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EXPLORING QUANTUM EFFECTS IN THE ATTOSECOND DOMAIN

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Abstract. Matter in strong laser fields poses many challenges, theoretically and experimentally. Not only are the field strengths comparable to the target's binding forces, but the attosecond (10^{-18}s) timescales involved are some of the shortest in nature. Although classical methods are hugely popular, the phenomena themselves seem to be inherently quantum. Here, I will exemplify my group's work on quantum effects in attoscience.

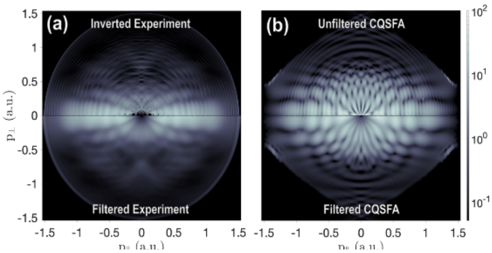

Figure 1: a) experimental and (b) theoretical photoelectron momentum distributions for argon, in a field of intensity of 2×10^{14}W/cm^2 and wavelength λ = 800 nm; from Werby et al 2021.

First, an orbit-based, UCL-developed approach that fully accounts for the laser field and the binding potentials, the Coulomb-Quantum Orbit Strong-Field Approximation (CQSFA) will be applied to ultrafast photoelectron holography. The CQSFA's huge predictive power allows to trace a myriad of holographic structures to specific types of quantum interference (Maxwell 2017, Maxwell 2020), assess the applicability range of standard theories (Rook 2024), revisit kinematic constraints using catastrophe theory (Rook 2024b), and explore applications with experimental groups (Kang 2020, Werby 2021,Werby 2022). Subsequently, I will discuss quantum interference in laser-induced nonsequential double ionization (NSDI). We have challenged the long-standing view that NSDI is classical by showing that quantum interference may survive focal averaging and integration over several degrees of freedom (Maxwell 2016), derived analytic interference conditions for NSDI in arbitrary fields and identified their building blocks (Hashim 2024).

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