face energy on the boundaries of the layers. When the current is sufficiently strong the layers should apparently turn perpendicular to the current and stop.

The motion of the normal layers is connected with the transport of entropy in the y direction, and a temperature difference should arise in this direction, especially at low temperatures when the superconducting layers provide good thermal insulation between the normal regions. Such an arrangement is in principle a continuously operating refrigerator, although the motion of the layers is connected also with dissipation of energy and produces resistance to the current I.

The resolution of the method, determined by the diameter of the microcontacts, can be improved to at least 10^{-5} cm, which may make this method suitable for investigations of the motion of vortices in superconductors of type II.

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IONIZATION AND SCATTERING WITH CHARACTERISTIC ENERGY LOSSES IN ATOMIC COLLISIONS

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Investigations of the elementary acts of atomic collisions were first reported in [1]. We studied collisions between ions and argon atoms having keV energies at impact parameters smaller than the atomic dimensions. Analysis of the inelastic energy losses in the collisions has shown that in addition to energy lost to ionization of the colliding particles, a so-called excess inelastic energy loss R*, consisting of the kinetic energy of the removed electrons and of the radiation energy, is also observed. It turned out that the spectrum of the excess inelastic loss is not continuous, but consists of relatively narrow discrete lines. For the $Ar^+ + Ar$ pair we found three characteristic lines, the energies of which (53, 263, and 475 eV) did not depend on the shortest distance between the nuclei, on the relative velocity of the particles, and on the scheme of the elementary process by which the charge states are changed.

To determine the extent to which the observed phenomenon is general, we investigated collisions between ions and atoms of different noble gases.

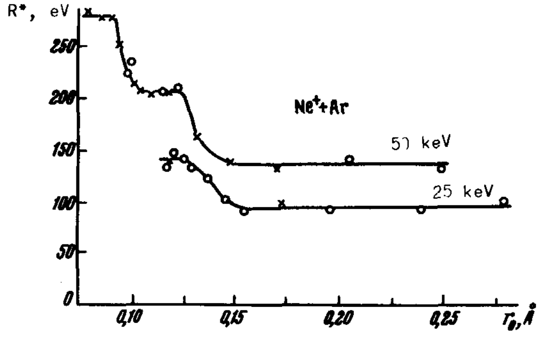

Fig. 1. Dependence of the excess inelastic energy loss on the shortest distance between colliding nucleons. ● - process 1023; x - average values of R* for the processes 1012, 1023, 1033, and 1043.

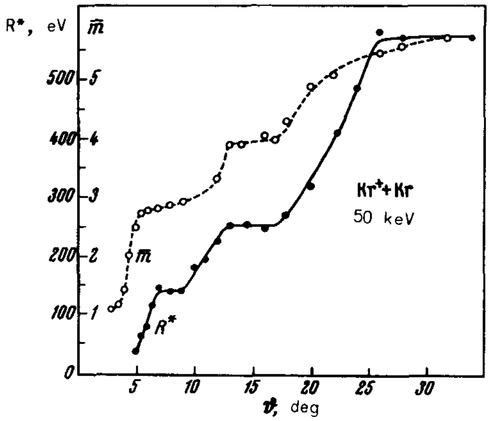

Fig. 2. Dependence of the excess inelastic energy loss and of the average charge of the scattered particles on the scattering angle.

Figure 1 shows by way of an example the measured inelastic energy loss for the Ne^+ + Ar pair. It turned out that the excess inelastic energy losses R*, like in the case of the Ar^+ + Ar pair [1], do not depend on the scheme of the elementary process. In the investigated interval of shortest distances r_0 between the nuclei of the colliding particles we observed the excitation of several R* lines (the plateau region on the $R^*(r_0)$ curves). The plateau regions in which one R* line is excited, and the region where the transition occurs from excitation of one line to excitation of another, do not shift when the relative particle velocity changes. However, excitation of lines with different energies is observed when the velocities are different.

Analogous results were obtained for the Kr^+ + Kr pair at 25 and 50 keV. In this case, three characteristic R* lines were observed in the interval 100 - 600 eV. For the Ne^+ + Ne pair at 50 keV, we observed one R* line with energy ~ 160 eV.

We investigated the connection between the excitation of the characteristic lines and the charges of the colliding particles. When like particles collide ("symmetrical" pairs Ar^+ + Ar, Kr^+ + Kr) this connection is manifest in a clear-cut correlation between the average charge of the scattered particles and the inelastic energy loss. By way of an example, Fig. 2 shows the data for the Kr^+ + Kr pair. No such correlation is observed, however, when an "asymmetrical" pair is investigated (Ne^+ + Ar, energy 25 keV).

We have also investigated in detail the scattering of the colliding particles. It was found that the total differential scattering cross section is not, as heretofore assumed [2,3], a continuous function of the scattering angle. At angles corresponding to a transition from the excitation of one line to the excitation of another, characteristic singularities appear on the $(d\sigma/d\omega)$ vs. v curves. These singularities are clearly seen when the measured cross sections are compared with the cross sections calculated for a continuously varying interaction potential, for example, for an exponentially screened Coulomb potential (see Fig. 3).

In the transition region, the experimental scattering cross sections differ most strongly from the calculated ones, with deviations in the form of maxima. Such an effect is observed for all the investigated pairs ($Ne^+ + Ar$, $Ar^+ + Ar$, $Kr^+ + Kr$). The observed form of the $(d\sigma/d\omega)$ vs. v curves gives grounds for assuming that the real interaction potential is not a continuous function of the shortest distance, and apparently changes abruptly on going from the excitation of one characteristic line to the excitation of another.

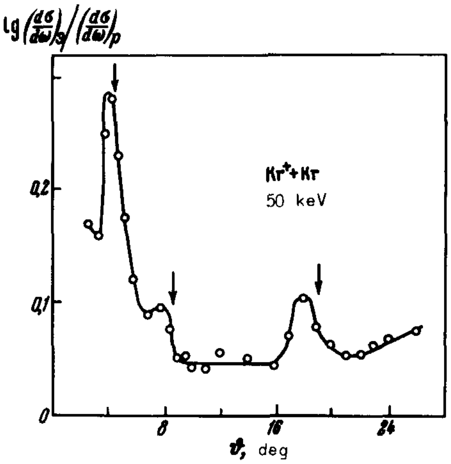

Fig. 3. Deviation of the total differential scattering cross sections from the calculated values as a function of the scattering angle. The arrows indicate the start of the transition from the excitation of one characteristic line to the excitation of another.

An essential question is whether the observed characteristic-loss lines belong to individual atoms or whether they characterize the system of colliding particles. Comparison of the inelastic-loss spectrum for the pairs $Ne^+ + Ne$, $Ar^+ + Ar$, and $Ne^+ + Ar$ has shown that the lines obtained for the $Ne^+ + Ar$ pair are not connected in some simple manner with the lines obtained for the $Ne^+ + Ne$ and $Ar^+ + Ar$ pairs. This means that the observed lines cannot be ascribed to the excitation of some energy levels which are characteristic of the isolated atom.

It is difficult at present to present an unambiguous interpretation of the observed effects. As indicated in [1], one of the possible explanations, based on the assumption that vacancies are produced in the inner shells of the colliding particles and are followed by Auger transitions, is in poor agreement with the experimental data. A modification of this model, proposed by Fano and Lichten [4], does not eliminate all the contradictions between calculation and experiment. A hypothesis that collective oscillations of the electron shells are excited has been under consideration recently [5,6]. There are still no numerical calculations based on this hypothesis, but its qualitative conclusions do not contradict the experimental results.

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