Circular dichroism in two-color multi-photon ionization of rare-gas atoms

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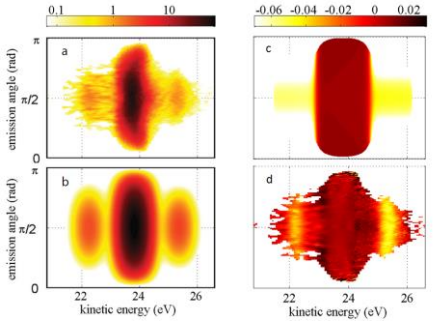
Synopsis We report on the study of two-color multiphoton ionization using circularly polarized XUV and IR radiation. The angle-resolved photoelectron spectra allow investigating the chirality of continuum and resonantly excited electronic states. The same two-color ionization scheme was used to characterize the polarization state of the radiation delivered by the FERMI FEL.

2-color experimental techniques involving ultra-short XUV and optical light are powerful tools for understanding the dynamics of electronic quantum systems and in addition have been demonstrated to be effective for the characterization of intense femtosecond x-ray radiation.

The availability of circularly polarized FEL radiation allows the tuning of an additional key parameter in this class of experiments, opening to the investigation of ultrafast dynamics in chiral samples such as magnetic systems or functional complexes with biomedical applications. In addition, it calls for an effective metrology tool for the polarization state of the radiation.

In this report we show how a straightforward 2-color ionization scheme of helium atoms allows an accurate measurement, independent on photon energy, of the circular polarization degree of a free electron laser beam using circular dichroism [1]. This approach allowed us to assess that radiation with a high (>90%) degree of circular polarization is delivered to the experiment at FERMI, consistent with pure source properties and with the characteristics of the beam transport system.

Two-color multiphoton ionization with circularly polarized light was investigated focusing on the photoelectron angular distribution under different polarization conditions [2]. The comparison of the experimental results with different theoretical descriptions based on Strong Field Approximation and time-dependent perturbation theory allows to access information on the contribution of different electronic partial waves to the ionization process.



Experimental (a,c) vs theoretical (b,d) cross section (a,b) and circular dichroism (c,d) in He 1s 2color photoionization. The dichroism is a direct measurement of the degree of circular polarization.

Thanks to the spectral properties of the FERMI seeded FEL, it was also possible to study the chirality of resonantly excited states in ionic atomic species created by circularly polarized XUV light and probed by optical radiation [3]. The first results of these investigations will be presented.

References

[1] T. Mazza et al., *Nature Communications* **5** 3648, (2014). [2] T. Mazza et al., *New Journal of Physics*, under review (2015). [3] M. Ilchen et al., *manuscript under preparation.*

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