# Photoionization of polarized Ne II in the region of autoionizing states

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**Synopsis** A detailed theoretical study on photoionization of polarized positive neon ion including its autoionizing states is presented, with reference to recent experiments at the free-electron laser FERMI. The feasibility for a complete photoionization experiment on positive ions is demonstrated.

By using intense linearly and/or circularly polarized extreme ultraviolet pulses of a free electron laser (FEL), the sequential two-photon double ionization (2PDI) has been realized in noble gas atoms (see reviews [1, 2]). Within the two-step model, the second step of the 2PDI represents the photoionization of the polarized positively charged ion, which can be studied by means of angle-resolved electron spectroscopy at FELs. Since the residual single-charged ion produced after the first step photoionization is generally polarized, a unique opportunity is opened to study photoionization of positively charged ions with an unprecedented level of detail, i.e. up to realizations of a complete experiment. Another poorly explored field is ionic autoionizing states, which may be now excited by photons from the polarized ground ionic state in the sequential 2PDI.

We calculated cross sections and angular distributions of photoelectrons produced upon ionization of $Ne^+(2p^5)$ in the region of the autoionizing states with dominant configuration $Ne^{+*}(2s2p^53p)$. The theoretical results are compared to recent recent measurements at FERMI. Two theoretical approaches were used: (a) perturbation theory for the both photoionization steps with multiconfiguration intermediate-coupling Hartree-Fock wavefunctions, combined with diagonalization method for treating the autoionizing states of $Ne^{++}$ and (b) perturbation theory for the first-step ionization and R-matrix calculations for the second-step ionization from polarized neon ion.

Using both circularly and linearly polarized FEL beams, the complete photoionization experiment on positively charged ions becomes possible, enabling us to find, within a certain theoretical model, any observable from the measured photoionization amplitudes. Furthermore, photoelectron angular distributions from the second-step ionization help to complete the experiment also on the first-step ionization. As an illustration of the theoretical work, Fig. 1 shows electron clouds reconstructed from the measured ionization amplitudes for both ionization steps.

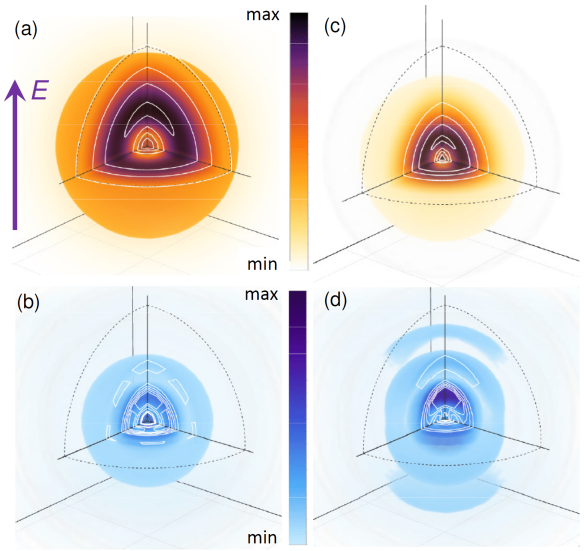


**Figure 1**. Inner structure of the spacial electron density of the residual ions $Ne^+(2p^5\,^2P)$ (a) and $Ne^{++}(2p^4\,^3P)$ (c) and the corresponding first-step (b) and second-step (d) photoelectrons. The photon energy of 56.5 eV is in the region of the autoionizing resonance $Ne^{+*}(2s2p^53p)$. The dashed line indicates the radius 5 a.u. (linear scale). The electric vector $\vec{E}$ of the linearly polarized FEL photons is indicated

Details of the calculations and their comparison with the experiment will be presented at the conference.

## References

[1] M. Braune *et al.* 2016 *J. Mod. Opt.* **63** 324

[2] A.N. Grum-Grzhimailo *et al.* 2016 *J. Mod. Opt.* **63** 334

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