LASERLAB-EUROPE

The Integrated Initiative of European Laser Research Infrastructures IV

Grant Agreement number: 654148

Work package 5 – Training and Development of User Communities

Deliverable D5.3
Intermediate Report on "Short-term training visits for scientists and technical staff"

Lead Beneficiary: 23 – UL

Due date: M24

Date of delivery: M24

Project webpage: www.laserlab-europe.eu

Deliverable Type	
R = Report DEM = Demonstrator, pilot, prototype, plan designs DEC = Websites, patents filing, press & media actions, videos, etc. OTHER = Software, technical diagram, etc.	R
Dissemination Level	
PU = Public, fully open, e.g. web CO = Confidential, restricted under conditions set out in Model Grant Agreement CI = Classified, information as referred to in Commission Decision 2001/844/EC	PU

1 Introduction

The training of new generations of future users is considered as one of the main tasks of Laserlab-Europe. The objectives of Work Package 5 "Training and Development of User Communities" are:

- Train a new generation of researchers and technical staff to enable them to make optimum use of laser facilities, to exploit new experimental and theoretical approaches in photonics and laser-related science and to use them in novel applications with high industrial and societal impact;
- Develop new laser user communities in domains of science such as bio photonics, medicine, pharmacy, ICT, material research, environment, in industry, and in European regions where laser user communities are still less developed;
- Increase efficiency in these activities through cooperation with externally funded activities, aiming at a similar development of human resources, and in close collaboration with other European facilities, networks, projects and industry, such as FELs of Europe, ELI, EuroBioImaging, Photonics21, EOS, etc.

2 Objectives of Task 2 – Short-Term Training Visits for Technical Staff and Scientists (Staff Exchange)

Short-term training visits are designed to i) increase the "hands-on" experience of potential European laser users and to improve specific experimental skills and competences for scientists, and ii) to assure that the operators and technicians of Laserlab-Europe infrastructures are trained at the highest possible level through sharing of expertise, procedures and knowledge. Support for short-term training visits is granted for proposals positively evaluated by a committee of experts under supervision of the Networking Board.

Lead partner: UL

3 Implementation

During the first 24 months of the project, Laserlab has issued two internal calls for proposals from Laserlab scientists or technicians for Staff Exchanges. For the evaluation of the proposals a Project Selection Panel, composed of representatives of the different Laserlab boards and one User Representative, was set up. Proposals were evaluated in view of the following criteria:

- Relevance of the objectives of the exchange and the needs of the sending institution;
- Appropriateness of the approach as well as of the host with respect to the objectives of the exchange;
- Qualification of the staff to be exchanged.

In each proposal the applicants explain how the proposed visit(s) will lead to important transfer of knowledge and/or good practice between partners of Laserlab-Europe. Out of the 21 applications received, 10 were found to be well justified and perfectly in line with the aims of the call and were selected for implementation. After selection, three proposed exchanges were cancelled due to internal reasons. 11 technicians and scientists from six laboratories benefited from the training at six different host institutions.

The following intra-consortium staff exchanges were performed:

a) CELIA – MBI

Sending Institution: Centre Lasers Intenses et Applications, University of Bordeaux, CNRS, Bordeaux, France

Hosting Institution: Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany

Duration: 1 week

Participating staff: Jean-Éric Ducret

Objectives of the exchange: The CELIA facility, in collaboration with the Institut Lumière Matière of Lyon, has recently built a spray source to perform experiments with its laser ECLIPSE. Such an experimental program will aim at nuclear fusion studies and building negative ion sources for different applications, such as neutral atom sources for magnetic confinement facilities. This spray source was designed on the model built at the Max Born Institute (MBI) in Berlin and patented by MBI. The objective of the exchange is for CELIA to learn from the experience developed at MBI on the use and optimisation of such a source for fs laser experiments and for MBI to share this experience. In particular, emphasis will be made on the technique developed at MBI using the Mie-scattering polar-angle dependence to determine the average size of the sub-micron droplets generated by the source, very well adapted to the range of droplet size in this source (above 100 nm radius). Other opportunities of exchange will be investigated during the stay, such as imaging.

