LASERLAB-EUROPE

The Integrated Initiative of European Laser Research Infrastructures III

Grant Agreement number: 284464

Work package 32 – Innovative radiation sources at the extremes (INREX)

Deliverable D32.5

Report on high photon energy attosecond pulses using plasmonic structures

Lead Beneficiary: 8 ICFO

Due date: M42

Date of delivery: M42

Project webpage: www.laserlab-europe.eu

Deliverable Nature	
R = Report, P = Prototype, D = Demonstrator, O = Other	R
Dissemination Level	
PU = Public PP = Restricted to other programme participants (incl. the Commission Services) RE = Restricted to a group specified by the consortium (incl. the Commission Services) CO = Confidential, only for members of the consortium (incl. the Commission Services)	PU

1 Work performed / results / description

D32.5: Report on high photon energy attosecond pulses using plasmonic structures.

CLPU in collaboration with ICFO, MPQ and Imperial College performed theoretical calculations focused on new routes in high-order harmonic generation, such as using nanotips as active non-linear media [1,2]. Also the HHG emission at high intensity regime beyond the saturation limit of atoms was studied [3]. LOA has contributed on the experimental side with a kHz repetition rate beamline dedicated to the production of intense attosecond pulses from relativistic plasma mirrors. This beamline is now operational and has enabled the first pump-probe experiments aiming at optimizing the high-harmonic yield in the relativistic regime via control of the surface plasma density gradient using fast electron emission as an in-situ diagnostic [4]. ICFO has developed a kHz high photon energy beamline and demonstrated first X-ray absorption measurements of a thin foil as precursor to nano patterned surfaces [5,6]. Implementation of photonic streaking, allowed placing an upper limit to the pulse duration which is 355 as and signifies the first isolated attosecond soft X-ray pulse measured [7]. While the precious parameters were achieved with a sub-2-cycle 2 micron system, a low energy, the mid-IR 3 micron source at ICFO was used to elucidate the possibility of field ionization and plasmonic enhancement from a gold film via evanescent coupling. It was shown that ponderomotive scaling to 3 micron permits transition from multiphoton to tunneling at a much lower peak intensity and emission of electrons to several hundred eV was demonstrated [8]. In collaboration with the Stanford PULSE Institute, CEA-SLIC started investigating high order harmonic generation from bulk crystals assisted by resonnant plasmonic effects (grating-like structure). In ZnO crystal, a clear effect of the plasmonic field enhancement was evidenced when studying the polarization direction dependency of the harmonic emission (low harmonics). The work is currently under progress, with the objective of reaching shorter wavelengths.

2 Conclusions

D32.5 addressed the possibility of using nanostructures to shape and influence strong field recollision and its subsequent electron or photon emission. Naturally, theoretical tools were developed and employed to describe high harmonic generation and above threshold ionization effects based on strong field approximation models but also ab-initio and in combination with finite element models. Experiments were successfully conducted at low intensities in plasmonic structures to investigate the accuracy of theoretical models, and at high intensities in plasmas and gases at higher pressures.

3 References

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4 Publications

(Publications resulting from the JRA need to indicate DOI and whether open access will be/is granted (yes/no). Remember the obligation to acknowledge EC support through Laserlab-Europe, EC-GA 284464)

[1] Coherent XUV generation driven by sharp metal tips photoemission. Marcelo Ciappina, Jose Antonio Pérez-Hernández, T. Shaaran, M. Lewenstein, Eur. Phys. J. D **68** 172 (2014). http://dx.doi.org/10.1140/epjd/e2014-50060-4

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