Secondary electron cascade in attosecond photoelectron spectroscopy from metals

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Synopsis In a recent attosecond photoelectron spectroscopy experiment from a metal surface [A. L. Cavalieri *et al.* Nature (London) **449**, 1029 (2007)] a tail of unexplained low-energy electrons was measured. These electrons are shown to be due to electron-electron scatterings as the photoelectrons leave the metal. We develop a model for single scattering and a model based on cascade theory to describe these electrons. Our model explains the observed background, and the amplitude of the measured streaking spectrum.

In spectroscopy from metals, as compared to atoms or molecules, there is a lot of secondary processes that may blur the picture. When an electron is leaving a metal, there is a host of other, lightly bound electrons that the primary electron may scatter from, leading to two electrons with energy below the primary peak. Furthermore, each of these electrons may scatter of other electrons releasing a cascade of lower energy electrons. Here, we present theory for both primary electrons, electrons leaving after exactly one scattering and electrons that come out of the metal as part of a cascade.

Starting from a three step model, we are able to find a simple, closed expression for the amount of electrons that come out as a result of one scattering and for the energy distribution. This is done under the assumption that only the density of states is important in the probability of scattering from one energy, E' and to another E within the metal.

Another model is presented, in which Boltzmann's transport equation is used to describe the propagation of the primary electron to the surface, while scattering with any number of electrons, releasing any number of electrons with lower energy than the primary. This is an extention of earlier work on secondary electrons from electron bombardement of surfaces [1], to the current scenario of very short xuv pulses as the source of the primary electrons. Our theory gives reasonable agreement with the tail of electrons seen in the experiment [2].

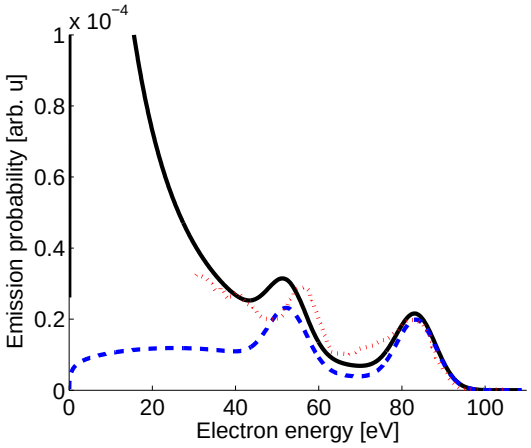

Fig. 1. Photoelectron distribution following a 300 asec pulse with up to one scattering (blue, dashed) and with the cascade theory (Black, full). The experimental results from [2] is shown too (red, dotted)

References

[1] P.A. Wolff, Phys. Rev. **95**, 56 (1954)

[2] A.L. Cavalieri et al., Nature (London) **449**, 1029 (2007).

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