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RELATIVE ROLE OF VARIOUS IONIZATION PROCESSES IN SLOW COLLISIONS OF K^+ IONS WITH INERT-GAS ATOMS

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One of the methods of investigating various ionization processes occurring in collisions between atomic particles is to analyze the energy spectra of the electrons released as a result of such collisions. Investigations have shown (cf. e.g., [1]) that the electron spectra can contain two components. One of them is characterized by a continuous energy distribution and includes mainly the slow electrons (≤1 eV), and the other constitutes groups of electrons with discrete energies on the order of 10 eV. The origin of the groups of fast electrons can be attributed to the excitation of autoionization states of the target atom in collisions and subsequent decay of these states:

$$A^+ + B \to A^+ + B^* \to A^+ + B^+ + e \qquad (1)$$

On the other hand, the appearance of slow electrons is connected with a number of processes: direct ionization

$$A^+ + B \to A^+ + B^+ + e, \qquad (2)$$

ionization with excitation

$$A^+ + B \to A^+ + B^{+*} + e, \qquad (3)$$

and multiple ionization

$$A^+ + B \to A^+ + B^{n+} + ne. \qquad (4)$$

However, there are serious difficulties when attempts are made to assess the relative roles of even these two groups of ionization processes, namely (1) and (2) - (4), on the basis of the energy spectra of the electrons. These difficulties are connected with the determination of the intensities of the electron-spectrum components, which leads to the need for the study of the angular distribution and of determining with sufficient accuracy the yield of the slow electrons.

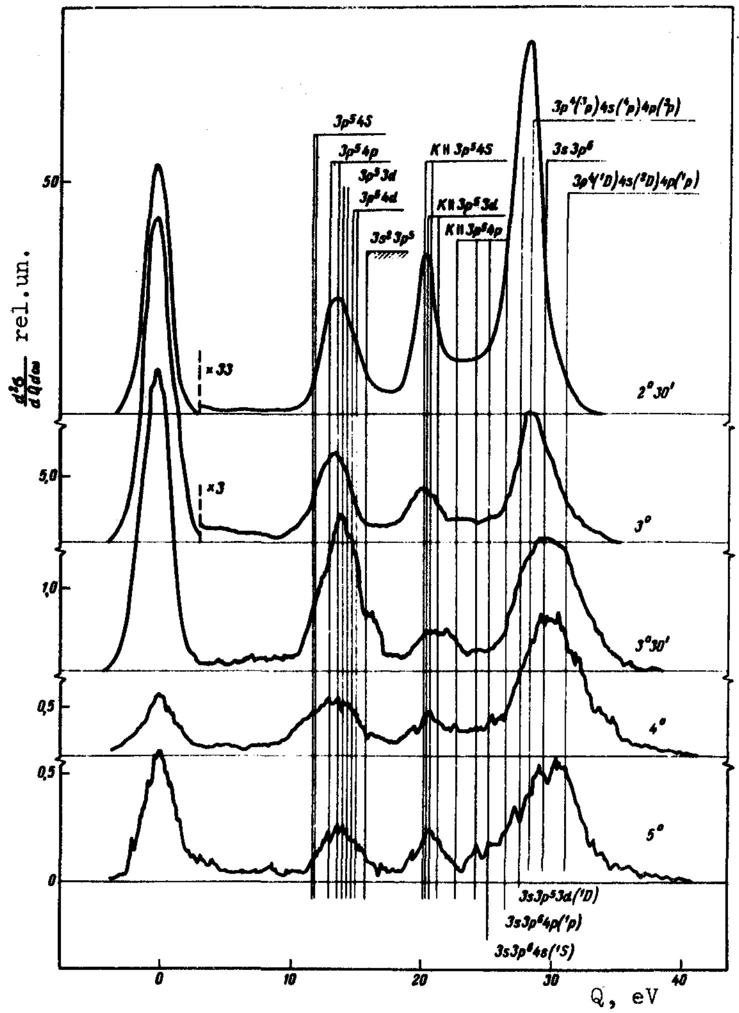
To determine the contributions of the different processes to the ionization energy in ion-atom collisions, we have used in this study the analysis of the kinetic energy of the incoming ions after they collide with the gas-target atoms. The experiments were performed with a setup that differed from that used by us in [2] to study electron-atom collisions in that the electron gun was replaced by a system consisting of a thermo-ionic source and a magnetic mass spectrometer with a sector field. We determined experimentally the dependences of the differential ion-scattering cross sections at fixed angles on the inelastic energy loss (inelastic-loss spectra) and the dependence of the differential cross sections on the scattering angle at fixed inelastic losses.

