# Attosecond spectroscopy of decoherence in liquid phase water

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## ABSTRACT

The dynamics of electron scattering in liquid water is central to a variety of fields, both in fundamental and applied science, including ultrafast chemistry and radiolysis [1]. At present, the comparison between the Photoelectron Angular Distribution (PAD) recorded in gas and liquid phase represents the experimental method of choice to characterize elastic and inelastic mean free paths in water [2]. Their values reported in the literature are consistently below 10 nm for photoelectrons with energies under 100 eV. These distances correspond to mean scattering times below few femtoseconds and thus attosecond spectroscopy should offer a complementary approach to the characterization of electron scattering in liquid water.

In this work, we performed Reconstruction of Attosecond Beating By Interference of two-photon Transitions (RABBIT) [3] on gas and liquid phase water over a broad kinetic energy range between 30 and 60 eV, exploiting the FAB1 laser of the ATTOLab platform [4]. RABBIT consists of an atomic scale electron interferometer realized through two-photon transitions induced by an IR dressing field overlapped with an XUV Attosecond Pulse Train (APT). It results in a photoelectron spectrum that exhibits a cosine modulation as a function of the delay between the APT and the IR. The phase of these oscillations usually encodes photoemission scattering dynamics while their contrast assumedly encodes the coherence of the Electron WavePacket (EWP). In the experiment, we measured a reduction in the oscillations contrast for liquid water compared to the gas phase. Various sources of decoherence were evaluated via control experiments and simulations. As a result, we were able to recognize elastic scattering of photoelectrons in the liquid environment as the dominant process leading to the observed contrast reduction. Moreover, we developed a stochastic model of RABBIT spectroscopy in liquids to interpret our findings and relate them to electron mean free paths and scattering phases.

This work represents, to the best of our knowledge, the first application of RABBIT spectroscopy to the study of electron scattering dynamics in liquids. Our results show that the EWP decoherence can be used as a novel observable to benchmark mean free paths reported in the literature and to measure the scattering phases of photoelectrons.

## REFERENCES

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