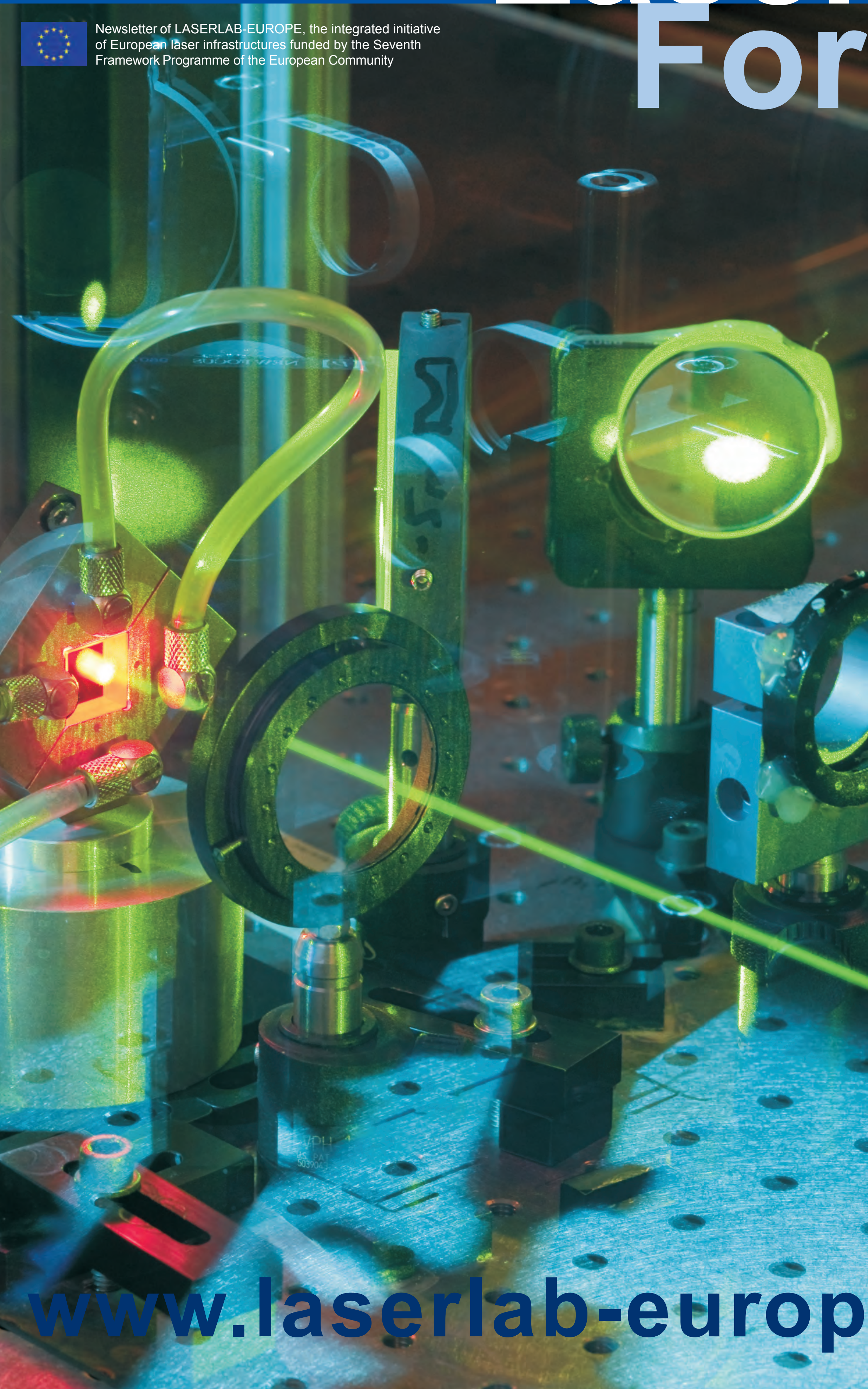
Issue 11 July 2011

Laserlab Forum

Newsletter of LASERLAB-EUROPE, the integrated initiative of European laser infrastructures funded by the Seventh Framework Programme of the European Community



IN THIS ISSUE

www.laserlab-europe.eu

Editorial

The spring of 2011 has turned out to be the driest and sunniest ever recorded in (western) Europe. Likely, this means a record amount of sunlight reached the surface of Europe in the past few months. I am not sure, though, whether many of the laser scientist involved in LASERLAB-EUROPE will have noticed this from firsthand experience, as they tend to spend much time in darkened labs, with blinds blocking any light that might interfere with their attempt to tailor their own light - laser light of exactly the right shape, colour and duration for their specific scientific needs. Unfortunately, such a dry and sunny spring promises a rather wet summer for those who decide to take a break from their quest.

