Ring Currents in Single Atoms – Ultrafast Preparation and Detection using Strong Field Ionization

Sebastian Eckart* [1], **Maksim Kunitski*, Martin Richter*, Jonas Rist*, Alexander Hartung*, Florian Trinter*, Kilian Fehre*, Nikolai Schlott*, Kevin Henrichs*, Lothar Ph. H. Schmidt*, Till Jahnke*, Markus Schöffler* and Reinhard Dörner***

* Institut für Kernphysik, Goethe-Universität Frankfurt, 60438 Frankfurt am Main, Germany

Synopsis We present selective tunnel-ionization of an electron with defined sense of rotation inside a single atom and analysis of the energy spectra of such electrons.

In semi-classical pictures electrons with non-vanishing magnetic quantum number **m** rotate around their ionic cores. Rotating charges are termed ring currents. Is the sign of **m** related to the sign of the ring current in a single atom? Is it possible to switch ring currents on and off with attosecond precision? Our experiment shows that elliptically polarized laser pulses selectively tunnel-ionize electrons with defined sign of **m** leaving behind an ion with defined ring current confirming theoretic predictions [1,2].

Further we find that the initial momentum distributions upon tunnel-ionization depends on **m** as well. This leads to a shifted energy dependent yield for ionization from **m**-prepared states. Finally we show how to demerge angular offsets for different **m**-states allowing for the preparation and detection of ring currents with sub-cycle temporal precision [3]. The three-dimensional electron momenta have been measured in coincidence with their ionic cores using cold-target recoil-ion momentum spectroscopy (COLTRIMS) [4].

[1] E-mail: eckart@atom.uni-frankfurt.de

References

[1] I. Barth and O. Smirnova 2011 *Phys. Rev. A* **84** 063415
[2] O. Smirnova *et al.* 2015 *Phys. Rev. A* **92** 063405
[3] P. Eckle *et al.* 2008 *Science* **322** 1525–1529
[4] O. Jagutzki *et al.* 2002 *IEEE Transactions on Nuclear Science* **49** 2477-2483