Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

The scientific report (WORD or PDF file – maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

Proposal Title: Characterization and optimization of a new ultra-broadband high-energy light source for attosecond science using the dispersion-scan technique

Application Reference N°: 6430

1) Purpose of the visit

The purpose of the visit was to perform the temporal characterization of the very short high-energy pulses produced at the Laboratoire d'Optique Appliquée (LOA), ENSTA – CNRS – École Polytechnique, France, in the group of Rodrigo Lopez-Martens. In order to achieve this objective, the new technique of dispersion scan (d-scan), developed jointly between the University of Porto and Lund University, was employed.

2) Description of the work carried out during the visit

The visit provided a unique combination of specialized know-how and state-of-the-art equipment from both institutions (Porto and LOA). The sofisticated laser system developed at LOA has unique characteristics in terms of energy and pulse duration. The compressed pulse duration had proved impossible to measure with traditional systems such as FROG or SPIDER. The challenge was to perform this measurment using d-scan.

The work consisted in installing the d-scan in the LOA laser system. To carry out the work we had to bring optical components and mounts specially designed to fully integrate the d-scan in the host institution system.

Day 1: Fist day was dedicated to unpacking and installing the components that were brought from Porto. We also had a meeting to coordinate the team and distribute tasks among the researchers.

Day 2: Measurements were started in the lab using different parameters of the laser system. We frist tried the d-scan configuration with a parabolic mirror with large focal length and a BBO crystal with 10um thickness. The crystal was limiting the bandwitdh of the second harmonic signal necessary to fully retrieve the pulse profile. The laser system was stable and we could do relevant measurements to further improve the d-scan setup. Also, we verified that the beam intensity on the nonlinear crystal was still too high (note that in this work it is important to focus the whole beam profile in the crystal due to the intrinsic radially symmetric spatial chirp in the output beam from the hollow fiber).

Day 3: A different configuration using mirrors with a larger spot targeting the nonlinear crystal was used. In order to improve the measurements the 10 um thick crystal was replaced by a 5 um crystal. In this day of the campaign the laser system was in the best conditions and systematic measurements varying spectral phase before the hollow fiber using a Dazzler system and measure the output pulse profile were performed, with the goal of attaining the shortest possible pulse in the end.

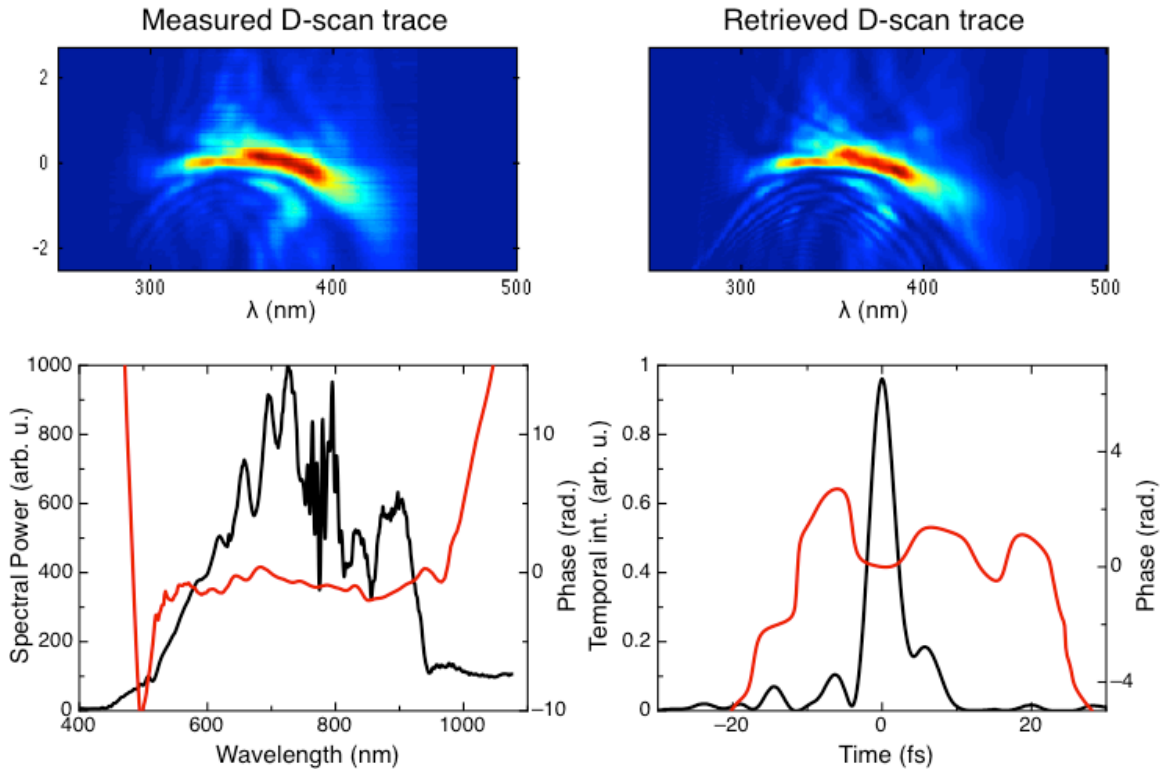
Day 4: The last day was dedicated to data processing. The preliminary numerical reconstruction already showed a pulse duration of 4.1 fs, which is very promising for such a high energy and unique source (3.5 milijoule output). We then proceeded to pack the components that came from Porto and prepare eveything for the return trip.

3) Description of the main results obtained

The main result was to perform the first complete characterization of the new high-energy ultra-broadband pulse source developed at LOA by means of the d-scan technique invented in Porto and Lund.

This mayor achievement, of full characterization of the LOA system, opens the possibility to even reduce the pulse temporal length of the host institution system. The d-scan traces and retrievals gave relevant information regarding the output of the laser system that can be optimized to an optimum configuration. This is also the shortest pulse with the highest energy ever measured. The best reconstruction

revealed a pulse duration of less than 4 fs, as shown in the figure below.



Another main result was the demonstration of the performance and accuracy of the d-scan technique in one of the most advanced laser systems that no other characterization system had been able to measure.

4) Future collaboration with host institution (if applicable)

Future work comprises the installation of a permanent d-scan system in the vacuum chamber that is currently being installed at LOA. This will enable measuring the pulse duration online and on-target, which is very important for the advanced high-harmonic generation and attosecond physics experiments to be performed at LOA. Both groups will work towards the integration of a permanent d-scan system in the vacuum environment and exchange information related with the important and critical parameters involved in the process.

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)*

A manuscript entitled "Compression of multi-mJ pulses to 4 fs duration in long hollow fibers" has been prepared and will be

submitted to Optics Letters over the next few days. Proper acknowledgment of SILMI and ESF support has been made in the respective section of the paper.

6) Other comments (if any)

The expected results will have a strong impact in the ultrafast optics and high-field / attosecond science communities and will help keep Europe at the forefront of the scientific and technological advances in these highly competitive domains, as envisaged by the SILMI Networking Programme. The proposed work actively involved senior scientists and post-doctoral researchers.

The visit also enabled the transfer of knowledge between the two participating groups. The Porto team associated with this proposal was comprised of Dr. Helder Crespo and Dr. Rosa Romero that were joined by Dr. Miguel Miranda from Lund University.

We are all very grateful for the financial support from the ESF.