Not much about sunlight in this issue of Laserlab Forum, though it includes a guest column from Paul Motalane, manager of the African Laser Centre, LASERLAB-EUROPE's counterpart on this sunny continent. And one learns more about excellent research conducted in sunny Greece and Italy on pages 9-11. In addition, this summer issue features articles on User Training Schools, the User Meeting held near Pisa's leaning tower, and an overview of the current status of the Joint Research Activities. Enjoy!

Tom Jeltes

News

ERC grant for Nobel laureate Theodor Hänsch

Theodor Hänsch, Director at MPQ Garching and professor of Experimental Physics at the Ludwig-Maximilians Universität in Munich, Germany, has been awarded an ERC Advanced Grant. Hänsch will use the grant of 2.39 million euros for new applications of frequency combs, of which he has been one of the inventors. In 2005 Hänsch received the Nobel Prize in Physics for his contributions to laser-based precision spectroscopy.

A laser frequency comb makes it possible to measure the frequency of any laser source with a precision that enables stringent tests of the fundamental laws of physics. This technique also paves the way for the creation of all-optical clocks and improved satellite-based navigation systems. Frequency combs are currently used by hundreds of laboratories worldwide.

With the ERC project, Professor Hänsch will explore a new application of frequency combs to molecular spectroscopy, which is used to detect and determine the composition of molecular samples in laboratories. It is also employed in "real life situations", for instance to analyse gases in the atmosphere, or to identify explosive or hazardous materials. These new instruments will improve the precision and sensitivity of molecular spectroscopy, but also make the recording of a spectrum much quicker, so that it can be used to study short-lived molecules or the details of chemical reactions in real time.

Optical nano-antenna steers single photon emission

Nanoscale TV-antennas have now been fabricated and brought into action to steer and brighten up the light of molecules and quantum dots by researchers at ICFO – the Institute of Photonic Sciences, in Barcelona, Spain. The achievement, with important implications for bio-sensing, was reported in Science last year.

Artist impression of the directional emission of the Yagi-Uda antenna driven by a single luminescent quantum dot. © ICFO

Optical antennas hold the promise to realise optical sensing and emission on truly sub-wavelength scales. But scaling up proven antenna technology to optical frequencies (around 500 THz), inevitably implies scaling down to a million times smaller, nanoscale structures. ICFO researchers decided to strive for directed light emission by constructing so-called Yagi-Uda antennas, made of parallel metallic bars. The realisation of the idea required a real team effort, involving both ICFO groups of Niek van Hulst and Romain Quidant, leading to an extremely compact optical Yagi antenna, with a largest dimension of only one wavelength.

Wiersma new director LENS

Prof. Diederik Wiersma

Diederik Wiersma has been appointed the new director of the European Laboratory for Non-linear Spectroscopy (LENS) in Florence, Italy. Wiersma (1967) leads the research group Optics of Complex Systems at LENS. He is also research director of the Italian National Research Council (CNR) and full professor in physics of matter at Roma Tre University. In addition, Wiersma is a member of the editorial board of Physical Review A and the former director of the International School of Physics 'Enrico Fermi'. The Dutchman is the successor of Roberto Righini, who was director of LENS from 2005 to 2010.

Cover Photo: Amplifier of a femtosecond Ti:Sapph laser system: A Ti:Sapph crystal is pumped with green laser light. Photo: L.M. Peter

Application Lab for MBI at TU Berlin

In February 2011 the official grand opening of BLiX, the 'Berlin Laboratory for innovative X-ray Technologies' was celebrated at TU (Technische Universität) Berlin. BLiX represents an Application Lab in the knowledge triangle of university, research and enterprises and is jointly operated by the Institut für Optik und Atomare Physik of TU Berlin and LASERLAB-EUROPE partner MBI.

BLiX is a "Leibniz-Applikationslabor" of MBI, one of 14 research laboratories of the Leibniz Association which address scientific issues of importance to science and industry in order to transfer research results into prototypes. The laboratories of BLiX cover an area of about 250 sqm and provide state-of-the-art equipment for users from science and industry. A novel thin disk laser system as a driver laser for a plasma-based highly brilliant x-ray source has been developed at MBI and transferred to BLiX. A laboratory based x-ray microscope will be transferred from MBI to BLiX in the next months, and TU will provide a 3D micro XRF system for sensitive samples like cultural heritage objects as well as a novel x-ray spectrometer. In addition BLiX will provide lecture rooms for training and education in the field of x-ray physics.

