CFEL SCIENCE

SEMINAR

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Attosecond dynamics in high-field controlled atoms

Attosecond physics has developed tools that allow the real time observation of electron dynamics and correlations in atoms, molecules and solids. However, a major goal of attosecond science goes beyond the simple observation of freely evolving systems: a great challenge will be the direct coherent control of attosecond processes by lasers. A requirement for the steering of electron dynamics at the attosecond timescale is the use of strong-field laser pulses that compete in electric field strength with the inner atomic binding forces. The process of strong field ionization is of fundamental importance in this regard. Precision measurements using the attoclock technique give insight into the timing of this process, about the geometry (i.e. where does the electron appear in the continuum), and the electron wavepacket spread in the continuum. Furthermore, attoclock measurements of strong field double ionization using elliptical laser polarization reveal unexpected ionization times and correlations (Fig. 1).

A strong-field laser pulse can also be used to engineer optical properties of gas-phase matter. If a strong femtosecond pulse is used to control the transmission of an isolated attosecond extreme ultraviolet pulse, then basic assumptions of traditional quantum optics break down. The rotating wave approximation becomes invalid, and the sub-cycle timing of the attosecond pulse within the optical cycle of the control pulse influences the transmission dramatically. The speed of the population transfer can be driven into the attosecond domain where the Rabi frequency exceeds the frequency of the strong control field, causing the transmitted radiation to be modulated over a wide frequency spectrum]. This effect is observed in a transient absorption experiment with Xenon atoms and can be explained in the framework of a few-level quantum model.

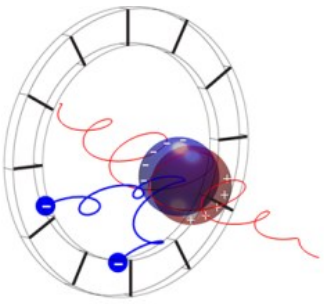

Fig. 1: The emission direction of the photoelectrons (blue) in streaking with an elliptically polarized laser pulse (red) is synchronized to the rotating electric field vector. This gives a mapping of time to angle similar to the hands of a clock.
The electric field of the laser pulse induces a dipole in the atom, which affects the exit of the tunnel and the trajectory of the electrons.

Host: Franz X. Kärtner, CFEL UX Seminar