PHYSIKALISCHES KOLLOQUIUM

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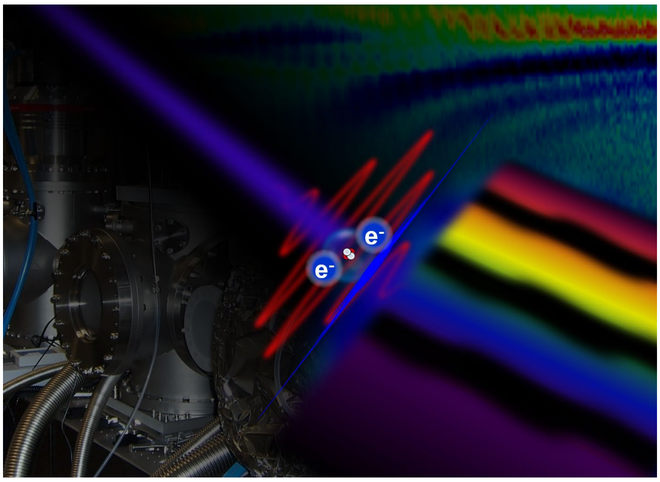
IM GROßEN HÖRSAAL



FROM ULTRAFAST LIGHT-MATTER INTERACTION TO TEACHING ELECTRONS HOW TO COMPUTE IN A (LASER) FLASH

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Light-Matter interaction has taught us many lessons of fundamental physics. To list only a few examples: Ray optics with lenses and telescopes, wave optics in diffraction experiments, discrete atomic energy levels and the photoelectric effect leading to the discovery of quantum mechanics, all the way to the laser principle itself along with its many applications, among them quantum optics in science and technology. The recent Nobel Prize in Physics honored the exploration of light-matter interactions at attosecond time scales, opening a portal to explore electrons in motion within atoms and molecules.
Here, I will give an overview of some of our recent experiments aiming at new routes opening up for the exploration, understanding, and control of electronic processes at ultrafast time scales. Employing intense short laser flashes/pulses of light, the fundamental properties of atomic and molecular states can be strongly modified and returned to their natural conditions within a few femtoseconds. These changes can be read out by spectroscopy, similar to Fraunhofer's approach of observing dark lines characteristic to specific atoms in the solar spectrum. Our approach builds on this principle and goes beyond in the analysis of the shape of time-dependent spectral structures, thus gaining access to the full quantum information, amplitude and phase, of dynamical modifications of atoms and molecules.
In recent experiments, we also demonstrated and studied the ultrafast preparation, coincidence measurement, and control of entangled states of electrons in hydrogen molecules by a combination of attosecond extreme-ultraviolet (XUV) and femtosecond near-infrared (NIR) laser pulses in a reaction microscope (ReMi) apparatus.
These experiments point towards potential future applications: An ultrafast quantum computer based on atomic or molecular states, programmable by intense fields of light. While not directly compatible with traditional quantum gates and operations, such a quantum computer could be used for machine-learning tasks and boost their speed by several orders of magnitude. Simulation results of a proof-of-principle idea will also be presented and discussed.