Achievements: In collaboration with the Institute for Light and Matter (ILM) of Lyon, CELIA is presently developing a spray source to produce sub-micron diameter droplets to study their Coulomb explosion in the high electric field of high-power femtosecond lasers. This spray source is to be used at CELIA but will take advantage of the CELIA/ECLIPSE laser upgrade, from 100 mJ on target to 2 J. The staff exchange action between CELIA and MBI found its motivation in this context for CELIA. The idea was for CELIA to take advantage of the many-year experience of MBI, even though this program is now finished at MBI. On the contrary, the experience at CELIA with spray source is small, even though CELIA physicists' experience with high-pressure gaseous source for atomic cluster production is large.

The work during this week was essentially based on the visit of the high-power femtosecond laser installation, M. Schnürer is in charge of, detailed discussions on the technology used at MBI to build their spray source and a dedicated time for a detailed bibliography investigation for J.-E. Ducret on the subject as well as on theoretical quantum molecular dynamics, which can be used for the interpretation of these experiments. The emphasis of the discussions was put on the Mie scattering technique to be implemented with the source in order to determine the average sub-micrometer droplet diameter. The experience of M. Schnürer is extremely valuable for us since such experiments of Mie scattering on objects of the size of a few 100 nm are difficult to perform successfully. J.-E. Ducret has had during his stay at MBI-Berlin the opportunity to detail all the material necessary for these experiments. Such a time was necessary as a complement with the information given in the publications by M. Schnürer's group on the subject.

Back at CELIA, J.-E. Ducret could order the different parts necessary to build these Mie scattering experiments

This staff exchange will have as a probable continuation an invitation of M. Schnürer to take part in experiments with the spray source at CELIA.

b) CLF – GSI

Sending Institution: Central Laser Facility, Rutherford Appleton Laboratory, STFC, UK

Hosting Institution: GSI Helmholtzzentrum für Schwerionenforschung Darmstadt, Germany (GSI)

Duration: 2 weeks

Participating staff: Parry Bryn

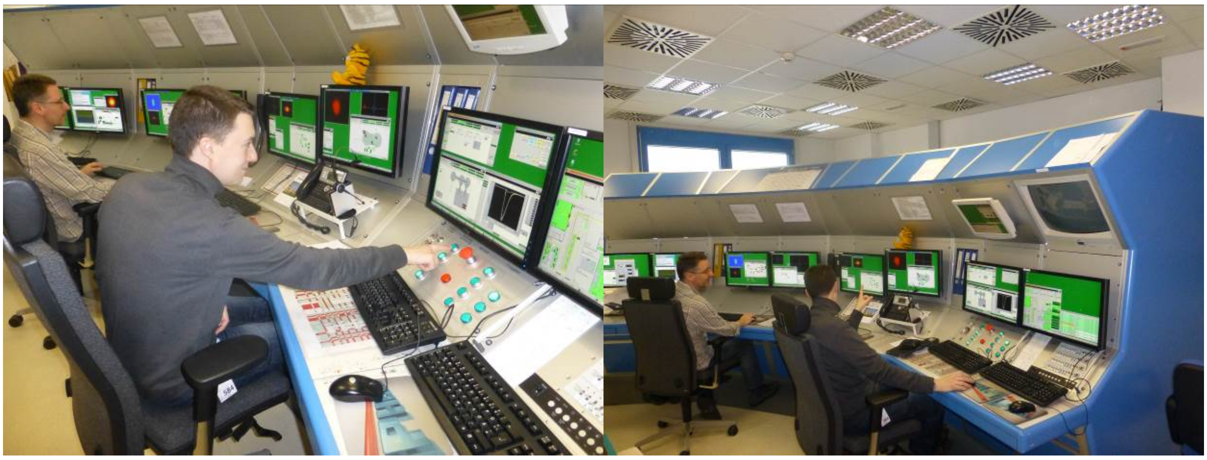
Objectives of the exchange:

- To gain knowledge and experience in the use of volume Bragg gratings for the stretching of laser pulses to several picoseconds for use in OPCPA pre-amplifiers.
- To exchange knowledge in the development and application of wave-front sensors for wave-front characterisation.
- To exchange knowledge and experience of developing and deploying deformable mirrors for wave-front correction of laser pulses.

