Excitation functions of the autoionization states $2s2p^63s(^1S)$ and $2s2p^63s(^3S)$ of Ne atoms colliding slowly with Na^+ ions

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We investitgated the excitation functions of the autoionization states $2s2p^63s(^3S)$ ($E = 43.36$ eV) and $2s2p^63s$ (^1S) ($E = 43.66$ eV), which are close in energy but differ in multiplicity, of Ne atoms colliding with Na^+ ions. Excitation of the autoionization state $2s2p^63s(^3S)$ of the Ne atom was seen to predominate at relative-motion energies up to $W \sim 150$ eV.

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In earlier investigations of the energy distributions of the electrons released upon decay of autoionization states produced when alkali-metal ions collide with inert-gas atoms, it was observed that excitation of these states is particularly clearly pronounced when the colliding particles have similar electron-shell structures (for example, Na^+ and Ne). For the Na^+-Ne pair, other interesting features were also observed, for example, polarization of the emitted radiation[1] and oscillations of the effective cross sections for charge exchange and excitation.[2,3]

An investigation of the energy distributions of the electrons for this pair, carried out in[4], has shown that at relative-motion energies W close to 150 eV a discrete group of electrons becomes resonantly excited, and the excitation receives contributions from the autoionization states $2s2p^63s(^1S)$ and $2s2p^63s(^3S$ (the energies of the released electrons are 22.1 and 21.8 eV, respectively). These states, however, were not separated in the cited paper, and the measured excitation function was a sum of the excitation functions of these two autoionization states, which are close in excitation energy but differ in multiplicity. We deemed it important to trace the influence of the multiplicity of the autoionization state on the probability of its excitation.

To this end we measured the excitation functions of each of the states separately. The general experimental setup is similar to that described earlier.[5] The main difference is an appreciable improvement in the resolution of the electron-energy analyzer, which now reached 0.7%. In addition, the angular resolution of the collimator was also increased—electrons were registered emitted at an angle $90 \pm 3°$ relative to the direction of the primary Na^+ ion beam. Since the registered electron flux was low, particularly in the near-threshold region, the measurements were performed in an individual electron counting regime in conjunction with modulation of the primary ion beam and synchronous detection of the particles. Since the lines corresponding to excitation of the individual autoionization states $2s2p^63s(^1S)$ and $2s2p^63s(^3S)$ were not completely separated under the experimental conditions, a fact possibly connected in part with the natural line width (the lifetimes of the autoionization states are 10^{-14}—10^{-5} sec[6,7]), the line contours were processed with a computer by a procedure analogous to that described in[8].

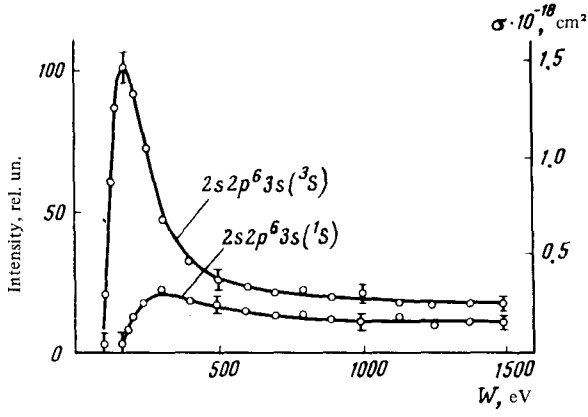

FIG. Excitation functions of autoionization states $2s2p^63s(^1S)$ and $2s2p^63s(^3S)$ of the Ne atoms. W is the energy in the c.m.s.

The figure shows the excitation function of the discrete groups of electrons connected with excitation of the indicated states. The absolute magnitude of the effective excitation cross sections of these states was obtained by resorting to data on the ionization cross sections for this pair[9] and to data on the integrated energy distributions of the electrons released upon collision of Na^+ ions with Ne atoms.[10]

Attention is called to the following important singularities of the excitation the radiated autoionization states.

1. Despite the small difference between the energies of the released elec- ons, the character of their excitation is significantly different. The excitation the autoionization state $2s2p^63s(^3S)$ proceeds in resonant fashion in a com- ratively narrow interval of the energies of the relative motion. This excita- n function differs essentially from the curve described by the Landau-Zener rmulas. At the same time, the excitation function of the state $2s2p^63s(^1S)$ is oser to such a curve.

2. There are significant differences between the excitation thresholds in the is (and also in the lab system): $W_{thr_1} = 170$ eV and $W_{thr_2} = 85$ eV for the states $2p^63s(^1S)$ and $2s2p^63s(^3S)$, respectively. Thus, selective excitation of the ates $2s2p^63s(^3S)$ takes place in the energy region $85 < W < 170$ eV.

3. A certain analogy can be noted between the ratio of the probabilities of the citation of these states in the investigated case and in the case of excitation the same state of the Ne atoms by electron impact,[7] but there are no data indicate whether these processes have a common physical basis.

There is no theoretical explanation for the results at present. One can ex- ct further theoretical and experimental investigations of this case to indicate e cause of the resonant excitation of the $2s2p^63s(^3S)$ state of the Ne atoms.

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