Johannes de Boer honoured with G.G. Stokes Award

Johannes de Boer has been awarded the G.G. Stokes Award by SPIE, the international society for optics and photonics. De Boer, director of LaserLab Amsterdam and head of the Physics of Complex Systems group, receives the award in recognition of his 'seminal contributions to the development of polarization-sensitive optical coherence tomography as a means for quantitatively assessing the depth-resolved birefringence of biological tissues, especially in ophthalmology'. The G. G. Stokes Award is given annually for exceptional contribution to the field of optical polarization. It includes an honorarium of $2,000.

Thin Disk Laser for Extreme Light Infrastructure

LASERLAB-EUROPE partner MBI Berlin has developed a short-pulse thin disk laser for use in the 10 Petawatt short-pulse laser system APOLLON, currently under construction at the Institut de la Lumière Extrême (ILE) at the Institut d'Optique Palaiseau.

The thin disk laser will be used for driving an OPCPA stage. The technology used for APPOLON is planned to be used also for the Extreme Light Infrastructure (ELI). In May 2011 the system has been delivered and was installed at ILE. The specified output parameters were demonstrated with a high degree of stability and reproducibility. It is planned to continue this successful project, using the next generation of MBI thin disk lasers with a pulse energy in the Joule range.

Helmholtz Association opens institute in Jena

The Helmholtz Association, the German organization of national Labs with large-scale research facilities and instrumentation, has founded a new institute. The new Helmholtz Institute Jena is located on the campus of the Friedrich Schiller University, partner of LASERLAB-EUROPE. The new institute's mission is to address the scientific and technological challenges at the interface of conventional accelerators and high-power lasers.

The establishment of the institute is strongly motivated by two major projects of the Helmholtz Association, namely the international accelerator facility for antiproton and ion research (FAIR), under construction in Darmstadt, and the European free-electron X-ray laser (European XFEL), under construction in Hamburg. The Helmholtz Institute Jena will work on the development of high-power lasers, laser particle acceleration, X-ray generation and spectroscopy, and relativistic ionization dynamics of heavy ions including strong-field QED.

The newly opened Helmholtz Institute Jena is a branch of GSI Helmholtz Center for Heavy Ion Research and has as additional partners the Helmholtz Centers DESY and Dresden-Rossendorf. The institute cooperates closely with university institutes in all of its research areas including the operation of the large-scale laser facilities JETI and Polaris. JETI is part of the Access program of LASERLAB-EUROPE and will be represented by the Helmholtz Institute Jena within this program in the future. In addition to its experimental activities, the institute will also strengthen its efforts in theoretical physics, in particular in the field of correlated quantum systems in intense fields.

'Bunker' creates new prospects for laser particle acceleration at MBI

A special lab, (colloquially 'bunker') has been built in the MBI high-field laser laboratory in Berlin. The bunker provides adequate radiation shielding for particle acceleration experiments with the new 25 fs - 100 TW laser. The interaction of fast protons or electrons with matter causes emission of neutrons and x-rays which require special shielding measures.

The walls of the new lab consist of special concrete with ferric oxide which gives it a characteristic red colour. A 60 tons heavy beam dump is put downstream of the accelerated particles. The energetic particles are slowed down inside the dump and the emitted secondary radiation is absorbed inside the bunker. The total construction has a weight of several 100 tons. Dozens of concrete pillars had to be placed into the ground to take the load and to avoid that the whole building sinks into Berlin's sandy ground. The entrance to the bunker is set up similar to a baffle. The central wall of the baffle construction is a moveable gate so that a complete apparatus may be moved into and out of the room.

With the installation of the bunker, experiments aiming for production of ultra-short GeV electron pulses may be initiated and ion acceleration with higher energy loads can be developed. This opens up a diversity of new research topics.

LASERLAB users meet at Leaning Tower

Some 40 users selected by LASERLAB-EUROPE facilities met with User Representatives and invited top scientists at the 2011 User Meeting devoted to "Updating Optical and Laser Methods for Energetics, Materials, Chemistry and Biomedicine". The meeting was hosted by the Intense Laser Irradiation Laboratory of the National Institute of Optics (INO) at CNR Campus, Pisa, Italy on March 28th and 29th.

