Correlation dynamics in double photoionization of excited helium atom by a single ultrashort XUV pulse

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Synopsis We study single- and two-photon double ionization of helium by short XUV pulses by numerically solving the time-dependent Schrödinger equation in full dimensionality within a finite element discrete variable representation scheme. We discuss the joint energy and angular distributions, identify sequential and non-sequential contributions in the double ionization by ultrashort pulse, and track the dynamics of the ionization process in distinct double ionization regimes.

Sequential and non-sequential double ionization of helium atoms has been well studied for decades in electron-momentum resolved spectra [1, 2 and refs. therein]. However with the availability and application of ultrashort subfemtosecond XUV pulses, the distinction of correlated and sequential double ionization has become blurred and requests new approaches and quantitative measures [1].

Solving the time-dependent Schrödinger equation *ab initio* with our recently developed implementation of a fully dimensional finite-element discrete-variable representation scheme [2] for few-photon double ionization of the helium atom, we investigate the single XUV photon double ionization of helium excited states [for example, He($1s2s\,^1S$) and He($1s2p\,^1P$)]. We studied electronic correlation based on joint photoelectron energy distributions and joint angular distributions. Our discussion of angular distributions reveals two different pathways to double ionization: (1) the inner K-shell electron absorbs one photon and knocks out the L-shell electron (This process favors 136° angular difference between emitted photoelectrons) or (2) the L-shell electron absorbs one photon and knocks out the K-shell electron (This process occurs predominantly at an angular difference of 65°).

Figure 1 displays the joint energy distribution of helium single-photon double ionization from the $1s2s\,^1S$ by 78 eV XUV photons. The uneven distribution is different from the single photon double ionization from ground state of helium atoms, even though both initial states have ^1S symmetry.

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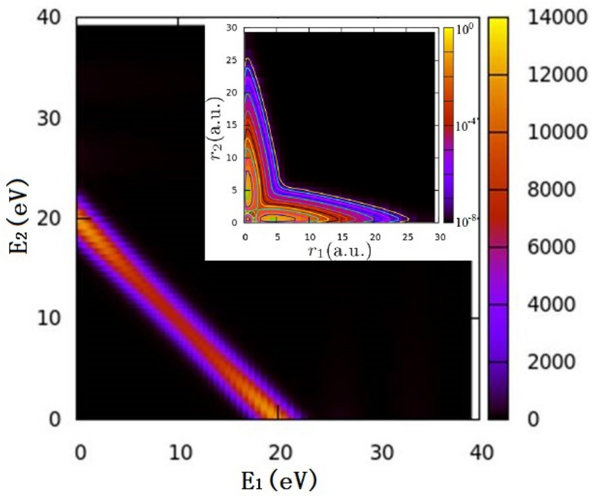

Figure 1. (Color online) Normalized joint photoelectron energies distributions for the double ionization of He($1s2s\,^1S$) by a single 78 eV photon. The XUV pulse has a peak intensity of $5 \times 10^{14} W/cm^2$ and pulse length of 2.12 fs (40 o.c.). The inset shows the undistorted excited initial state. The color bar is in arbitrary units.

References

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