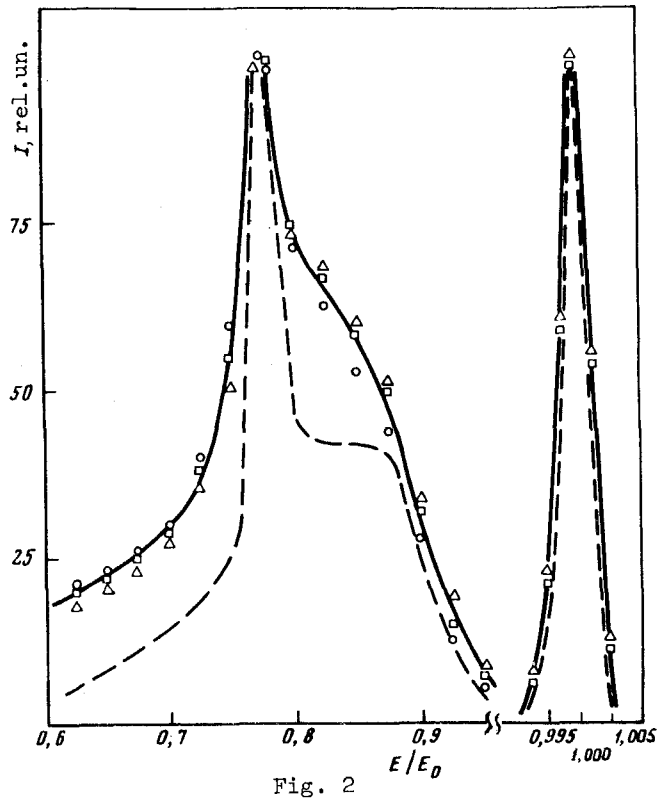

Fig. 2

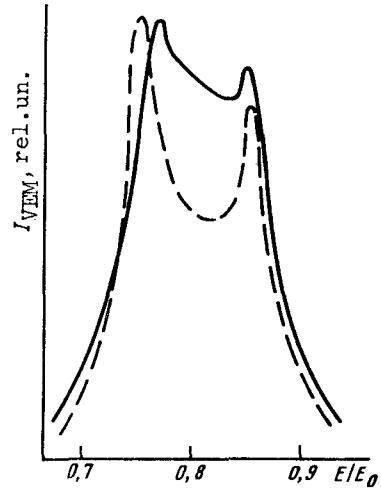

Fig. 3

Fig. 2. Energy spectra (normalized at the maximum) of scattered particles; target - polycrystalline copper bombarded with argon ions of initial energy E_0 = 16 keV, θ = 40°, α = 15%. Dashed curve - spectrum of scattered ions, solid - spectrum of scattered neutrals; triangles - stripping in argon, squares - stripping in helium, circles - stripping in hydrogen. In the right side of the figure: solid curve - spectrum obtained at the output of the energy analyzer when a monokinetic beam of argon atoms with initial energy E_0 = 16 keV is applied to its input: triangles - stripping in argon, squares - stripping in helium, dashed curve - ion spectrum.

Fig. 3. Energy spectrum of scattered ions (dashed) and of fast neutral atoms (solid), obtained by argon-ion bombardment of the (100) face of a copper crystal; the scattering plane coincides with the (110) plane; the bombarding-ion energy is E_0 = 9 keV.

The agreement between the spectra obtained by applying to the input of the energy analyzer monokinetic beams of atoms and ions (Fig. 2) allows us to state that the influence of the energy lost in stripping (cf., e.g., [10]) on the form of the investigated spectra can be neglected. This is also evidenced by the practically complete coincidence of the forms of the energy spectra obtained by stripping in different gases (Fig. 2).

We see that the spectra of the fast neutrals turned out to be similar, in main outline, with the ion spectra.

Attention is called, however, to the following circumstance. In the case of scattering by a single crystal, the positions of the peaks in the ion and neutral-atom spectra do not coincide. The top of the left-hand peak in the spectrum of the neutrals is clearly shifted towards higher energies. The right-

hand wing of the spectrum, which is due to scattering of higher multiplicity, has a higher intensity in the spectrum of the neutrals.

These results indicate that different mechanisms govern the production of ionic and neutral components. Apparently, the mechanism of scattering by a chain of atoms [11] plays a relatively larger role in the formation of the neutral component, whereas the ionic component is produced predominantly via pair collisions.

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SPLITTING OF THE SPECTRUM OF LOW-FREQUENCY ANTIFERROMAGNETIC RESONANCE IN $NiCl_2$

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The low-frequency antiferromagnetic resonance (LF AFMR) in $NiCl_2$ was investigated in [1, 2], where it was shown that it can be described by the expression

$$\nu_{LF} = \frac{\gamma}{2\pi}\sqrt{H_0^2 + \Delta^2}, \qquad (1)$$

where Δ is the isotropic gap, which in all likelihood is due to magnetostriction [3, 4]; Δ = 3 kOe at T = 4.2°K [2].

We have investigated the frequency-field dependence of LF AFMR in the frequency region 27 - 43 GHz. Samples, in the form of single-crystal plates measuring 1.5 - 3 × 2.5 - 5 × 0.1 - 0.5 mm, were placed near a short-circuiting plunger in a waveguide of cross section 3.6 × 7.2 mm. The waveguide was placed in a duct passing inside a superconducting solenoid. The duct was filled with helium gas, and a thermoresistor, a bifilar heater winding, and insulating liners of teflon film and wool filaments were placed at the end section of the waveguide. This construction has made it possible to vary the sample temperature from 4.2 to ∿70°K. The magnetic field was directed along the waveguide axis. The C_3 axis of the sample was always perependicular to the plane of the employed plate. By varying the mounting of the samples we could perform