Recoil momenta distributions in the double photoionization

M. Ya.Amusia[*,†][1], **E. G. Drukarev**[‡], **E. Z. Liverts** [*], **A. I. Mikhailov**[‡]

[*] Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem 91904, Israel
[†] Ioffe Physical-Technical Institute, St. Petersburg 194021, Russia
[‡] Konstantinov Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188300, Russia

Synopsis We calculate the distributions in recoil momenta for the high energy double photoionization of helium caused by *quasifree* mechanism. The distributions obtain local maxima at small values of the recoil momenta. This agrees with earlier predictions and recent experimental data. Angular correlations which reach the largest value for "back-to-back" configuration of photoelectrons are also obtained.

The recent measurement of the yield of double charged ions in photoionization of helium [1] confirmed the exitance of the *quasifree mechanism* (QFM) of the double photoionization which was predicted in [2]. The differential cross sections of the double photoionization were calculated earlier in a number of papers where the authors studied the distributions in characteristics of each photoelectron. In the pioneering experiments [1] the distribution in momentum transferred to the nucleus q (recoil momentum) was measured and the local peaks at small values of q^2 were observed. Thus the problem of calculation of such distributions as $d\sigma^{2+}/dq^2 d\varepsilon$ with ε the energy of one of the photoelectrons and $d\sigma^{2+}/dq^2$ became actual.

The key point of the QFM is that two electrons can absorb a photon almost without participation of the nucleus. This is impossible in two other mechanisms which were known by the time of publication of [2], i.e. in the shake-off and knock-out mechanisms. In these cases the single photoionization which is not allowed for the free electrons is an intermediate step. Thus large momentum $q \gg \eta$ should be transferred to the nucleus. The QFM can takes place only in the vicinity of the center of the spectrum, when the relative difference between the energies of the outgoing electrons $\varepsilon_{1,2}$ is small, i.e. $\beta = |\varepsilon_1 - \varepsilon_2|/\varepsilon_1 + \varepsilon_2| \ll 1$.

The QFM is not possible in the dipole approximation [2] and requires inclusion of the quadrupole terms of the interaction between photon and electrons. In QFM the two bound electrons approach each other at the distances which are much smaller than the atomic size. In order to describe the QFM contribution an approximate wave function of the ground state of helium should satisfy the second Kato cusp condition $\Psi(r_1, r_2, r_{12}) = 2\partial\Psi(r_1, r_2, r_{12})/\partial r_{12}$ at $r_{12} = 0$. We employed the functions for which this condition is true. An example of the distribution $d\sigma^{2+}/dq^2 d\beta$ for the photon energies used in [1] is presented in the Figure. It shows the shape of the peak at small q^2.

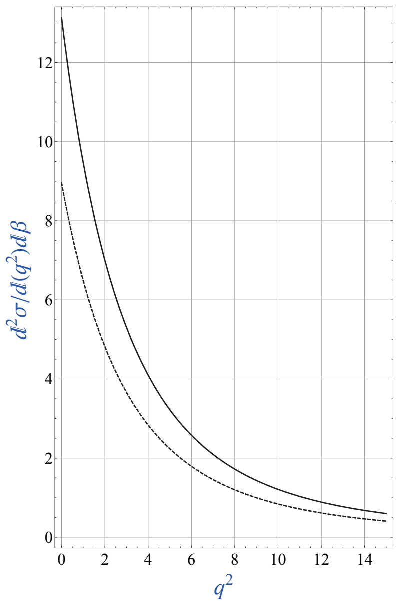

Figure 1. Distribution $d^2\sigma/dq^2 d\beta$ in $10^{-10} r_0^4$, $r_0 = 1/m\alpha$ for $\beta = 0$. Solid line is for $\omega = 800$ eV, dashed line is for $\omega = 1$ keV. The recoil momentum q is in atomic units.

References

[1] M. S. Schöffler *et al.* 2012 arXiv: 1207.7181 [physics.atom-ph].

[2] M. Ya. Amusia, *et al.* 1975, J.Phys. B **8**, 1248.

[1]E-mail: Amusia@vms.huji.ac.il