The sessions were opened by the INO Director Paolo De Natale and introduced by a survey of the Transnational Access Program given by Pascal D'Oliveira from SLIC-CEA, Saclay.

A dense and intense program allowed a significant crop of fresh scientific results and ideas to be exchanged in the usual friendly atmosphere of LASERLAB events. An up-to-date review on "Interactions at Extreme Energy Densities" was introduced in a keynote presentation by Josef Feldhaus on European Free Electron Lasers facilities and followed by several exciting presentations on high power laser and dense plasma physics, including novel data from experiments performed in capillary tubes, presented by Brigitte Cros.

A session devoted to "Ultrafast Laser Probing of Matter" was opened by the keynote lecture of Giulio Cerullo and provided a rich overview of emerging studies and related techniques from femtosecond time-resolved spectroscopy (Juliane Koehler) to attosecond Stark spectroscopy (Franck Lépine). A third session was devoted to "Advanced Laser Technologies for the Progress of Chemical and Life Sciences". The keynote presentation given by Javier Laserna depicted the impressive progress of laser spectroscopy working "from laboratory to extreme scenarios". Talks from users gave insight in a wide range of applications and advanced studies, including one on conical intersection dynamics in Rodhopsin and Isorodhopsin (talk given by Philipp Kukura).

A Round Table chaired by Annie Klisnick and Rosa Weigand stimulated the discussion among attendees on how to further improve relationships of users with LASERLAB and host institutions with the qualified contribution of Diederik Wiersma, director of LENS, and Oldrich Renner, LASERLAB-EUROPE User Representative. A number of possible actions were considered to make more efficient each of the phases to be faced by users: before the access, during the stay in the host infrastructure, and afterwards. User needs were considered by participants and discussed in some detail. Minutes of the Round Table evidencing the main issues have been delivered to the LASERLAB-EUROPE User Representatives and members of the LASERLAB-EUROPE Boards.

The two-day meeting included a visit to the ILIL-INO laboratories mostly devoted to femtosecond ultra-intense laser plasma interactions for the production of high energy particle and radiation. Informal discussions were stimulated by the nice atmosphere of the CNR Campus. Participants could enjoy a visit to the enchanting old town of Pisa and a social dinner inside S. Francesco monastery in a hall fully decorated by 14th Century frescos.

Further information about the meeting, the book of abstracts and a photo gallery can be found at: http://www.laserlab-europe.eu/events-1/laserlab-events/2011/march-laserlab-user-meeting-pisa-italy/

We were very pleased to chair the meeting!

Marta Castillejo and Antonio Giulietti

New sophisticated laser technology needs prepared people

User training activities in LASERLAB-EUROPE increase the experience of Access Users providing special experimental and theoretical skills that are instrumental in specific areas of laser science, and expand the pool of prospective Users in new areas of science.

Provision of equal opportunities to benefit from EU top-level laser systems is one of the key objectives of the Access programme of LASERLAB-EUROPE. The truth is that a new and highly sophisticated technology naturally requires adequately prepared people. This need is well recognized within the LASERLAB-EUROPE consortium and special attention is devoted to the training of new users entering the Access scheme. This issue is even more important if we take into account that lack of experience in laser techniques may translate into incomplete applications or into a lack of efficiency during the course of the experiment. Therefore, several specific training actions aimed at new Users are available with the ultimate aim to achieve the most efficient Access programme.

The LASERLAB-EUROPE User Training activities are based first of all on periodical User Training Schools and also on the User Training for Advanced Optical Techniques in Bio-imaging and Bio-processing (OPTBIO), which is a specialized user training programme provided by the Access Training Facility CLLC (Chemistry LASER Lab Coimbra, Portugal). The focus of these actions is to increase the quality and/or to expand the pool of prospective Users and is targeted mostly to:

- *i)* new research groups, e.g. from new members states within the EC or groups from other scientific disciplines (biology/medicine) whose participation in the Access programme is gradually increasing;
- *ii)* younger scientists, at the doctoral or post-doctoral level, while respecting the diversity and specific needs for different levels of collaboration with LASERLAB-EUROPE infrastructures.

In both cases, training actions aim at increasing the experience of the potential Users, and at providing special experimental skills that are instrumental in specific areas of laser science.

Taking into account the geographical varieties as well as the wide spectrum of research areas covered by the project consortium, three tailored **User Training Schools** have been organized so far since the start of the second phase of LASERLAB-EUROPE.

