Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

Scientific report (one single document in WORD or PDF file) should be submitted online within one month of the event. It should not exceed eight A4 pages.

***Proposal Title**:* Attosecond pulse generation using sub-4-fs pulses

Application Reference N°: 5778

1) Purpose of the visit

The purpose of the short-visit is to make a joint experiment between the Porto and Salamanca optics groups in the Porto laboratory.

Porto laser laboratory counts with a laser source with the capability to achieve pulses with a duration, measured at full width half maximum, under 4 femtoseconds. This regime is the so-called few cycle regime. In this regime, the slow variable envelope approximation is not valid and the carrier envelope phase (CEP) of the pulse plays a fundamental role in nonlinear processes.

On the other hand, in the laser laboratory from Salamanca, it is available an XUV spectrometer. This spectrometer is specifically designed to measure high order harmonics. In particular, it can be used with the XUV radiation obtained in the Porto lab. In addition, Salamanca group counts with an HHG chamber and has experimental knowledge of the field and experience working with HHG in the laboratory.

The purpose is to use the HHG spectrometer and the experience of the Salamanca group together with the few cycle source provided by the Porto group. This experiment allow us to achieve a regime where the XUV radiation has a high dependence on the CEP of the generating pulse. The objective is measure this dependence. Besides this measuring, we will also work in extract information of the structure of the pulses from the CEP dependence, as well as from its relation to the phase matching of the high order harmonics.

2) Description of the work carried out during the visit

Week 1.- The first week was dedicated to the installation and first running proofs of the HHG spectrometer from Salamanca in Porto laboratory. The transfer of the system was critical and some checks of correct working are needed after arriving to Porto laboratory. We observed that everything worked properly and the more sensitive parts were not damaged in the move.

Once the spectrometer is installed, it has to be aligned correctly. This step can be done using a Helium-Neon laser. The spectrometer has to be placed in a position where the grazing-angle grating refracts the beam towards the multi-channel plate where the XUV will be measured. After that, the system can be pumped in order to achieve a pressure that allows us to obtain the HHG signal. However, as the inner parts of the system have been manipulated, this step take some time.

Finally, the infrared laser can be sent to the HHG system. If it is aligned properly, and every parameter in the generation of the high order harmonics, as gas backing pressure or gas-jet open time, is fixed at its correct value, we can observe the grating zero-order signal in the MCP of the spectrometer, which means that the XUV radiation is been generated. After a fine adjustment, this signal can be high enough to allow us to observe the separate high order harmonics in the first order of the grating. This was the objective of the first week.

Week 2.- Once the system is working properly, a week is enough time to obtain the required results. The generation of high order harmonics is a highly nonlinear process, and the CEP of the infrared pulse is therefore a critical parameter when we are working with few-cycle laser pulses. For this reason, the first step is to study the dependence of the XUV spectrum on the CEP. Thanks to the Porto system, the CEP can be controlled easily and we observed that it affects to the generation.

After prove that the CEP can be controlled, we made a preliminary study on the relative position between the focus of the infrared pulse and the gas jet. In the HHG process the phase matching of the harmonics can lead to a enhancement or depletion of the signal, so the focus position is the key for achieving a correct measure. Furthermore, in the few-cycle regime, a correct phase matching is needed for a better measuring of the CEP dependence.

Finally, once the phase matching is optimized and the CEP controlled, we perform a systematic study of the HHG for different conditions of CEP and phase matching. The results prove that the XUV signal has the expected dependence on the CEP and the infrared pulse focus was correctly placed in the propagation coordinate.

When the experiment was done and the results were preliminary analysed, all the equipment from Salamanca was packed and prepared to move back to Salamanca laboratory.

Scheme of the visit:

1.- Installation of the HHG system.
2.- Alignment of the HHG system.
3.-Vacuum proofs and final achieve of the final vacuum value.
4.- First zero-order signal in the HHG spectrometer.
5.- First high order harmonics signal obtained in the spectrometer.
6.- Study of the dependence on the CEP of the infrared pulse.
7.- Study of the dependence on the relative position between the focus of the infrared pulse and the position of the gas jet.
8.- Measure of the HHG signal while the CEP of the infrared is varied.
9.- Analysis of the measures obtained and removal of the HHG spectrometer from the Porto laboratory.
10.- Move of the HHG spectrometer back to Salamanca laboratory.

3) Description of the main results obtained

This experimental period has been very fruitful. The planned objective, which was observe the HHG dependence on the CEP of the infrared pulse, was achieved. Below the most important scientific results are listed:

1.- We have obtained HHG signal with a few-cycle infrared laser pulse. The generation of high order harmonics with a pulse as short as 3 fs is on the forefront of the ultrashort science.
2.- It has been observed the dependence of the XUV spectrum on the CEP.
3.- Differente phase matching conditions in the HHG have been tested.
4.- We have measured this effects and obtained valuable results of the HHG in this regime.

4) Future collaboration with host institution (if applicable)

Up to now, many results have been obtained from the Salamanca and Porto optics group collaboration, as "Characterization of sub-two-cycle pulses from a hollow-core fiber compressor in the spatiotemporal and spatio-spectral domains" (Appl. Phys. B, accepted (2013)), by Benjamín Alonso et al, or "Characterization of broadband few-cycle laser pulses with the d-scan technique" (Opt. Express 20, 18732-18743 (2012)) by Miguel Miranda et al.

In order to reinforce our collaboration, we proposed this short visit, which has ended with promising results.

In the future, we expected to continue this good collaboration by making short visits or publishing joint papers. Furthermore, Salamanca is planning to perform researching in the few-cycle regime, since a new ultrashort laboratory is under developing. We will apply the experience of this short-visit to the experiments that will take place in that laboratory, and, as Porto group has a huge kwnoledge of this field, joint experiments will take place in that laboratory.

5) Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)*

W. Holgado et al. "Study of the dependence on the CEP of the infrared pulse in high-order harmonic generation" (2013) (in preparation)

6) Other comments (if any)

This short-visit has been a great opportunity of integrate two very complex systems and, thanks to the experience of each group, achieve a vanguard regime which won't be possible without the collaboration.