Nonlinear Cooper minimum as a precise tool for understanding multiphoton photoionization

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Synopsis A new approach to accurately assess multiphoton ionization is suggested. Vanishing of the dominant ionization channel in nonresonant (direct) multiphoton ionization is predicted for a specific incident photon energy. The exact energy position of such *nonlinear Cooper minimum* can be accurately measured and requires calculations of the complete electronic spectrum. Measurements of various observables at these photon energies are desirable for further evaluation of theoretical calculations at hitherto unreachable accuracy.

The advances and increasing number of free electron lasers (FELs) revolutionized the exploration of inner-shell electron dynamics and nonlinear light-matter interaction by delivering intense extreme-ultraviolet and x-ray beams. However, the accuracy of the extracted cross sections is bound by the systematic uncertainty in the beam parameters which determine the absolute intensity. This causes large experimental uncertainties which in return do not allow to resolve differences between various theoretical approaches [1].

We suggest alternative measurable quantities which promise more accurate comparison of experiment with theory. It is generally expected that the properties of multiphoton ionization are dominantly determined by ionization channel with the highest angular momentum. Here, we show that this rule is broken not only at photon energies matching intermediate electronic resonances, but also at a nonlinear equivalent of Cooper minimum, where the dominant ionization channel drops to zero. We further suggest that measuring observables such as fluorescence polarization, photoelectron or Auger distributions (see Figure 1 for a graphical example) will accurately determine the position of these *nonlinear Cooper minima* and will allow for comparison of experimental measurements with theory at hitherto unreachable precision. Measurements of fluorescence or angular distributions of escaping electrons as a characteristic of multiphoton ionization are well established, and hence, measurements of these properties at the nonlinear Cooper minimum could readily find applications beyond fundamental importance, as it could also serve for applied fields such as spectroscopy of atoms and molecules [2].

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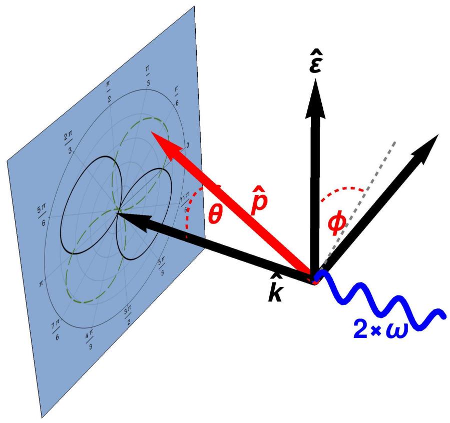

Figure 1. Schematic representation of possible determination of nonlinear Cooper minimum position with the detection of maximum elliptical dichroism in two-photon ionization of He. Photoelectron distribution are detected in dipole plane for incident left- (black) and right-(green) handed elliptically polarized light.

References

[1] Ghimire S *et al* 2016 *Phys. Rev. A* **94** 043418
[2] Hofbrucker J *et al* 2018 *Phys. Rev. Lett.* **121** 053401

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