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Accessing correlated electron motion on the attosecond timescale

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In the last decade, there have been tremendous advances in the production of coherent ultrashort light pulses as short as 80 attoseconds (1 as = 10^{-18} s). The availability of these pulses has led to the development of the field of attosecond physics, which aims to follow and control electron motion on its natural timescale (1 atomic unit of time is about 24 attoseconds). One of the major goals of attosecond physics is to access correlated electron dynamics. This requires a description of the target system that goes beyond the commonly used single-active-electron approximation. The large bandwidth of ultrashort pulses and many-photon absorption in strong infrared fields make such a description extremely challenging. I will discuss our work on the full numerical solution of the two-electron Schrödinger equation for helium, which already displays rich correlation effects. I will focus on two applications: The first is attosecond streaking, in which temporal information about the photoionization process in an attosecond pulse is mapped into a momentum shift by a synchronized infrared pulse. This promises to give access to the Eisenbud-Wigner-Smith time delay of photoionization. I will discuss the additional effects that are induced by the infrared field, and how these have to be taken into account for attosecond streaking to fulfill its promise. I will then discuss the possibility of accessing two-electron wave packet dynamics in doubly excited states of helium by an attosecond pump-attosecond probe setup. Such experiments have been called the "holy grail" of attosecond physics and should come within reach in the near future. I will discuss our recent proposal of using two-photon absorption from a single pulse as a coherent reference wave, which can be used to increase the experimental signal by almost two orders of magnitude. This provides direct access to time-dependent observables (e.g., the distance between the two electrons) of the two-electron wave packet.