MAP-fis Essay Proposal, 2016-2017

(*please write in English*)

Supervisor

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Title

Plasmonics with CEP stabilized ultrashort laser pulses

Area

(*Materials, Optics, Condensed Matter Theory, High Energy Theory, ...*);

Ultrafast Optics and Photonics; Nanotechnology

Summary of Proposal

The collective oscillations of conduction electrons (plasmon excitations) strongly influence the optical properties of metal nanostructures. Such systems are highly promising for novel photonic devices and applications, from sensing to optical information processing and energy harvesting, which should have a very strong impact in science, technology and society. When a light field impinges on a metallic nanostructure, the transmitted field carries information about different properties of the excited plasmons, including their resonances and decay times. Linear techniques, such as spectral interferometry, have been used to reconstruct the transmitted field in linear arrays of grooves in gold and deduce the lifetime of the excited plasmons [1]. In principle, any temporal diagnostic for ultrashort laser pulses could be used for this purpose. The dispersion scan (d-scan) technique, developed in the group of H. Crespo [2, 3] in collaboration with Lund University in Sweden, is very well adapted to the measurement of broadband laser pulses, and its unique reliability and performance could provide new insight on the behavior of plasmons.

In few-cycle ultrashort laser pulses, the so-called carrier envelope phase (CEP), which is the phase between he actual maximum peak of the electromagnetic field and the peak of the envelope, plays an important role in the interaction with matter. It has been demonstrated that the CEP may affect some properties of the nanostructure, in particular its electron photoemission [4, 5]. The influence of the CEP on the optical properties of nanostructures is a yet unexplored field of great interest, and the skills developed in our group in CEP control [6] should enable important contributions to the field of plasmonics.

On the one hand, the student will apply the d-scan technique to measure the field transmitted by metallic nanostructures and will compare the results with those obtained with standard techniques

such as spectral interferometry. From both techniques, the properties of the excited plasmons, such as resonances and lifetimes, will be deduced. On the other hand, the student will study the effect of CEP-stabilized laser pulses on the plasmonic excitations by using the d-scan technique and spectral interferometry. This information will help design new nanostructures with tailored and enhanced properties, suited for particular photonic applications of relevance.

The experimental work will be mostly performed at the University of Porto (femtolab laboratory, within FCUP and IFIMUP-IN). The metallic nanostructures will be supplied by the group of R. Weigand, within the scope of an ongoing collaboration with Porto through Grant FIS2013-41709-P (Nanophotonics with sub-two-cycle femtosecond laser pulses) from MINECO, Spain.

(*continue if necessary*)

References

(*to allow students a first look at the topic*)

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[3] M. Miranda, C. L. Arnold, T. Fordell, F. Silva, B. Alonso, R. Weigand, A. L’Huillier, and H. Crespo, "Characterization of broadband few-cycle laser pulses with the d-scan technique," Opt. Express 20, 18732-18743 (2012).

[4] E. Irvine, P. Dombi, Gy. Farkas, and A.Y. Elezzabi. “Influence of the Carrier-Envelope Phase of Few-Cycle Pulses on Ponderomotive Surface-Plasmon Electron Acceleration”. Phys. Rev. Lett. 97, 146801 (2006).

[5] B. Piglosiewicz, S. Schmidt, D. J. Park, J. Vogelsang, P. Groß, C. Manzoni, P. Farinello, G. Cerullo and Ch. Lienau. “Carrier-envelope phase effects on the strong-field photoemission of electrons from metallic nanostructures”. Nat. Photon. 8, 37-42 (2014).

[6] F. Silva, M. Miranda, B. Alonso, J. Rauschenberger, V. Pervak, and H. Crespo, “Simultaneous compression, characterization and phase stabilization of GW-level 1.4 cycle VIS-NIR femtosecond pulses using a single dispersion-scan setup,” Opt. Express 22, 10181-10191 (2014).