User Community Training: the Regional Baltic / Northern Europe Training School for potential users, held in Riga, Latvia, April 22-25, 2010. The first Training School was focused on laser applications in spectroscopy, industry and medicine, fostering the networking and cooperation of scientists between the Baltic region and the EU. Young scientists participating in the Training School also had an opportunity to benefit from the 6th International Student Conference on Developments in Optics and Communications. The event organized by the University of Latvia, Riga was attended by 86 participants from 6 countries.

General (Iberian) User Training workshop, held in Salamanca, Spain, November 8-9, 2010. The Iberian User Training School was organized by CLPU Salamanca and was devoted to the user community interested in high-power femtosecond lasers in the TW-PW range. The school involved 39 attendees and 9 speakers.

Central-European User Community Training School, held in Bratislava, Slovakia, July 4-7, 2011. During the Training School in Bratislava participants had an opportunity to benefit from the Workshop on Advanced Optical Techniques in Bio-Imaging, organized jointly by ILC Bratislava and Becker-Hickl GmbH, followed by 2 days of practical training on advanced laser and photonics technologies. The focus of this Training School was bio-imaging and biomedical spectroscopy, with 38 registered participants from 6 countries and 16 lecturers.

Training School for potential users, held in Riga

In addition to the contracted training schools one additional thematic school was organized in collaboration with PYLA, France: *Laser-created secondary sources of electromagnetic radiation and energetic particles, held in Bordeaux, France, September 21-25, 2009*. The courses in laser-created secondary sources were dedicated to the formation of graduate students and post-docs from European countries specializing in this domain. The program included the theoretical courses delivered by leading European scientists complemented by the demonstration of operating research laser facilities in CELIA and applications in the innovation group AlphaNov. 11 students and 16 instructors have been involved in this activity.

Finally, specific **short-term training visits** were designed to increase the experience of potential European Users and to provide European scientists with special experimental skills and competencies in the scientific area related to the JRA OPTBIO. Both the proposals and the visits already performed cover all laser facilities available at CLLC: Single photon counting Lab, Transient Absorption and Photoacoustic Lab and Molecular Spectroscopy Lab. Training visits typically last for 2-3 weeks and in total 43 full experimental laser days have been provided during the visits.

For all training activities realized so far it may be stated that contact with first class European scientists who delivered the courses provided a very stimulating and friendly atmosphere of creativity and international cooperation, which opened new possibilities for mobility and scientific exchanges between the countries and universities.

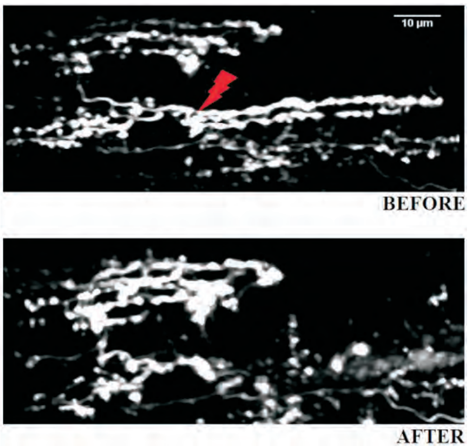
Dusan Chorvat

Joint Research Activities: highlights so far

OPTBIO

The OPTBIO JRA provides a Europe-wide concerted effort to improve laser-based methods in biomedicine and to offer access for the biomedical community to state-of-the-art instruments.

The first objective of OPTBIO addresses the need of efficient handling of tiny biological objects such as individual cells or even molecules, strands of DNA and polymer strings, and to simultaneously perform advanced optical and mechanical measurements on them. In this area, significant progress has been done by LENS, LCVU, FORTH, CLF and ICFO.



Coupling of two photon imaging with laser-induced lesions allows in vivo multiphoton nanosurgery in living mice brain. 20 um z-projections show the degeneration of the distal portion of a climbing fiber after nanodissection.

The second objective is to bring significant improvement in capacities for advanced imaging beyond what is commercially available and to the development of novel methodologies for the investigation of living cells and animals. LCVU and ICFO set important steps in the development of multiphoton microscopy and in developing microscopy workstations with extended spatial resolution, whereas ILC focussed on non-label methodologies. FORTH developed a work-station for combined two-photon and second and third harmonic generation microscopy and LENS and ICFO exploited second harmonic generation to image and measure structural dynamics of living muscle and neuronal cells. Finally POLIMI designed and developed a first version of a pump-probe system to perform transient absorption in real-time.

