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OSCILLATIONS OF EXCITATION FUNCTION OF HELIUM RESONANCE LINE AND INTERFERENCE OF TWO VACANT STATES IN COLLISIONS OF Na+ IONS WITH HELIUM

S.V. Bobashev and V.A. Kritskii
A.F. Ioffe Physico-technical Institute, USSR Academy of Sciences
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One of the authors has previously observed [1], in a study of the glow produced by the collisions $Na^+ + Ne \rightarrow Na^+ + Ne^*$, regular oscillations of the excitation function of two resonant lines of the helium atoms. At sodium ion energies from 0.2 to 11 keV, eight maxima, equidistant in the reciprocal relative-motion velocity, were observed. The observed oscillations were attributed to interference between the excitation channel and the charge-exchange channel adjacent to it in energy, both channels being coherently excited in the Na^+ + Ne collisions. The interference of the states in such a case is the consequence of the additional interaction of two quasimolecular terms when the particles move apart. This interaction is the result of either intersection of the terms [2] or their very close approach [1] at a large internuclear distance. It was noted in [1] that in such a case the oscillations in the two inelastic channels in question should be in antiphase.

We report here experimental data which, in the authors' opinion, represent one more case wherein singularities, due to interference of two states when the particles move apart, have appeared in the total cross sections of two inelastic channels.

We measured the intensities Q_1 of the He I resonance line ($\lambda = 584.3$ Å) excited in the reaction

$$Na^+ + He \rightarrow Na^+ + He(2p\,^1P^0) - 21.22 \text{ eV.} \tag{1}$$
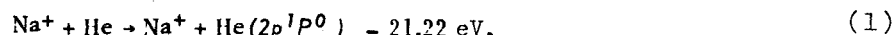
The measurements were made in the 1 - 13 kV energy range. The experimental setup and the procedure used to investigate the spectral lines lying in the region of the vacuum ultraviolet are described in [3, 1]. The points on the figure represent the values of Q_1 in units of the reciprocal velocity of the relative motion of the colliding partners. It is seen from the figure that the positions of the three maxima on the curve are approximately equidistant, the distance between the extrema being $\Delta v^{-1} = 1.2 \times 10^{-8}$ sec/cm. The dashed curve represents Maurer's prewar results [4] on the measurement of the cross section Q_2 for the excitation of the yellow doublet of sodium Na I (5890/5896 Å) in the process of charge exchange of Na^+ ions on He atoms

$$Na^+ + He \rightarrow Na^+ (3p^2 P_{1/2,3/2}) + He^+ - 21.55 \text{ eV.} \tag{2}$$
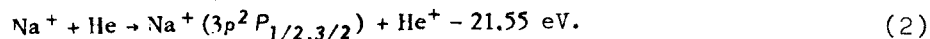
It should be noted that at low energies (large values of v^{-1} in the figure) the details of the relative course of the cross section Q_2 might have been omitted by Maurer, since he used a photographic registration procedure, and the measurements were made with appreciable intervals between the energy values. The relative course of the excitation function of the doublet lines can be regarded as reliably established in the region of the extrema (i.e., at Na^+ ion energies above 5 keV, $v^{-1} < 5 \times 10^{-8}$ sec/cm. The absolute values of Q_2 were obtained in [4] by comparing the summary intensity of the yellow doublet with the then-known value of the cross section for the excitation of the 5876-Å He I line by electron impact.

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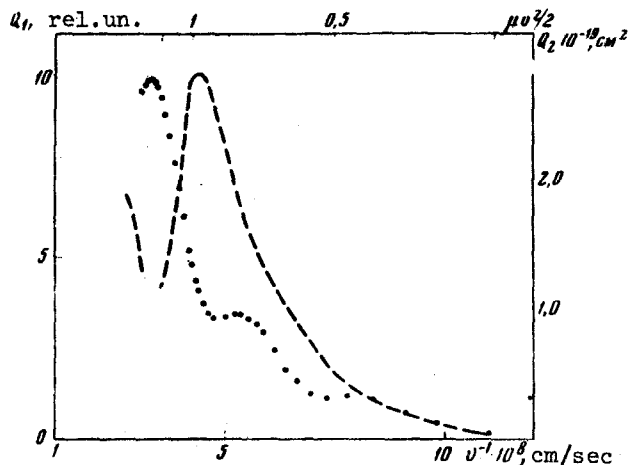
The authors of the present article propose that the structure of both curves shown in the figure is due to interference of the two inelastic channels of the reactions (1) and (2). This conclusion is based on the results of a theoretical paper submitted to Zh. Eksp. Teor. Fiz. (Sov. Phys.-JETP) by Ankudinov, Bobashev, and Perel'. That paper considers the simplest model of collision of two atomic particles, leading to oscillation of the total cross sections of two inelastic processes with a large resonance defect. It was assumed in the model that when the two atomic particles come close together the term of the ground state of the system intersects in succession two vacant energetically-adjacent terms of the quasimolecule. After population of the terms in accordance with the Landau-Zener scheme, their additional interaction at a large internuclear distance, resulting from the intersection or very close approach of the terms, was considered. Expressions were obtained for the amplitude, the period, and the phase of the oscillations. It was established that under certain conditions the oscillations are harmonic in the reciprocal velocity, and that the oscillations in both channels should be in antiphase when only two terms interact. Indeed, the extrema observed on both curves (see the figure) are in antiphase, and the distance between extrema on the curve for the reaction (1) (Q_1) is approximately equal to the distance between the maximum and the minimum of the cross section Q_2.

In this case we can estimate the absolute value of the cross section for the excitation of the 584.3-Å He I line, assuming that the oscillating components of the cross sections Q_1 and Q_2 are equal. Using the absolute values of Q_2, we obtain an estimate for the value of Q_1 at the maximum, $Q_1 \simeq 7 \times 10^{-19}$ cm^2 at an Na$^+$ ion energy 11.5 keV ($v^{-1} = 3.25 \times 10^{-8}$ cm/sec, $\mu v^2/2 = 1.7$ keV, where μ is the reduced mass of the colliding particles).

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EXTENDED SEMICONDUCTOR LASER WITH RADIATING LATTICE

O.N. Prozorov, L.A. Rivlin, and S.D. Yakubovich

One of the direct methods of increasing the power of coherent radiation of an injection semiconductor laser (SL) is to increase the area of the p-n junction involved in the stimulated-emission process, either by synchronizing the oscillations of several coupled SL [1 - 4], or by increasing the length L of the Fabry-Perot resonator. In the latter case the phenomenon of gain saturation limits L to a value of the order of the saturation length L_s. In the