Temporal Characterisation of Attosecond Pulse Train for Simulated Surface High Harmonics Generation

Lu Li¹*, Mark Yeung¹, Steven Cousens¹, Matt Zepl¹,², Brendan Dromey¹
¹CPP, School of Mathematics and Physics, Queen’s University Belfast, Belfast BT7 1NN, UK
²Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany
*Email: lu.li@qub.ac.uk

To date, the high harmonics generation (HHG) has provided a promising route to generate coherent extreme ultraviolet (XUV) radiation with attosecond pulse duration [1]. With the fact of the multi-cycle driving pulse and discreet XUV spectrum, the attosecond pulses normally are consisting of a train of individual attosecond pulses (APT). In order to characterize the APT profile, many measurements have been carried out by means of photoelectron spectroscopy requiring high flux and shot-to-shot stability, which is not promised by most HHG sources. Therefore, it is worth to consider a method with single-shot fully-optical setup method.

Moreover, for the surface HHG (SHHG) source, the only temporal measurements [2] have been performed so far are based on the photon-electron spectroscopy. In this study, we propose two fully-optical-setup and single-shot measurable approaches for the APT from the SHHG source: APT-SPIDER (spectral phase interferometry for direct electric field reconstruction [3]) and APT-SEA-SPIDER (spatially encoded arrangement SPIDER [4]). The APT-SPIDER apparatus is the traditional SPIDER coupled with 1D-EPOCH PIC code. In this case, different initial driving pulse durations (5 fs-20 fs) in the SHHG modeling were manipulated. The reconstructed APT temporal profiles are in excellent agreement with the Fourier limited APT for the selected spectral bandwidth. In the APT-SEA-SPIDER mechanism, the interferogram is generated spatially in the far-field (2D-EPOCH). The accurate temporal reconstruction of this method gives promise to a more flexible experiment design with respect to the APT-SPIDER. Reconstruction accuracy of both methods haven been discussed with various parameters, such as time delay, spectral shear, spatial shear and ac filter (alternating current term). Moreover, full experiment design for both characterisation methods are proposed separately with the respective requirements for the spectrometer resolution.