Streaked photoelectron spectra from polycrystalline gold

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Synopsis We present streaking traces for polycrystalline gold, generated by single-photon photoelectron emission in attosecond XUV pulses and an assisting non-ionizing time-delayed IR pulse. We analyze the effects of Fresnel reflection of the incident IR pulse and final state approximations on the center of energy and higher moments of the streaking traces.

We model the electronic structure of the metal surface in jellium approximation [1] and represent the final state of the emitted photoelectron as a modified Volkov wavefunction [2, 3] that includes the effects of (i) Fresnel reflection of the IR pulse at the solid-vacuum interface [4], (ii) exponential damping of the final-state probability density inside the solid due to collisions of the photoelectron before being released from the substrate [1], and (iii) the sudden change of the photoelectron's momentum at the metal-vacuum interface. From our numerical simulations we conclude that (iii) is significant for 20 eV and irrelevant for 93 eV XUV photon energies, while (ii) distorts the streaking traces even at the higher XUV photon energy. We assume photoemission in the direction perpendicular to the surface plane. Figure 1 reveals the influence of (i) on the center of energy (COE) of the streaking traces as a combined phase shift and modification of the streaking amplitude.

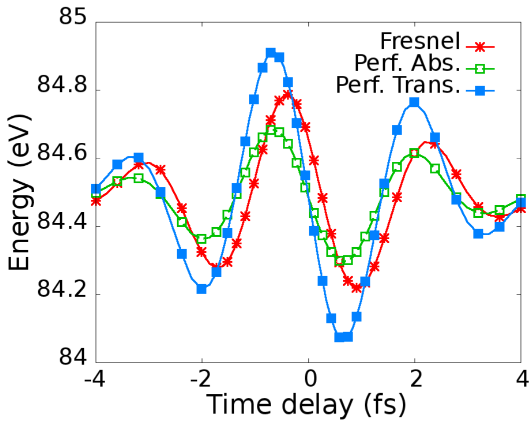

Figure 1. Center of energies for streaking traces from polycrystalline gold for 93 eV XUV photons for three assumptions: Fresnel reflection, complete IR absorption at the surface, and full transmission through the substrate of the incident IR pulse.

The phase shift and amplitude change of the streaking trace for Fresnel reflection as compared to complete absorption of the assisting IR pulse are imposed by the phase shift and amplitude enhancement of the net (incident plus reflected) IR electric field near the surface relative to the incident-IR-pulse electric field. The effects of the local momentum inclusion in the final state on the streaking traces for 20 eV XUV photons can be seen in Fig. 2. The streaking amplitude $\mathbf{k}_{in} \cdot \mathbf{A}_{IR}(z,t)$ [1] is given by the electron momentum $\mathbf{k}_{in}$ and IR vector potential $\mathbf{A}_{IR}(z,t)$. Inside the solid, the vector potential is dampened by Fresnel reflection at the surface. $\mathbf{k}_{in}$, and thus the streaking amplitude, is larger in Fig. 2(a).

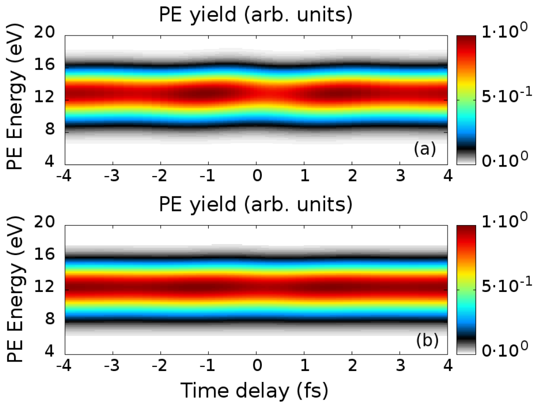

Figure 2. Streaking trace from the polycrystalline Au conduction band (20 states sample), for 20 eV XUV photons, (a) allowing for the fast deceleration of the emitting photoelectron at the surface, $k_{in} = \sqrt{k_{out}^2 + U_0}$, (b) for $k_{in} = k_{out}$. U_0 is the depth of the jellium potential and k_{out} the asymptotic momentum of the photoelectron.

Acknowledgements

We acknowledge the support from NSF grant PHY-146 4417, the A. v. Humboldt foundation, and the Division of Chemical Sciences, Office of the Basic Energy Sciences, Office of Energy Research, US DoE.

References

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