Passive Attosecond Pulses and the Breakdown of the Single Active Electron Approximation

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When one irradiates a system with intense infrared light, an electron can tunnel. Usually, but not always, the hole stays in place. If the hole is static, only one electron is involved, but, in xenon, we create a superposition of states in the ion. Any coherent superposition of states describes a hole wave packet that moves through the atomic core. An imbalance in the superposition also creates a static hole.

Using the perturbed trajectory measurement method we observe the spin-orbit motion in the emitted radiation. Surprisingly, we find that even the very high frequency light (that gains cross section from the 4D giant plasmon resonance) shows spin-orbit wave packet dynamics. The timing is shifted from the timing of radiation where there is no hole motion, but only by a small amount.

The most important observation is that the ion contributes substantially to the photon energy of these 90 eV photons. The ion contribution can even exceed the recollision electron's kinetic energy at the moment of recollision. We will show that the cut-off frequency, and the chirp, depends on the field of the laser as well as the kinetic energy of the recollision electron while the duration of the pulse is fixed to 300 as by spin-orbit dynamics.

The single active electron approximation applied to atoms seemed valid for 30 years but it is severely violated for xenon as it has been, since the beginning, in solids.