Slow, slower, and even slower electrons from strong-field ionization

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Synopsis The underlying mechanisms of the formation of various low-energy structures — namely the low-energy, the very low-energy, and the "zero-energy" structure — in the photo-electron spectrum from atoms and molecules in strong long-wavelength laser pulses are discussed. Our theoretical explanations are backed up by high-resolution measurements.

Slow electrons from strong-field photo-ionization of atoms and molecules has been attracted great interest recently. Starting with the first experimental observations [1] of a so-called low-energy structure (LES) there has been many theoretical (and further experimental) studies.

We have shown numerically and analytically [2] that *soft* recollisions — laser-driven recollisions far away from the atom or molecule — cause a bunching of photo-electron energies through which a series of low-energy peaks emerges in the electron yield along the laser polarization axis. Dedicated experiments with few-cycle pulses [3] confirmed the soft-recollision mechanism as shown in Fig. 1. The universal dependence of the LES-peak energy on the pulse duration emerges from an analytical description as a product of two factors: one contains the influence of the laser parameters and the target, while the other one describes the pulse duration dependence in terms of optical cycles.

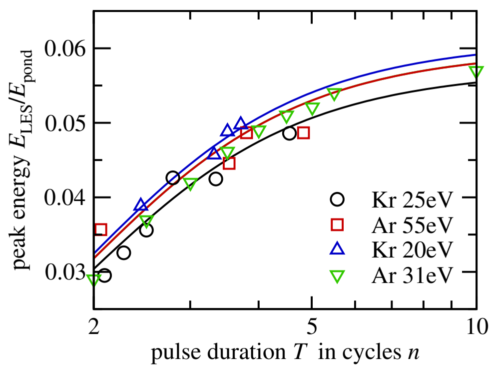

Figure 1. Shifting of the LES peak position with few-cycle laser pulse [3]. Experimental data points (for various atoms and ponderomotive energies) are compared with theoretical lines.

Recent high-resolution photo-electron spectra from strong-field-ionization experiments [4] have shown yet another structure at extremely low energies, which was termed "zero-energy structure" or just ZES. We explain the reason behind this observation [5] and discuss the generic dynamics of electrons in the combined potential of an attractive Coulomb core and a homogenous electric field (Stark geometry). In particular we show that the ZES does *not* appear at zero energy as shown in Fig. 2, which compares the peak position from experiment and theory for various extraction-field strengths.

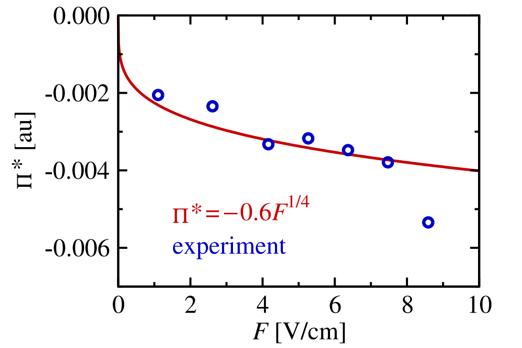

Figure 2. Shifting of the ZES peak position with the extraction field strength F for the photo-ionization of N_2. Note that the pre-factor "−0.6" has been obtained theoretically and is not a fitting factor [5].

Possible quantum effects are addressed by calculating electronic above-threshold resonances for the Stark geometry.

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References

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