Effects of autoionization in electron loss from helium-like highly charged ions in fast collisions with light atoms

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Synopsis We study theoretically single electron loss from helium-like highly charged ions in fast collisions with light atoms which involves excitation and decay of autoionizing states of the ion. We present a detailed analyzes of how the shape of the emission pattern depends on the atomic numbers of the ion and atom as well as on the collision velocity.

In this work we study single electron loss from helium-like highly charged ions (HCIs) which occurs in fast collisions with light atomic particles. The main interest of the present study concerns the role of doubly excited (autoionizing) states of the HCI in the loss process. The later can be substantially influenced by such states when the energy of the emitted electron is close to the difference between the energy of an autoionizing state and the energy of a final state of the residual hydrogen-like ion. In such a case an autoionizing state can participate in the process via the corresponding excitation-autoionization (EA) channel. This is illustrated in Fig. 1, where both the direct and indirect (EA) channels of electron loss are schematically depicted.

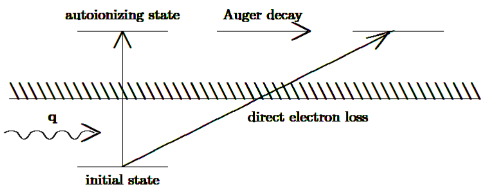

Figure 1. Electron loss from HCI by a single interaction with an external field.

Our consideration of electron loss from HCIs is based on the two main ingredients.

First, in order to describe electronic states of a free HCI we use the line-profile approach (LPA) [1, 2] of quantum electrodynamics (QED). The Furry picture is employed, in which the Coulomb interaction of the electrons of the HCI with its nucleus is fully taken into account from the onset. The bound electrons and the emitted electron are treated fully relativistically. The interaction of these electrons with the quantized electromagnetic and electron-positron fields is considered according to the standard QED perturbation theory. This interaction is taken into account in the zeroth and first orders of the perturbation expansion. Besides, the leading parts of the higher order corrections in the electron-electron interaction are also included into the treatment according to the LPA [2].

Second, the interaction between the electrons of the HCI and the atomic particle is taken into account using the first and second orders of relativistic perturbation theory.

For illustration, Fig. 2 shows the doubly differential cross section of electron loss from $Ca^{18+}(1s^2)$ by electron with kinetic energy 1 MeV (or the equivelocity proton with kinetic energy 1.84 GeV). The cross section is given in the rest frame of the HCI.

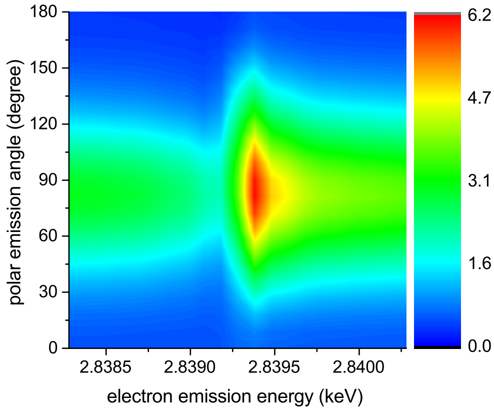

Figure 2. Doubly differential cross section (in barn/keV/st) for electron loss from $Ca^{18+}(1s^2)$ by electron (proton) impact. The emission energy range corresponds to the participation of the $(2s2p_{3/2})_{J=1}$ autoionizing state. For more information see the text.

References

[1] O. Yu. Andreev, L.N. Labzowsky and A. V. Prigorovsky 2009 *Phys. Rev. A* **80** 042514

[2] O. Yu. Andreev, L.N. Labzowsky, G. Plunien and D. A. Solovyev 2008 *Phys. Rep* **455** 135

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