Achievements:

The two labs both use adaptive optic systems which are a hybrid of commercial and internally developed components. In the case of CLF, the deformable mirrors are fabricated in-house, and the mirror driver is a bespoke device produced for the purpose by an external company. At PHELIX the wavefront sensors are assembled and calibrated from stock components, and the software in use has been written by one of the operations team. The CLF largely uses commercial software, home-made software is in use in some parts; however it is not being actively developed and does not run on modern operating systems.

The areas of expertise developed by the two labs are clearly complementary, combining the various elements would potentially produce an entire AO system. The exchange was a useful step in realising this possibility, and facilitated the exploration of various other topics relating to wavefront control and focal spot optimisation. I presented a summary of adaptive optics used in the CLF to the whole PHELIX group, and had in-depth discussions with their specialists in this field. It was very useful to see the functioning of their system in an operational capacity, and to explore in detail the construction and calibration of their home-built Shack-Hartmann wavefront sensors. We were also able to compare our respective efforts in sensorless AO methods and identify common areas of study. Pre-compensating pump induced on-shot aberrations is another subject of ongoing effort in Vulcan. The solutions implemented by GSI are effective and well integrated, so it was very helpful to see them in operation.



I was given an in depth explanation and demonstration of the software being developed at GSI for wavefront analysis and AO system control. GSI have shared a beta copy of this software for demonstration and testing purposes. Steps required to integrate the software with the CLF mirror driver were discussed, and an agreement made in principle to loan a driver to PHELIX for this purpose. It was agreed that the next phase of the collaboration would be to provide training at the CLF in techniques of mirror fabrication, and work on system integration.

The ps OPCPA at GSI achieves good performance, and the design incorporating a volume Bragg grating was of particular interest. I was provided with a comprehensive overview of the design and operating considerations by the resident experts in this system. This included not only the technical aspects needed to assess suitability for implementation at the CLF, but also practical and operational considerations essential for running such a system in a facility context.

Vulcan and PHELIX are similar systems, both using flashlamp pumped, large aperture Nd:glass amplifier chains with OPCPA pre-amplifiers, as such they share many common issues, both technical and operational. The duration of the exchange and the fact that I was able to participate in laser operations during a user experiment meant that it was possible to explore a wide variety of topics, from spatial and temporal laser diagnostics to safety and operational procedures. I found this a valuable and informative experience, and I hope that my hosts on the PHELIX team found our discussions mutually beneficial.

c) MBI – PALS-HiLASE

Sending Institution: Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany

Hosting Institution: Institute of Physics, Prague, Czech Republic

Duration: 4 weeks

Participating staff: Xavier Mateos, Valentin Petrov

Objectives of the exchange: The general objective of the present proposal is to transfer know-how in both directions, to realize a compact 2-micron picosecond cryogenic microchip laser based on Tm-doped materials with very high peak-power. To accomplish this general objective, four specific tasks will have to be accomplished (two concern the transfer of knowledge and the other two are related with the experimental work):

MBI has extensive experience in the development of 2-micron lasers at room temperature (RT) based on Tm ions in several host materials operating in different temporal regimes. The pump geometry and laser cavity design (microchip configuration) for such lasers are very well known at MBI and the transfer of this know-how is an essential prerequisite for achieving the general objective.

Concerning the second task of knowledge transfer, HILASE at the Institute of Physics has large experience in the development of cryogenic lasers based on Yb ions operating at 1 micron. Such a know-how related to cryogenic technology will play a crucial role for the realization of the present Laserlab project proposal.

