

Electron impact multiple ionization

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Synopsis We present theoretical calculations of electron impact multiple ionization of rare gases (single to quintuple for Ne, Ar, Kr and Xe). The theoretical model used is the CDW-EIS, adapted for electron impact, and the first Born approximation for the high impact energies ($E > 0.6$ keV). The results presented here take into account the direct and the post-collisional ionization. The latter by including experimental branching ratios of Auger type processes. This formalism describes the experimental data quite well. In the case of Kr and Xe we obtain good tendency even for sextuple ionization.

The central key of our approach is to adapt the heavy-ion atom collision results to cope the physics of light particle impact. Results for protons (antiprotons) will be the seeds for the transition amplitudes as a function of the impact parameter for electron and positron impact. As a first step, we show here the triple ionization cross sections by electron impact (Figure 1).

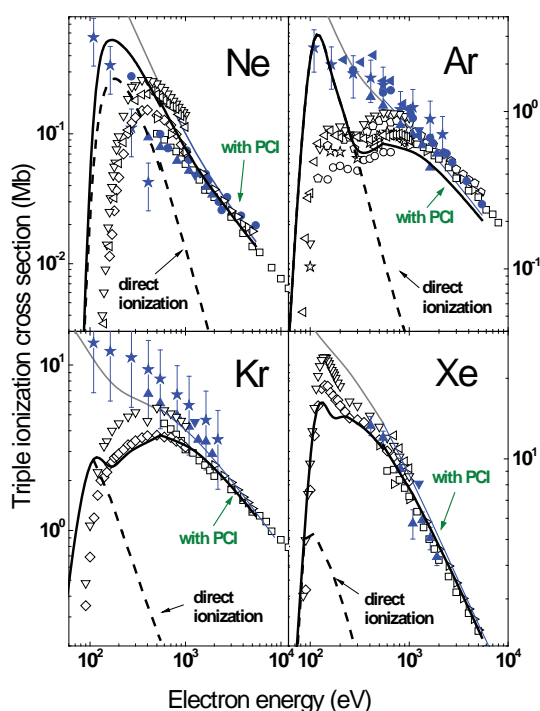


Figure 1. Triple ionization cross section of rare gases by electron (hollow symbols) and proton (filled symbols) impact. Curves: present results for electron impact including direct and post-collisional ionization (solid-lines) or only direct ionization (dashed-lines); previous results for proton impact ionization including PCI (grey thin solid-lines) [1]. Symbols: see [1] and references therein.

Our starting point is the T matrix element of ionization as a function of the momentum transfer of a given initial state $n l m$ by protons $T_{nlm}^+(\eta)$ or antiprotons $T_{nlm}^-(\eta)$ [1]. The theoretical considerations are:

- i) Charge effect: It is fulfilled from the starting point through the CDW-EIS approximation. At very high velocity impact the results are independent on the sign and the first Born approximation holds.
- ii) The electron impact energy: for each initial state $n l m$ it must be enough to allow the ionization
- iii) The transversal momentum transfer: for electron impact the maximum momentum transfer η_{\max} is finite and must be considered
- iv) The trajectory correction: for light particles it is far from being a straight line. We appealed to the Abel transformation to incorporate the effect of the trajectory with the knowledge of the probabilities as function of the impact parameter for protons and antiprotons.
- v) The independent electron model: multiple ionization is calculated within this approximation by using the multinomial expansion and post-collisional branching ratios [1-3]. For electron impact the independent electron model is clearly valid for energies equal or above that of maximum cross section. On the other hand, the multinomial expansion must include an energy correction to cancel those terms that are not energetically allowed.

References

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