EUROPHOTONICS-POESII MASTER COURSE

PROPOSAL FOR A MASTER THESIS

Dates: April 1st, 2016 – September 30th, 2016

Laboratory: Attoscience and Ultrafast Optics
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: Development of enhanced apparatus for laser-induced electron diffraction

Name of the tutor of the master thesis: Dr. Michael Pullen (co-tutor Prof. Jens Biegert)
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Summary of the subject (maximum 1 page):
The Attoscience and Ultrafast Optics (AUO) laboratory of Prof. Dr. Jens Biegert is looking for an enthusiastic masters student who wishes to advance their career in the promising and rapidly advancing field of laser-induced electron diffraction (LIED). The position will be to greatly improve an already functioning LIED experimental apparatus so that new and exciting experiments will be possible.

Imaging of many types of matter is an extremely important research topic with applications in all sciences. Knowledge of somethings function requires a detailed understanding of how its internal structure changes with time. Imaging the dynamics of fundamental systems such as a molecule requires spatial and temporal resolutions on the sub-Angström and femtosecond scales. Traditional techniques such as conventional electron diffraction and X-ray diffraction are able to extract detailed spatial information yet are temporally limited. Up until now, no measurement method is able to achieve the required spatial and temporal resolutions simultaneously. LIED is an exciting new technique that promises to address this limitation by ionising the molecular sample with a mid-IR laser and then using the ionised electron wavepacket to re-scatter (diffract) off of its parent ion. Structural information can then be extracted from the resultant diffraction pattern using the concepts of the quantitative re-scattering (QRS) theory and conventional electron diffraction. This method is extremely promising as recent results have shown that LIED can be applied to polyatomic molecules [1].

The AUO group has developed a state of the art optical parametric chirped pulse amplification (OPCPA) laser system that provides intense laser pulses at a centre wavelength

of 3.1 μm at a repetition rate of 160 kHz. This is the ideal laser system for LIED experiments as the long wavelength causes the electron to experience large momentum transfers during diffraction and the high repetition rate ensures a high data collection rate. Combined with the laser system is a reaction microscope that collects all particles created during the interaction so that a complete picture of the process can be obtained. Future experiments on more complex and exciting molecules will require significant modifications to be made to this experimental apparatus. It will be the applicants job to 1) determine what modifications will be required, and 2) implement and test these changes.

The applicant will be under the direct supervision of Prof. Dr. Jens Biegert and Dr. Michael Pullen and will be involved in the ongoing experimental endeavours to improve and test the LIED experimental apparatus. They should be hard working and have good communication skills as the research will be performed in an open team environment. Preferably they will have a physics degree with experience utilising vacuum apparatuses and programming in at least one language.

[1] Pullen *et al.* Nat. Commun. **6**, 7262 (2014).

Keywords: Laser-induced electron diffraction, ultrashort lasers, atomic and molecular imaging, molecular structure determination, OPCPA, reaction microscope, COLTRIMS, vacuum

Additional information:
* Required skills : physics undergraduate degree, laser and vacuum experience preferable, programming experience, good communication skills
* Miscellaneous :