Non-PCI higher-order effects in fully differential ionization cross sections

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Synopsis We measured fully differential cross sections (FDCS) for single ionization of Helium by Proton impact far from the matching velocity regime to investigate higher order effects (non-PCI)

We investigated higher-order effects in single ionization of 75 keV p + He by measuring the momenta of the scattered projectiles and recoil ions. From the measured momenta of these ions, we obtained fully differential cross sections (FDCS) for electrons ejected into the scattering plane as a function of their emission angle θ_e at different values of fixed projectile energy loss and momentum transfer q from the projectile to the target atom.

Previously, we reported on several FDCS studies for scattered electron energies close to the projectile speed (velocity matching) [e.g. 1,2], where higher-order contributions were known to be dominated by the post-collision interaction (PCI). This mechanism involves the projectile interacting with the active electron at least twice: first, transferring enough energy to lift the electron to the continuum, and second, focusing the projectile and ejected electron towards the initial beam axis. In previous data, we observed two signatures of PCI: a forward shift of the so-called binary peak relative to q and a pronounced peak structure in the initial projectile beam direction (forward peak).

The objective of this project was to investigate higher-order non-PCI effects, particularly those involving the interaction between the projectile and the target nucleus (PT interaction). To suppress PCI contributions, we selected electron energies of 1 eV and 75.4 eV, which are far from the velocity matching.

At 1 eV, we found the forward peak, one of the signatures of PCI, is completely absent in the FDCS. On the other hand, at 75.4 eV, the forward peak was significantly reduced compared to the velocity-matching regime, but a significant residue remained. Suprisingly, the forward shift of the binary peak, the second signature of PCI, at 1 eV was as dominant as in the velocity-matching regime and even more noticeable than at 75.4 eV. However, it was previously pointed out that not every forward shift indicates PCI; it could also be caused by the PT interaction [3].

Fig. 1 illustrates the forward shift of the binary peak as a function of energy loss (ε), which includes the electron energy and ionization potential. The data exhibit two distinct regions:

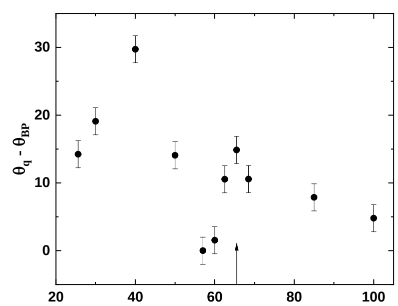

Figure 1 Forward shift of the binary peak as a function of energy loss

one at very small ε and another in the velocity-matching regime and at large ε. We interpret these regions as being influenced by PCI (velocity matching) and higher-order effects involving PT interaction (small ε), respectively. Hence, we conclude that at 1 eV, non-PCI higher-order contributions dominate the FDCS, while PCI dominates at 75.4 eV.

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[2] M. Dhital et al., PRA 102, 032818 (2020)
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