Footprints of electron correlation in strong field double ionization of Kr close to sequential ionization regime

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With combination of kinematically complete measurement and semiclassical Monte Carlo simulation we study the correlated electron dynamics in strong field double ionization of Kr from nonsequential double ionization (NSDI) plateau to sequential double ionization (SDI) domain. In the NSDI regime, the measurements on Kr show consistent crossover behavior in comparison with early results on Ar and Xe, reveal the complex competition between the screening effect of inner-shell electrons and the Coulomb focusing of nuclei. In the SDI regime, we find that the electron correlation still gets involved in a subtle way.

Nonsequential double ionization (NSDI) always catches people's great attention because it contains electron correlation in the interaction between laser field and atoms or molecules. The well established recollision model[1] can explain the general feature of NSDI, however, more in-depth studies is needed to achieve a comprehensive understanding of the microscopic dynamics. Significant target dependence of SFDI does exist[2] and the role of the electron correlation in SDI regime is still debatable.

We have performed the differential measurements of SFDI of Kr in a Cold-Target Recoil-Ion-Momentum Spectroscopy (COLTRIM-S) at four typical laser intensities covering NSDI and sequential double ionization (SDI) regime. Figure 1 (A1-A4) shows the correlated electron momentum distributions which strongly depend on intensity. It evolves from a roughly round-shape distribution to an elongated pattern with substantially more population in the first and third quadrants, and this feature survived even for 3.5×10^{14} W/cm^2 which is expected to be in SDI regime. This clearly reveals the electron correlation still exist in the SDI regime.

To understand the experiment observations, we perform numerical simulations with the helium-like model and an improved Green-Sellin-Zachor (GSZ) model including screening effect. We find that the joint momentum spectra with the GSZ model agrees better with experiment at lower intensities, and it is more consistent with the helium-like model for higher intensities. This comparison reveals the competition between the screening effect of inner-shell electrons and the Coulomb focusing of nuclei. Another strong evidence for the existence of electron correlation in SDI regime can be revealed by the sum-energy spectra of two electrons. Our experimental data show good match with the fitting[3] at energies lower than 4Up, but reveal upward long tails deviating the fittings, indicating the high probability of hard recollisions. Only the numerical simulations with GSZ model have reproduced this feature, which can be understood as a result of the fact that the GSZ core has a stronger Coulomb singularity[4] because the effective nuclear charge increases from 2 to Z as the radial position goes from infinity to zero.

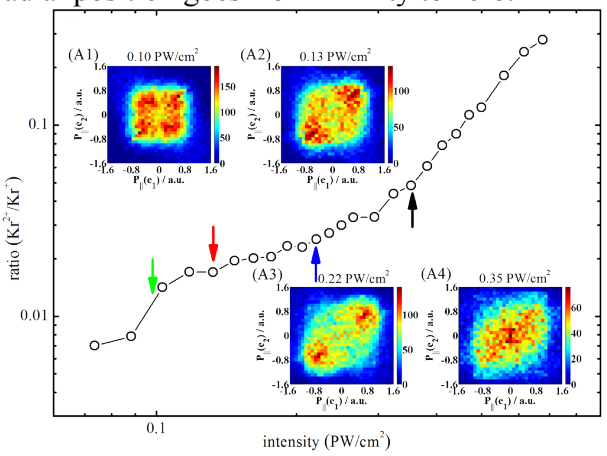

Figure 1. The measured ratio of doubly over singly ionization yield as a function of laser intensity and the correlated electron momentum spectrum.

References

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