Inner-shell ionization-excitation cross sections of Li and Na atoms in the ground and excited states

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For the calculation of simultaneous ionization and excitation of atoms by photons and electrons, two simple methods of sudden perturbation [1] (SP) and relaxed-orbital Hartree-Fock [2] (RO) approximations often are used. The SP method represents the case when the escaping electron leaves an atom so fast that the remaining electrons do not rearrange in time. In RO method, it is supposed that the first step of the process is the rearrangement of spectator electrons, therefore, the electron escaping from an atom feels the field of relaxed ion. The main task of our work was the comparisons of ionization cross sections, asymmetry parameters β of photoelectron angular distribution and alignment of remaining ions calculated with the help of both methods.

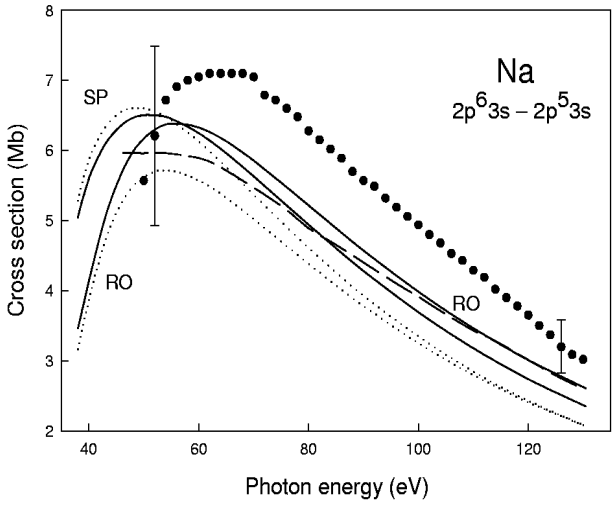

Figure 1: 2p photoionization cross sections of Na atoms calculated in SP and RO approximations. Solid line shows length form, dotted line is for velocity form, dashed line represents R-matrix calculation, and full circles indicate experimental data [3].

For the investigation, the process of inner-shell ionization of Li and Na atoms in the ground

and in a number of excited states was chosen:

$$A(n_0 l_0^{4l_0+2} nl) + h\nu \rightarrow A^+(n_0 l_0^{4l_0+1} n'l) + e,$$
$$A(n_0 l_0^{4l_0+2} nl) + e \rightarrow A^+(n_0 l_0^{4l_0+1} n'l) + e' + e''.$$

Here A means Li (n=2,3; n'=2,3,4; l=0,1,2) and Na (n=3,4; n'=3,4,5; l=0,1,2,3) atom. The ionization cross sections by electron impact integrated over the energies of escaping electron were calculated in plane-wave Born approximation. The 2p subshell photoionization cross sections of Na atoms in the ground state are presented in Fig. 1 as an example. The results of Fig. 1 show that the SP cross sections are larger than RO ones near the threshold of ionization both for length and velocity forms, but they decrease more rapidly with growing photon energy. The shape of RO cross section resembles more closely the shape of the experimental one [3] than that of SP in the whole interval of photon energies. For the case of ionization by electrons, the cross sections of SP method are larger than those of RO approximation about 1.4 times at the maximum value and 1.3 times at the energy of 1000 eV of impinging electron. Fig. 2 displaces the 1s-shell ionization cross sections of Li atoms in the ground and first excited states. The asymmetry parameters β of SP approximation have much deeper minimum at threshold than the RO one, but the parameters of both methods merge with growing photon energy. The alignment parameters of SP method are larger at threshold and lower at high photon energies than those of RO method.

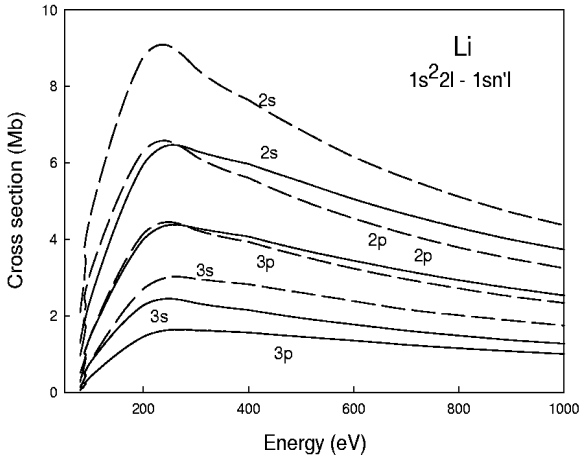

Figure 2: Li 1s-shell ionization cross sections calculated in RO (solid line) and SP (dotted line) approximations

[1] T. Aberg, *Phys. Rev.* **156** 35 (1967).
[2] R. Rakštikas and A. Kupliauskienė, *Physica Sripta* **58** 587 (1998).
[3] D. Cubaynes *et al*, *Phys. Rev. A* **57** 4432 (1998).