

PhD THESIS DEFENSE: Laser-induced electron interferences from atoms and molecules

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Since discovering wave-particle duality, science has changed our perception of light and matter, especially at the subatomic level. Thanks to such discoveries, we have been able to develop and expand our scientific knowledge over the past two centuries, crossing those limits. For instance, let us take the famous double-slit experiment from T. Young (1801). This experiment has been extended after the twentieth-century quantum revolution, revealing electron and neutron diffraction used nowadays to measure the nuclei separation from complex structures. Similarly, the experiment of Michelson and Morley (1887), which follows T. Young foundations, got a fair success in astronomy, enabling high-resolution imaging of stars in the universe. In this thesis, we use light to generate electrons and produce interferences similar to the double-slit experiment, which is analyzed further to study the

atomic properties.
On the dynamics of an atom, that is, attoscience, we use ultrafast laser pulses to trigger motions on a femtoseconds time-scale.
Together with the use of strong intense laser fields in the Mid-IR regime, the electron is ionized with zero-kinetic energy and subsequently accelerated by the laser ponderomotive energy.
Strong field dynamics offer rich structures that are encoded in the photoelectron momentum distribution. Since we use two-color combined laser fields, we can gate and control those dynamics further down on the sub-cycle scale. More precisely, we show that with the help of a Reaction Microscope, we can extract both electron information and nuclear dynamics within extraordinary sub-cycle temporal resolution.
Finally, the strong-field recollision model is investigated with molecules through the previously developed laser-induced electron diffraction (LIED) method. We show that backscattered electron interferences, issued from strong field at low impact parameters, embedded a particular molecular orientation that can be reproduced when the molecule is considered aligned with the laser field polarization. Those findings seem to encode a more profound property about wave diffraction in molecules until recently unexplored due to the imposed conditions given in conventional electron diffraction (CED).

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