Triply excited autoionizing states in resonance electronic recombination with He-like uranium

K. N. Lyashchenko[*1] **and O. Yu. Andreev** [*]

[*] Department of Physics, St. Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034, Russia

Synopsis Calculation of total and differential cross sections for the electronic recombination with He-like ions of uranium within the framework of QED is presented. Energy region involved triply excited states of Li-like uranium is considered.

Electronic recombination (ER) is a common process in nature which may occur in collisions of free or quasi-free electrons with ions. ER with highly charged few-electron ions is under great attention from both experimental and theoretical research. If ER involves participation of at least two electrons, then not only direct channel (with simple nonresonant electron capture) occurs but also various resonant channels such as dielectronic, trielectronic and etc. recombinations take a place. For the latter one the autoionization states play a crucial role. Resonant ER with highly charged ions (HCIs) presents a tool for investigation of the Breit interaction. In our previous works [1, 2] we studied dielectronic recombination with initially H-like and He-like HCIs where we focused our attention on doubly excited states and the corresponding resonances. These studies reveal that the Breit interaction may give important and even dominant contribution to the cross section of ER with few-electrons HCIs. In the present work we expand the area of our interest on resonances caused by the triply excited states of He-like uranium. We note that the contribution of these states to the cross section is in 8-11 orders smaller than the corresponding contribution of the nonresonant channel of ER with He-like uranium initially being in its ground state [2]. Therefore we consider ER with He-like uranium initially being in a metastable state. Schematically the resonance channel of ER looks like

$$U^{90+}(i) + e^- \to U^{89+}(m) \to U^{89+}(f) + \gamma \quad ,$$

where i, m and f denotes singly, triply and doubly excited states, respectively, and γ represents emitted photon.

Our description of the resonance electronic recombination is based on the line-profile approach (LPA) [3, 4] of QED. The Furry picture is used, in which the Coulomb interaction of the electrons of the HCI with its nucleus is fully taken into account from the onset. The Dirac equation is employed to treat both the bound electrons and the incident electron. The standard QED perturbation theory is employed for description of the interaction of the electrons with the quantized electromagnetic and electron-positron fields. This interaction is taken into account in zeroth and first orders of the perturbation theory. The main parts of higher order corrections of electron-electron interaction is also taken into account according to LPA [4].

For illustration, Fig. 1 shows the total and differential cross sections of electronic recombination with U^{90+} initially being in its singly excited metastable states $(1s2s)_{J=0}$ and $(1s2p)_{J=0}$. The cross sections is given in the rest frame of the HCI.

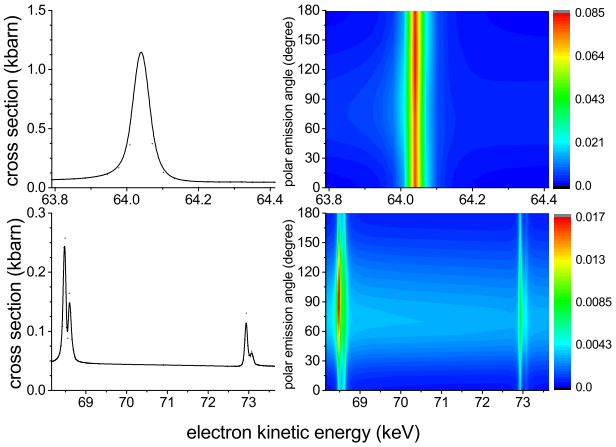

Figure 1. Total and differential cross sections (in kbarn and kbarn/st) for electronic recombination with He-like uranium as a function of kinetic energy of incident electron and polar emission angle of emitted photon. The energy range corresponds to the participation of triply excited $(2s2s2p)$ and $(2s2p2p)$ states.

References

[1] K. N. Lyashchenko and O. Yu. Andreev 2015 *Phys. Rev. A* **91** 012511

[2] K. N. Lyashchenko and O. Yu. Andreev 2016 *Phys. Rev. A* **94** 042513

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

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

[1] E-mail: laywer92@mail.ru