Intensity-dependent shift in transverse electron momentum distribution for strong field ionization

Nida Haram*, Han Xu*, Atia-tul-Noor*, Satya Sainadh Undurti*, Igor Ivanov§, Igor Litvinyuk*, R.T. Sang*

*Centre for Quantum Dynamics and Australian Attosecond Science Facility, Griffith University, Nathan, Queensland 4111, Australia

§Centre for Relativistic Laser Science, Institute for Basic Science, Gwangju-500-712, Republic of Korea

Synopsis We present an intensity dependent study of transverse electron momentum distribution obtained from strong field ionization of argon using linearly polarized few-cycle (6 fs) laser pulses in the intensity range 10^{15}W/cm^2-10^{16}W/cm^2.

In order to explain the correlated many-particle dynamic in atoms and molecules, Cold Target Recoil Ion Momentum Spectroscopy (COLTRIMS) provides a kinematically complete picture of fragmentation process with high momentum resolution and detection efficiency [1,2]. In this project, we are interested in investigating the influence of laser intensity on transverse electron momentum distribution (TEMD) with COLTRIMS.

TEMD describes the photoelectron momenta in the direction perpendicular to the polarization plane of the laser pulse. The effect of varying ellipticity on TEMD in strong field atomic ionisation was studied by our group earlier [3]. In this work we investigate the effect of photon momentum as a function of laser intensity on the TEMD by examining the peak shifts with reference to zero transverse momentum i.e. $P_{\perp}=0$ using linearly polarized few-cycle laser pulses. Figure 1 shows the projection of three dimensional electron momentum distribution onto a two-dimensional imaging detector. The detector plane contains the axis of gas jet (x) and laser propagation direction (y), whereas (z) corresponds to time-of-flight axis.

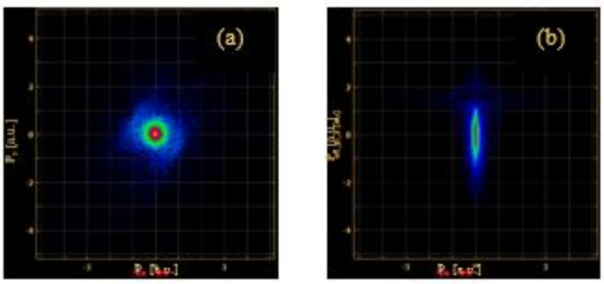

Figure 1. Electron momentum spectra in (a) xy and (b) xz plane at 800nm, 1.7x10^{15}W/cm^2

For a linearly polarized laser beam this distribution exhibits a cusp-like peak at zero momentum due to Coulomb focusing effect at $P_{\perp}=0$ — a long-range Coulomb interaction between emitted electron and its parents ion [4,5]. The shifts of the central peaks have been observed experimentally at intensities on the order of 10^{13}W/cm^2 in both directions; parallel as well as anti-parallel to the photon momentum direction; due to the complex contribution of Coulomb attraction from ion and magnetic Lorentz force [5,6].

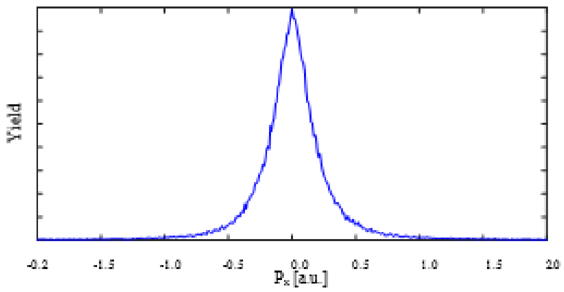

Figure 2. Projection of electron momentum distribution on laser propagation direction at 1.7x10^{15}W/cm^2

Experimentally, we observed that the peak of transverse electron momentum distribution along beam propagation direction is shifting with increased intensity. We compare our measurements with *ab initio* fully relativistic simulations of Ar ionisation. This study might help to resolve the questions related to time-resolved atomic and molecular holography, as the influence of photon momentum is noticeable in the holographic patterns [7].

References

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[1]E-mail: R.Sang@griffith.edu.au