Single ionization of Helium at 0.5 - 2 MeV proton impact: On the quest for projectile coherence effects

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Synopsis: We investigated single ionization in proton-helium-collisions at 0.5, 1 and 2 MeV for various beam properties (divergence/coherence length).

Single ionization, induced by a fast charged particle has been investigated since a long time. While electron impact experiments – at least on a helium target – agreed well with theory in lowest order perturbation theory, impacting heavy particles, such as protons or highly charged ions never agreed well with theory. The typical electron angular distribution shows two peaks, the pronounced binary and the recoil peak, and a nodal structure in-between them. In a collision experiment with C^{6+} projectiles at 100 MeV/u [1], the node was mostly filled, and the disagreement with state-of-the-art theories, started an avalanche of discussions and further experiments. 15 years later, the issue is still not solved and two explanations are heavily debated: insufficient momentum resolution and the influence of transversal beam coherence. According to [2] the macroscopic geometrical preparation of the beam, e. g. its divergence, should influence the microscopic scattering behavior and therefore for example the electron's angular distribution.

In a series of single ionization experiments, we investigated p+He collisions at impact energies from 0.5 to 2 MeV, produced by a Van-de-Graaff accelerator. We applied the COLTRIMS reaction microscope technique [3], optimized for highest momentum resolution, to determine the momentum vectors of all emitted particles in coincidence. For the highest projectile energy (2 MeV), we manipulated the beam divergence by utilizing an electro static quadrupole lense. The electron angular distribution in the scattering plane is shown in Figure 1, both with lense being turned on and off. Within the experimental error bars we don't observe any difference.

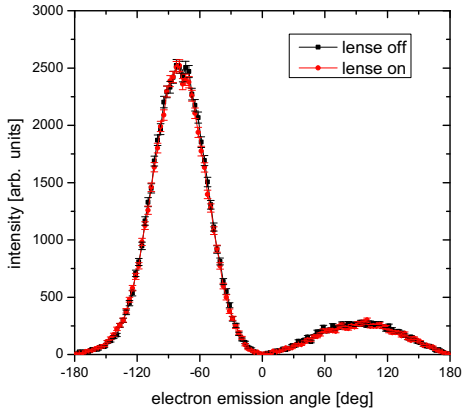

Figure 1. Electron emission angle in the scattering plane for 2 MeV p+He, E_e=6.5±3.5 eV, q=0.75±0.25 au, with projectile lense turned on (red circles) or turned off (black squares).

References

[1] Schulz et al., Nature, **422**, 48, (2003)
[2] Schulz et al., Phys. Rev. A, **76**, 032712, (2007)
[3] Gassert et al., Phys. Rev. Lett **116**, 073201, (2016)
[4] Dörner et al., Phys. Rep. 330, 95 (2000)

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