Coherent control of the photoelectron angular distribution in photoionization of neon

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Synopsis We investigate bichromatic photoionization of neon induced by linearly polarized XUV femtosecond pulses. The fundamental frequency is tuned near an optically allowed transition to create an interference between one-photon and two-photon ionization pathways. The asymmetry in the photoelectron angular distribution is analyzed for a variety of pulse characteristics.

Light-induced coherent control of the photoelectron angular distribution (PAD) in neon was recently achieved using the Free-Electron Laser (FEL) at FERMI [1]. This experimental tour de force promises a rich field of possibilities in the control of matter and has prompted new research in this exciting field. In order to gain a better understanding of these processes, we investigated two-pathway interferences in the ionization of neon induced by the fundamental and second harmonic of a femtosecond XUV pulse, i.e., the $\omega + 2\omega$ process. We consider the cases for which either $(2p^5 3s)^1P_1$ [2] or $(2p^5 4s)^1P_1$ are chosen as intermediate states to enhance the two-photon ionization probability.

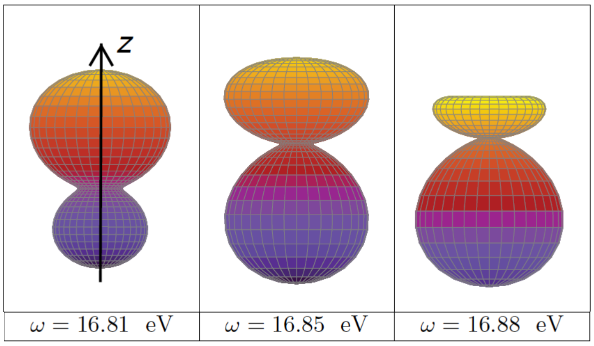

Figure 1. PAD at three fundamental frequencies near the $(2p^5 3s)^1P_1$ resonance for a 250-cycle bichromatic XUV pulse with fundamental peak intensity 10^{12}W/cm^2. The relative intensity of the second harmonic is equal to 1% of the fundamental. The Z-axis represents the direction of light polarization.

Using a time-dependent approach supported by a perturbative formalism, we analyze the effects on the PAD when varying the fundamental frequency (see Fig. 1), the intensity ratio between the harmonics, and the carrier envelope phase. The role of the pulse length, fundamental intensity, and experimental averaging is also discussed in detail. Our results are compared with new experimental data [3]. We also discuss the additional degree of freedom provided by adding an infrared field [4], thereby leading to above-threshold ionization (ATI) processes (Fig. 2). We compare the PADs of the sidebands obtained in time-dependent calculations with those from a model based on the strong-field approximation (SFA) using Coulomb-Volkov wavefunctions.

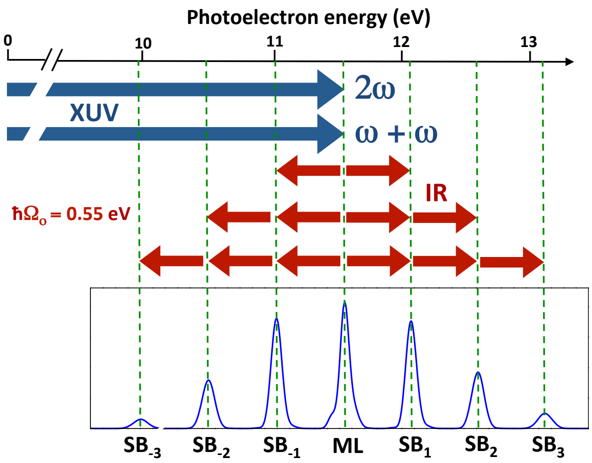

Figure 2. Photoionization scheme and associated spectrum for the $\omega + 2\omega$ process with an additional optical field. The blue arrows indicate XUV photon absorption while the red arrows show the minimum number of photons absorbed or emitted to produce the different sidebands (SBs) around the mainline (ML).

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References

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