PECULIARITIES OF AUTOIONIZATION INDUCED BY FINE STRUCTURE TRANSITION

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The autoionization of doubly excited states can be induced by transitions between the fine structure sublevels of the weakly excited electron. Since the fine structure splitting ΔE is quite small, this autoionization channel becomes operative only when the principal quantum number n_1 of the outer electron is high enough ($n_1 \geq n_{1th}$). While this additional channel is open, it enhances appreciably the autoionization width Γ_{n_1}. The related peculiarities in the serial behaviour of Γ_{n_1} (stepwise increase with n_1 at n_{1th} were observed experimentally [1] (see also the bibliography in Ref.[2]).

The important point is that the decay induced by the fine-structure transition corresponds to very small values of the ejected electron momentum p. Therefore the estimate holds: $Z/p \gg n_1/\sqrt{l_1}$, where n_1, $l_1 \gg 1$ and Z is the charge of the residual ion ($Z = 1$ for autoionization of neutral atom). We have carried out the asymptotic analysis of this case (which was not considered previously [3]) assuming that $Z/p \sim l_1$. It is convenient to present result for the ratio $\gamma = A_2/A_1$ of two autoionization amplitudes.

(i) A_2 is induced by the fine-structure transition $(n_2l_2)\; j_2 = l_2 + 1/2 \Rightarrow (n_2l_2)\; j_2 = l_2 - 1/2$. Here the dipole transition is forbidden and the inner electron undergoes *quadrupole* transition. The outer electron is emitted with the momentum p_2.

(ii) A_1 is induced by the conventional autoionization decay $(n_2l_2) \Rightarrow (n_0l_0)$. The *dipole-allowed* transition is presumed for the inner electron; the outer electron is ejected with the momentum p_1. Here (n_2l_2), (n_0l_0) are the principal quantum number and orbital momentum for the inner active electron, j_2 is its total angular momentum. Our asymptotic estimate for γ reads:

$$\gamma \sim \frac{\langle n_2l_2 \mid r^2 \mid n_2l_2\rangle}{\langle n_2l_2 \mid r \mid n_0l_0\rangle} \left(\frac{l_1}{a}\right)^{l_1} l_1 \left(1 - \frac{l_1}{n_1}\right)^3, \tag{1}$$

where the parameter $a \sim 1$. This result reproduces the stepwise enhancment of the autoionization amplitude mentioned above.

Additionally, in the region under consideration ($Z/p \sim l_1$) we have obtained the following estimate for the matrix element

$$\frac{\langle n_1l_1 \mid r^{-k-1} \mid pl_1 + \Delta\rangle}{\langle n_1l_1 \mid r^{-k-1} \mid pl_1 - \Delta\rangle} \sim \left(\frac{l_1}{\lambda_0}\right)^{2\Delta-1/2} \left(1 - \frac{l_1}{n_1}\right)^{2\Delta-1}, \tag{2}$$

where k is the order of multipole producing decay, l is the orbital momentum of the ejected electron. This result implies priority of the channels leading to the enhancment of the orbital momentum for the outgoing electron (analogue of the well-known Bethe rule). For the conventional decay channels this rule was formulated in Refs.[3,4]; it was confirmed by subsequent theoretical and experimental studies.

References

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[4] S.I.Nikitin. // Opt.Spektrosc. 1977. v.**42**. p.793.