Strong field ionization driven by tailored laser fields

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Synopsis We present a study of the photo-electron spectra for the ionization process driven by counter- and co-rotating circularly polarized fundamental and odd order harmonic fields. Main features of the spectra, such as symmetric lobed structures, are understood using simple arguments based on the strong field approximation (SFA) picture of ionization. A deviation from this picture is, most notably, the presence of the low energy structures (LES) in the spectra. We show that the Rydberg states populated as a result of the combined absorption of the photons from the fundamental and harmonic fields are responsible for the origin of LES.

Strong field ionization process driven by a circularly polarized laser pulse and its second harmonic received recently considerable attention in the literature [1, 2, 3]. A natural generalization of this setup would be a field configuration consisting of the circularly polarized fundamental field and its higher harmonics.

We present a study of the photo-electron spectra for the ionization process driven by counter- and co-rotating circularly polarized fundamental and harmonic fields of odd order q. General features of the photo-electron spectra for such field configurations can be inferred from the simple SFA picture of ionization. SFA predicts that for the co-rotating geometry photo-electron spectrum forms a regular structure with $q+1$ lobes in the polarization plane of the pulse. For the case of the co-rotating circularly polarized fundamental field and its q-th harmonic the photo-electron spectra should exhibit a structure with $q-1$ lobes in the polarization plane of the pulse.

Using the procedure we described in [4], we studied ionization process driven by the circularly polarized fundamental field and its higher harmonics by solving the time-dependent Schrödinger equation (TDSE). An example of the photo-electron spectrum given by the TDSE calculation is shown in the Figure 1. Main difference with the SFA predictions which can be observed is presence of the low energy structures (LES). Of all the field configurations we considered, LES were present only for the case of the ionization driven by the counter-rotating fundamental field and its fifth harmonic. LES were found neither for the co-rotating fundamental field and harmonic fields, nor for the case of the counter-rotating fundamental field and its third harmonic. In the case of the counter-rotating fundamental field and its fifth harmonic, LES were found to disappear if we used screened Coulomb potential in the calculations. It is known that LES can appear in the spectra due to the soft recollision processes [5]. This possiblity is ruled out for the field geometry we consider since in the present case there are no classical returning trajectories. The fact that LES are absent in the case of the Yukawa potential hints that LES in our case might be due to the presence of manifold of the Rydberg states. A detailed study shows that resonant population of the Rydberg states by the process of a combined absorption of the photons from the fundamental and harmonic fields is responsible for the origin of LES.

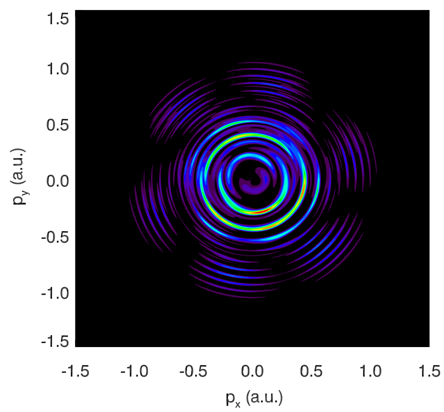

Figure 1. Ionization probability distribution in the polarization plane for the counter-rotating fundamental and fifth harmonic fields.

References

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