We investigated collisions between K^+ ions and Ne, Ar, and Xe atoms in the inelastic-loss region from 0 to 50 eV and at lab scattering angles from 1 to 10°. The interval of the initial K^+ ion energies was (1 - 3) keV.

Typical energy-loss spectra for the K^+-Ar case are shown in the figure; we see that they have a discrete structure. The first peak corresponds to elastic scattering, the second to excitation of the 3p electron and single ionization of the Ar atom (process (2)), the third to excitation of the 3p electrons of the K^+ ion, and the fourth the excitation of autoionization states of the Ar atom connected with excitation of one 3s or two 3p electrons (process (1)) and ionization with excitation (process (3)). The spectra were identified from data on the energy levels of the incoming ion and the target atom [3, 4]. The only autoionization levels of the atom shown in the figure are those revealed by the electron spectra in ion-atom collisions [4].

It is obvious that the threshold energy of the direct-ionization process (2) is determined by the ionization potential of the Ar atom. Therefore for each scattering angle the direct-ionization contribution can be estimated from the area under that part of the second peak which is located to the right of the $3s^2 3p^5$ line. (When separating this part of the peak it is necessary, of course, to take into account the influence of the apparatus function of the setup on the contours of the excitation lines of the Ar atom, forming the principal part of the second peak.) Since the fluorescence yield from the decay of

Spectra of inelastic energy losses of K^+ ions scattered at various fixed angles by Ar atoms. The initial ion energy is 2.0 keV. The vertical lines indicate the positions of the energy levels of the isolated Ar I and K II.



the autoionization states of Ar is small [5], the contribution of the processes of autoionization and of ionization with excitation can be found directly from the total area of the fourth peak. Finally, the contribution of the double ionization can be estimated from the form of the loss spectrum in the region Q ≳ 42 eV adjacent to the threshold for this process (not shown in the figure).

The analysis of the loss spectra has shown that the cross section of any of the inelastic process remains small with increasing scattering angle, up to a certain threshold value (different for each transition). After these thresholds are attained, the cross sections increase rapidly and experience more or less clearly pronounced oscillations at large angles. The existence of threshold scattering angles has made it possible to integrate the differential cross sections corresponding to the ionization processes with respect to the angle, and to obtain data on the relative contributions of these processes to the total ionization cross section.

It was found that the contribution of the direct ionization (2) for the K^+-Ar case, in the investigated incoming-ion energy interval does not exceed 5%. The contribution of the double ionization (4) likewise does not exceed several per cent. The ratio of the cross sections of the ionization processes remains approximately the same also for collisions of K^+ ions with Xe atoms.

It can thus be concluded that in the investigated collision-energy region the ionization of the Ar and Xe atoms by K^+ ions is determined practically completely by the autoionization process (1) and by the process of ionization with excitation (3).

In the investigation of the scattering of K^+ ions by Ne atoms, no inelastic energy losses connected with the processes of excitation of autoionization states and ionization with excitation were observed.

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CURRENT INSTABILITY IN $CdSnP_2$

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The semiconducting compound $CdSnP_2$ is one of the most interesting representatives of the class of ternary semiconductors of the type $A^2B^4C^5_2$. Comprehensive studies of the properties of $CdSnP_2$ have shown that this material is a straight-band semiconductor (ΔE = 1.16 eV, T = 300°K) with high carrier mobility and with a many-valley conduction band [1, 2]. $CdSnP_2$ is the first ternary superconducting compound in which the laser effect and high-frequency current oscillations have been observed [3, 4].