The two experimental tasks include the preliminary CW assessment and the final development of the picosecond cryogenic laser. The work will include the utilization of several saturable absorbers such as Cr:ZnS or PbS quantum dots embedded in glass that have already shown excellent performance at RT, including sub-nanosecond pulse generation

Achievements: The exchange was divided into two visits from the sending facility (MBI) to the hosting facility (HILASE). Within the first visit, four important meetings took place besides a tour to the laboratories. The first meeting focused on the presentation of the HILASE center including an extensive talk to know the skills of the hosting facility and the activities they offered as realistic for consolidation of the collaboration. The second meeting was a similar one including the presentation of the skills of MBI. The third meeting was dedicated to generate novel ideas once each partner knew the skills of the other partner within the framework of the proposal. This meeting was very positive and fruitful with many ideas for the present and future. The last meeting was related to the decision and agreement of the experiments to carry out with more urgency and for those at medium and long term with special emphasis to the required equipment, people, where to carry out each part of the experiments and how to plan the dissemination of results (publications and conferences).

The second visit was also very fruitful. Some of the experiments planned during the first visit were started and the next experiments to carry out in the near future were fixed.

Among the achievements (experimental results) achieved during this second visit (and the following weeks) according to the scheduled experiments, one of them has been submitted to a conference (CLEO Europe), June 2017 in Munich. They are related to the preliminary continuous-wave multiwatt laser generation at cryogenic temperatures which will also be submitted soon to a peer review journal. The short, near and long term scheduled experiments are in agreement with the submitted proposal and some extension is included for novel laser materials.

The exchange has been very cordial and very positive to establish the collaboration between the two institutions that will provide many important results.

d) MBI – LOA

Sending Institution: Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany

Hosting Institution: Laboratoire d’Optique Appliquée, Palaiseau, France

Duration: 1 week

Participating staff: Tamas Nagy

Objectives of the exchange: The objective of the exchange was to provide the MBI scientist an in-depth training about the integration of a complex measurement device such as a d-scan pulse characterization apparatus into a vacuum beamline. On the other hand the MBI scientist could provide his expertise about using different nonlinearities for the d-scan apparatus. In our case the integration of pulse characterization into the vacuum beamline has been a very important aspect, since both groups at LOA and also at MBI are dealing with ultrashort pulses containing less than 1.5 optical cycles (~4fs). For such pulses in situ characterization is needed (direct in the beamline under vacuum), because the pulses with over-octave spanning spectrum are extremely sensitive on material dispersion as small as of ambient air.

Achievements: From technological point of view it was useful for me to learn working with motorized optics in vacuum from a team which is very experienced in this field: see which hardware, which materials can be used in vacuum, and what is an efficient way to organize these components for providing the necessary degrees of freedom for the application. Specifically, we could build up a rather complicated optical arrangement involving motorized components for the implementation of XPW d-scan measurement. The main problem was the implementation of large variable attenuation of the beam from 3mJ down to the few microjoule level, and the accurate beam sampling of the signal into a spectrometer without cutting or falsifying its spectrum.

The campaign was very useful for both parties, as we compared the d-scan method using second harmonic generation (SHG) and cross-polarized wave (XPW) generation as nonlinearity for measuring ~4fs pulses directly in vacuum environment. Both methods delivered very comparable pulse shapes, showing pulse durations of 4.24fs and 4.28fs, respectively. This measurement is also valuable in scientific point of view, as it is the first comparison between the two methods for sub-2-cycle pulses. We expect a publication about these results.

Due to the very complex experimental setup involving a unique double-CPA short-pulse laser and a complicated beamline, we naturally encountered many technical difficulties during the work. Thanks to the flexibility and hospitality of the colleagues of the host institute we could manage to bring this experiment to the end in spite of the very limited time available. It was a very intensive time for exchanging ideas and sharing technological knowledge for the profit of both sides.

e) ILC – VULRC

Sending Institution: International Laser Centre, Bratislava, Slovakia

Hosting Institution: Quantum Electronics Department and Laser Research Center, Vilnius University, Vilnius, Lithuania

Duration: 2 weeks

Participating staff: Tibor Teplicky

Objectives of the exchange: Our objective is to improve the fabrication of microstructures by 2 photon photopolymerisation in order to produce 3D microstructures of precise shape and stability. We would like to improve our know how in creating the microstructures, form choosing right parameters of polymerization to improving cleaning processes of the final structure.

