ABSOLUTE MEASUREMENTS OF EXCITATION FUNCTIONS FOR K II *LINES PRODUCED IN COLLISIONS BETWEEN* K⁺ *IONS AND* Ne *ATOMS*

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The emission spectrum arising in collisions between K^+ ions and Ne atoms is investigated. The behavior of the absolute excitation functions for several K II and Ne I lines is plotted at ion energies from threshold to 30 keV. For most lines of the potassium ion qualitatively similar behavior of the excitation functions is found. The largest cross sections for K II lines lie in the range (0.3–1.7) $\times 10^{-18}$ cm^2. The total cross section for the excitation of all K II lines in the visible spectrum is $\sim 10^{-17}$ cm^2. The experimental data are interpreted theoretically on the basis of the Landau-Zener adiabatic model.

1. EXPERIMENT

THE excitation of K^+ ions in collisions with neon atoms has been investigated to obtain new experimental information about excitations produced in collisions between atomic particles. The experimental apparatus used to investigate this excitation in the case of K^+–Ne collisions has been described in[1]. The previous technique was used to determine the absolute intensities of the spectral lines; however, the optical excitation functions were investigated with both dc and pulse-counting procedures. In the latter case the signals from an FÉU-64 photomultiplier were amplified and registered with a PP-12 scaler. At the same time a current integrator and a PST-100 scaler measured the total charge of the ions traversing the collision chamber. The number of background pulses (photomultiplier noise and scattered light) was monitored regularly and was taken into account in the treatment of the data.

Spectroscopically pure neon was used in our work; the gas pressure in the collision chamber never exceeded 3×10^{-3} mm Hg. The ion beam current density varied within the range 10^{-6}–5×10^{-5} A/cm^2. The line intensities varied linearly in these pressure and current density ranges.

The maximum error of the absolute cross sections for the excitation of the spectral lines was 40%. The error in measuring the relative behavior of the excitation functions was 3–7%.

2. RESULTS AND DISCUSSION

In the visible region (3900–6200 Å) of the spectrum arising from K^+–Ne collisions 34 potassium ion lines and 11 neon atom lines were registered. For the strongest K II and Ne I lines we obtained excitation functions at energies from threshold to 30 keV (Figs. 1 and 2).

Most of the excitation functions for K II lines representing transitions from 4p levels resemble each other, with a quite rapid growth of the cross section at ion energies T > 1.5 keV, slight variation in the range T = 14–20 keV (for the 3898-Å line of K II a distinct peak is observed at ~15 keV), and renewed rapid increase thereafter. For λ = 4388 and 4149 Å of K II the excitation functions behave somewhat differently, having a relatively flat peak at ~20 keV. These lines corre-

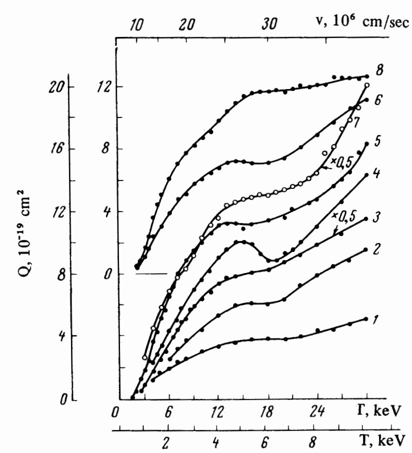

FIG. 1. Cross sections for the excitation of K II lines: 1–λ = 4135, 2–4505, 3–4223/6, 4–3898, 5–4305/9, 6–4596 + 4608, 7–4263, 8–4186 Å, v–K^+ velocity (lab system), T–K kinetic energy, E–energy of relative motion. The origin was shifted for curves 6 and 8.

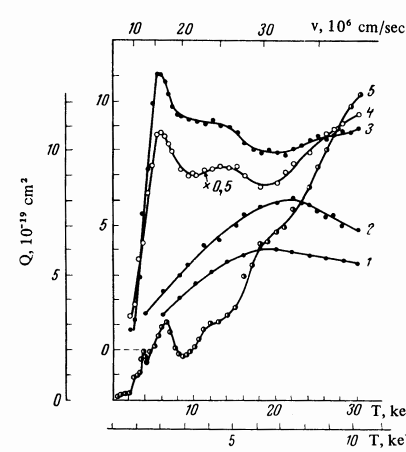

FIG. 2. Excitation cross sections: 1–K II, λ = 4149, 2–K II, λ = 4388, 3–K II, λ = 4829 + Ne I, λ 4827, 4–K II, λ = 5006 + Ne I, λ = 5005, 5–Ne I, λ = 5852 Å. The origin was shifted for curves 1–4.

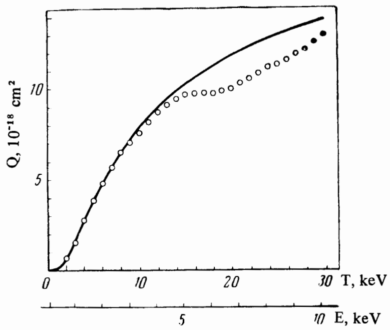

FIG. 3. Combined cross section for the excitation of K II lines in the visible spectrum. The continuous curve represents the Landau-Zener cross section.

spond to transitions of identical multiplicity from the same upper $4p_6$ level (in the Paschen notation). The largest cross sections for the investigated K II lines lie in the range $(0.3-1.7) \times 10^{-18}$ cm^2.

The excitation functions for the unresolved lines of the potassium ion and the neon atom (curves 3 and 4 in Fig. 2) are of approximately identical shape, with a very rapid rise near the threshold, a pronounced peak at ~ 5.5 keV, a weak second maximum at $\sim 13-14$ keV, and further increase for $T > 20$ keV. The K II lines contributing to the cross sections for these unresolved lines have a common upper $4p_1$ level.

Figures 1 and 2 show that Ne I lines are registered at ion energies as low as ~ 0.4 keV, while K II lines appear at considerably higher energies (~ 1.5 keV). Curve 5 of Fig. 2, which is typical for the neon lines, exhibits a distinct structure resembling the oscillations in the excitation functions of He I lines[2,3] from the He^+-He process. We note that definite structure has also been observed in the neon resonance-line curves for K^+-Ne.[4]

It is difficult to interpret the complex behavior of the K II and Ne I excitation functions because we lack information about other processes occurring in K^+-Ne collisions. Some interpretation of the general shape of these excitation functions is possible if we neglect the mutual influence of different channels and use the two-term Landau-Zener model.

We have already mentioned the overall similarity of the excitation functions for most K II lines. Reasons have been given in[1] why the Landau-Zener adiabatic model can therefore be used to describe the combined cross section for the excitation of all the lines but not of individual lines.

Figure 3 shows the combined cross section[1)] for the excitation of all the K II lines in the visible spectrum; we can assume, with some error, that this is the excitation cross section for the 4p sublevels. The solid curve is the Landau-Zener cross section calculated with the parameters (in the notation of[1]) a = 5.7 keV, U_0 = 0.18 keV, and r_0 = 0.34 Å. This cross section has a very flat maximum (1.6×10^{-17} cm^2) at T = 105 keV. The figure shows that the calculated curve fits the combined cross sections very well in the region $T < 14$ keV. The divergence at higher energies probably reflects the influence of other possible channels for which the two-term Landau-Zener model does not allow.

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1)To the sum of the cross sections for the 10 strong K II lines we added the 25% contribution for 16 weak lines measured at T = 7 keV and the 7% contribution for two unresolved lines (taken to be one-half of their cross sections at 30 keV).

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