Theoretical description of laser-dressed photoionisation for the quantum tomography of electron wavepackets

G. Granveau[1], M. Berkane[2], J. Im[1,3], P. Salières[3], J. Caillat[2] and C. Bourassin-Bouchet[1]
[1] *Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Laboratoire Charles Fabry, 91127 Palaiseau, France*
[2] *Sorbonne Université, CNRS, Laboratoire de Chimie Physique-Matière et Rayonnement, 75005 Paris, France*
[3] *Université Paris-Saclay, CEA, CNRS, LIDYL, 91191 Gif-Sur-Yvette, France*
gabriel.granveau@institutoptique.fr

We rewrite laser-dressed photoionisation using the formalism of Quantum Information Theory, allowing the use of already existing tools to describe photoelectron density matrices.

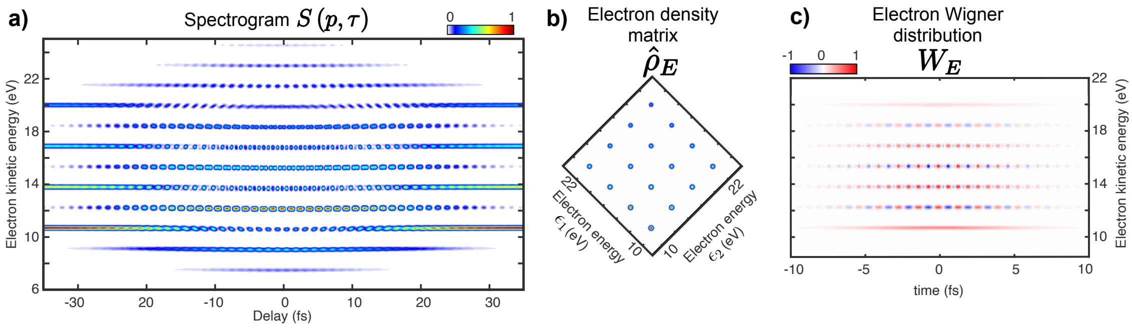

Figure 1: a) Spectrogram, b) density matrix and c) Wigner distribution of the electron wavepacket

The probability $S(p,\tau)$ of measuring an electron with a given momentum p during laser-dressed photoionisation with laser-XUV delay τ, that is the so-called spectrogram, is often described using the Strong Field Approximation (SFA) [1]. We show that it can be rewritten as a Positive Operator-Valued Measure (POVM) of the electronic density matrix $\hat{\rho}_E$, where the set of quantum operators $\hat{M}_{p,\tau}$ contains the influence of the dressing laser pulse, or equivalently as an overlap of two Wigner functions [2].

$$S(p,\tau) = Tr(\hat{\rho}_E \hat{M}_{p,\tau}) = \int\int d\Omega\, dt\, W_E(\Omega,t) W_{p,\tau}(\Omega,t) \tag{1}$$

Using the tools developed in Quantum Information Theory [3], we then identify which experimental conditions are required to perform a quantum tomography of photoelectron with guaranteed high fidelity. This paves the way to the study of electron-ion entanglement with laser-dressed photoionisation.

References

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