Achievements: At the beginning of my stay I was welcomed at VULRC with excursion of laboratories and equipment. Prof. Gadonas arranged a meeting with his group where I presented current progress and issues with pulsed-laser fabrication technology at ILC, Bratislava. We further discussed issues with material properties for our application and potential improvement of ILC setup for better fabrication results. Also, the post-processing steps (such as technical details of drying process and hardening) of fabricated samples were discussed. After the initial meeting we planned my detailed schedule of experiments in Vilnius, together with member of the VULRC team.

At first I got familiar with the setups for 2 photon polymerisation present at VULRC. Then I cooperated with the team members and Phd students on their own experiments. Several posible applications of technologies based on utilization of fs-laser pulses were demonstrated. Later, microstructures dedicated for further use and biological applications at ILC were created out of the pre-polymer SZ-2080 and Ormocomp. Models for the 3D structures were designed for demonstration of resolution limits and stability of created structures.

Next stage was information and knowledge exchange related to development and post-processing of fabricated 3D structures. Post-processing and its challenges for high-resolution complex microstructure formation were discussed and practically demonstrated in details.

In summary, my staff exchange visit in Vilnius University allowed me to consult, see and take part in various fabrication scenarios and to discuss applications of fs-laser based photopolymerisation together with leading experts in this field. After the visit, based on the obtained knowledge, we will be are able to significantly impove the quality of fabrication process of microstructures created by 2-photon photopolymerisation in the laboratories of the Department of Biophotonics, ILC in Bratislava. Our 2PP setup will be upgraded based on aquired knowledge to meet the level needed for fabrication of 3D microstructures with precise shape, higher resolution and enhanced stability.

f) USZ – LOA

Sending Institution: University of Szeged, Department of Physics, Szeged, Hungary

Hosting Institution: Laboratoire d’Optique Appliquée, Palaiseau, France

Duration: 1 week

Participating staff: Janos Csontos

Objectives of the exchange: In ultrafast laser physics, a number of measuring techniques are available for characterizing pulse duration. The so-called dispersion scan (D-scan) is commonly used in the case of few-cycle pulses because of its simplicity and flexibility. It is particularly suited for direct integration in few-cycle beamlines as the dispersion scan is realized by the insertion of material already used for pulse compression. It can be easily implemented under vacuum and is therefore ideally suited for direct pulse characterization inside the vacuum chamber where the laser pulses are used for applications. The Laboratoire d'Optique Appliquée (LOA) boasts a state-of-the-art few-cycle laser beamline featuring a fully integrated vacuum-compatible D-scan measurement device. The Szeged team has been developing spectral interferometry techniques for characterizing the spatio-temporal properties of ultrashort laser pulses. We propose to exchange our experience and knowledge on pulse characterization techniques and consider the improvement of existing devices or even the development of novel ones.

Achievements: I participate in the Laserlab staff exchange project, as a PhD student from the University of Szeged. The hosting institute was the Laboratoire d'Optique Appliquée (LOA), where Rodrigo Lopez-Martens group has a unique laser system for relativistic laser-matter interaction experiments. At the end of the laser system a vacuum compatible dispersion-scan (d-scan) setup with second harmonic generation (SHG) is used for the pulse characterization in daily routine. The objective of this project was to approve the applicability of the d-scan measurement technique with a different nonlinear process, namely the Cross-Polarized Wave generation (XPW) for close to single-cycle laser pulses.

