Coherence and Entanglement in the Attosecond Domain

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Project Summary:

The project involves extending the UCL developed Coulomb Quantum Orbit Strong-Field Approximation (CQSFA) to compound systems, such as correlated multielectron systems, for which the core dynamics are importance, and seeking ways to characterize coherence and entanglement in this context. Possible observables are photoelectron spectra, stemming from ultrafast holography (C Faria, AS Maxwell, Rep. Prog. Phys. 83 (3), 034401 (2020)), and correlated electron-electron distributions (A. S. Maxwell and C. Faria, Phys. Rev. Lett. 116, 143001 (2016)). A key obstacle towards the realization of quantum technology schemes is decoherence caused by noise, additional degrees of freedom and/or thermal fluctuations. This may be avoided if the decoherence timescales are much longer than those of the system. Attoscience studies extremely short timescales (10^{-18}s), for which usual decoherence mechanisms may not develop. Therefore, it may lead to novel quantum technologies, such as extremely precise quantum sensing devices. Furthermore, pump-probe schemes, using attosecond pulses, explore coherent superpositions of bound states and quantum-phase relations. For simple diatomic molecules, ion-electron entanglement causes decoherence, and this entanglement can be controlled using time-delayed attosecond pulses (Vrakking, Phys. Rev. Lett. 126, 113203 (2021)). Possible attosecond decoherence mechanisms were discussed by Professor Faria's team within ponderomotive quantum sensing (Maxwell, et al, Phys. Rev. A 103, 043519 (2021)). T

he proposed project will seek to identify, quantify and control entanglement and coherence using sculped fields and appropriate compound systems. We also intend to seek and propose witnesses to for that purpose. A key question is how to model the environment in a highly transient, out-of-equilibrium regime. The semi-analytic or hybrid theory developed by us will be tested against ab-initio methods developed by Professor Hugo van der Hart and Dr Andrew Brown at Queen’s University Belfast. Throughout, we will seek advice from quantum technology experts at UCL and elsewhere.