Momentum-resolved study of strong-field multiple ionisation

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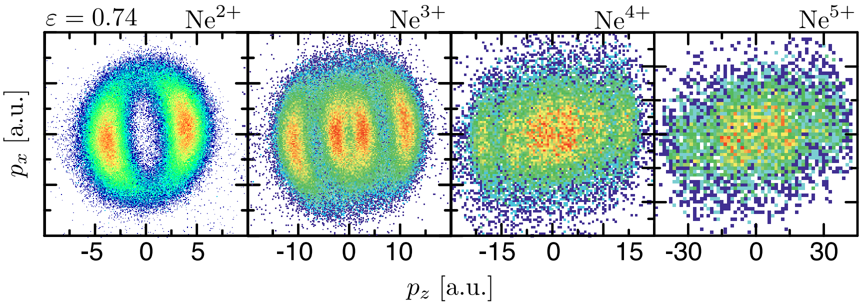
Multiple photoionization to high charge states is the hallmark of intense laser matter interaction at all wavelengths. Ionizing more than one or even several electrons inevitably raises the question whether the ionization proceeds sequentially or in a correlated way. One known pathway to correlated electron emission proceeds via recolliding electrons. The perspective of our work is to explore the territory of correlated ionization dynamics where recollision is suppressed, e.g. by the use of highly elliptical polarization. The use of elliptical polarization additionally enables taking advantage of the remarkably simple atto clock technique [1, 2] for extracting timing information on the ionization dynamics. Such information is of crucial significance for the identification of correlated dynamics.

Another important aspect of our work is the use of an ion beam apparatus [3]. This has two advantages: Firstly, ions have a high ionization potential and thus may be exposed to high field strengths such that tunneling ionization dominates. Secondly, transversally very cold beams can be readily produced such that the momentum transfer to the ion can be precisely measured. Together with the ability to measure the charge state of the ion after interaction with the laser, this provides a new window into the dynamics of multiple ionization.



The figure displays momentum spectra of Ne^+ ionized by 800-nm, 35-fs laser pulses with an intensity of 5×10^{16} W/cm^2. Ionization up to Ne^{5+} is observed for polarization with an ellipticity of $\varepsilon = 0.74$. The basic interpretation of the momentum spectra is straightforward: The outer half-moon-like structures of the Ne^{3+} spectra, e.g., correspond to events where both photoelectrons were emitted into the same direction, whereas the inner half-moons correspond to photoelectron pairs emitted in opposing directions. We have developed an algorithm that performs the deconvolution of the multiple ionization spectra such that the instants of individual ionization steps can be reconstructed.

Lit.:

[1] C. M. Maharjan et al., Phys. Rev. A **72**, 041403 (2005).
[2] P. Eckle et al., Science **322**, 1525 (2008).
[3] T. Rathje et al., Phys. Rev. Lett. **111**, 093002 (2013).
[4] P. Wustelt et al., Phys. Rev. A **91**, 031401(R) (2015).