For the experiments a CPA laser system combined with hollow fiber was used. After the hollow fiber the main part of the XPW d-scan setup starting with a fused silica wedge pair. With these wedges the dispersion of the pulses can varied. After this, there is paired chirp mirrors, which add pure second order dispersion to the pulses. The wedge pair and the chirp mirrors together do the compression of the pulses, and after the chirp mirrors the pulse duration reach the transform limit, 3.6 fs. After the chirped mirrors there is the experimental setup which was built to the XPW d-scan measurements. The first element was a fused silica wedge pair in reflection configuration with Brewster-angle of incidence to attenuate and cleaning the polarization of the beam. After the two parallel wedge pair a spherical mirror focused the beam to the BaF2 nonlinear crystal. A Glan-Taylor prism was placed after the nonlinear crystal to filter out the fundamental beam. The signal and the fundamental spectrum was recorded with an intensity calibrated Avantes spectrograph.

During the experiments two different nonlinear crystal thickness, a 50 and a 200 micrometre thick was tested to find the best solution for the characterization of the sub 4 fs pulse duration. The retrieved phase information with the two different crystal provided similar information, but the measured d-scan traces with the thinner crystal is more structured and can provide more accurate information. The accuracy of the setup and measurement method was proved with a commercial SHG d-scan setup. During the measurements some minor changes was done in the laser system which resulted in minor changes in the phase of the pulses at the end of the system. Both d-scan measurement method follow these changes and resulted in comparable results. The average difference between the retrieved SHG and the XPW d-scan pulse duration was approximately 1%. The uncertainty of the measurements was approximately 0.2 fs.

From the measurements it is come out that the XPW D-scan measurement technique is well suited for measuring close single-cycle pulse durations. Although with the thin BaF2 crystal provided more structured traces, the thick one also suitable for XPW D-scan measurements and both crystal provided similar phase information.

g) IST – CLPU

Sending Institution: Instituto Superior Técnico, Group for Lasers and Plasmas, Lisbon, Portugal

Hosting Institution: Centro de Laseres Pulsados, Salamanca, Spain

Duration: 2 weeks

Participating staff: Victor Hariton (IST) and Mauricio Rico (CLPU), Mariano Jubera (CLPU), Alejandro San Blas (CLPU)

Objectives of the exchange: IST is now in the process of expanding the capabilities of its laser development and applications. This involves among other areas the development of sources in the mid-IR spectral range, as well as applications for these sources, such as pulse and beam shaping aiming for controlled laser ablation in the mid-IR. The main objective of this staff exchange was acquiring practical know-how in a number of laser ablation techniques, with femtosecond lasers, relevant to the experiments that we are carrying out at IST, setting the groundwork for the geometrical shaping of the laser beam applied to laser ablation in an industrial setting. In particular, the experimental setup was adapted to achieve the desired ablation pattern, in both copper and teeth samples. Preliminary results of square shaping were performed in a high performance regime.

Achievements: In the first week of the exchange, the training process started by learning how to operate a high intensity, average power laser system, mainly because of the uniqueness of the laser setup and for safety precautions. I gained knowledge on the remote controlling and handling of this laser system. We had the opportunity to test preliminary configurations for focusing on metal samples, namely copper. We then studied sample preparation in order to increase the overall ablation efficiency, in particular, roughness, thickness and pre-ablation cleaning methods. We also discussed alignment and techniques for obtaining better and faster measurements.

I had the opportunity to discuss in detail with the local team my work on the benefits of beam and pulse shaping for laser ablation. We implemented the shaping device and its operation and obtained images of the geometrical profile in the focusing point of the shaped laser beam. One of the shaping components became damaged during operation, which prevented us from completing all the goals for the week, but nevertheless this period was an overall success due to the global experience gained.

The second week was dedicated to learning and applying the techniques to the ablation of biological material. Dentine sample preparation and storage was accomplished, ensuring similar conditions to the metal samples for comparison reasons. The same method was applied for the ablation process. I acquired know-how on how to avoid nanoparticles formed in this environment and discussed analysis techniques of the ablated samples. Finally, the operation of a perfilometer was addressed this week, one of the most relevant and important steps for the evaluation of this and future work. One-dimensional profiles for ablation lines and two-dimensional profiles for holes were retrieved and their analysis was performed.

The second week staff-exchange went according to the planning and was a success due to the many accomplishments of the proposed milestones and the gained and shared knowledge.