The third objective is focussed on biomedical imaging and is moving the capacity from point measurements into imaging. POLIMI and LLC developed and potentiated their time-resolved diffuse spectroscopy systems leading to great increase in dynamic range and reduction in acquisition time. FORTH has been adapting multispectral capabilities to their existing tomographic device; LENS coupled two photon imaging to laser-induced lesions to perform *in vivo* multiphoton nanosurgery in living mice brain; and ICFO used different techniques to image at high resolution the process of nano-neurosurgery on the *C. elegans* nematode. Finally, UL studied *in vivo* skin autofluorescence bleaching as function of irradiation power and dose and VULRC developed a scanning multispectral imaging system.

SFINX

The objective of the SFINX JRA is to develop new architectures for ultra-intense, high peak power soft X-ray lasers, progressing towards the keV range. During the first two years of SFINX projects, the collaboration between the European teams led to important progress.

The bidimensional hydrodynamic fluid code, ARWEN, aims at becoming the European and international reference code for the soft X-ray laser community. A fast ionization routine has been successfully implemented in a test hydrodynamic routine leading to time-dependent gain modelling (fig. 1).

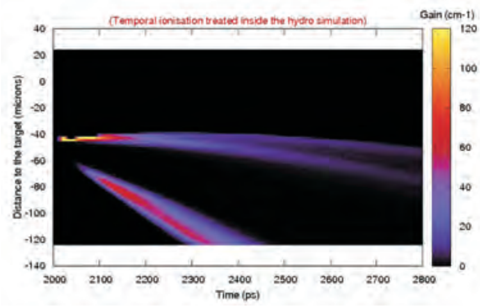


Fig. 1: Gain spatio-temporal evolution displayed in false colours.

ARWEN gives the spatio-temporal evolution of the amplifying plasma state. Recently, we implemented a new Bloch-Maxwell code (DeepOne) for modelling the pulse shape evolution during amplification and found an elegant and easy-to-implement seeding condition for generating 15 µJ, 130 fs, 115 MW pulse free of ASE, pre and post-pulse (fig. 2). Such high power fully coherent beam holds many promises for demanding applications like femtosecond single-exposure imaging or high field physics.

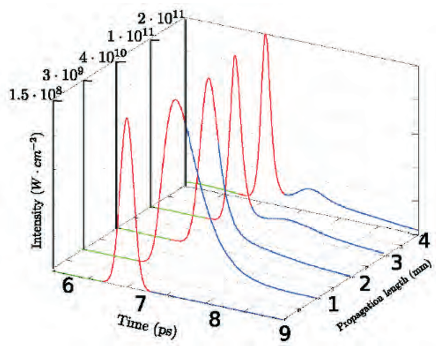


Fig. 2: Pulse shape variation along the plasma amplifier. In green is displayed the ASE, in red the seed and in blue the coherent wake generated by the seed.

GSI laboratory demonstrated an original mechanism of parametric amplification high harmonic. A small-signal gain of 8,000 has been measured at 40 and 260 eV in Argon and Helium respectively.

HAPPIE

The HAPPIE JRA is structured around 24 tasks concerning Diode Pumped Solid State Laser (DPSSL) Technology, Parametric Conversion, and Coherent Aperture Combination. A few activities are singled out, highlighting results on DPSSL and specific diagnostics tools to be developed.

In order to characterize the spectral phase of a supercontinuum light source, the Instituto Superior Téchnico, Lisbon, Portugal assembled an SFG-XFROG diagnostic, using the compressed 1053 nm pulses as probe. The first results were obtained at the end of 2010. Such a trace is shown in the figure below. It reveals that the observed broad spectrum will allow a significant pulse compression (down from 250 fs) after Optical Parametric Chirp Pulse Amplification (OPCPA).

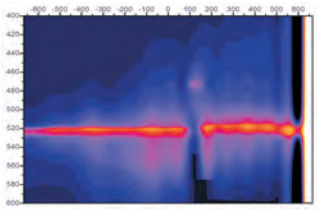


Fig. 1: SFG-XFROG trace obtained with a compressed 1053 nm pulses as probe.

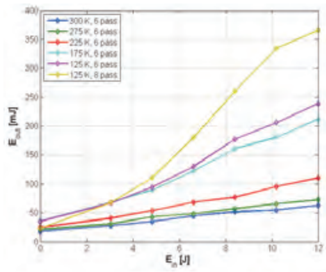


Fig.2: Temperature dependent output energy versus diode pump energy for the Yb:CaF$_2$ amplifier seeded with a 57mJ,6ns long pulse.

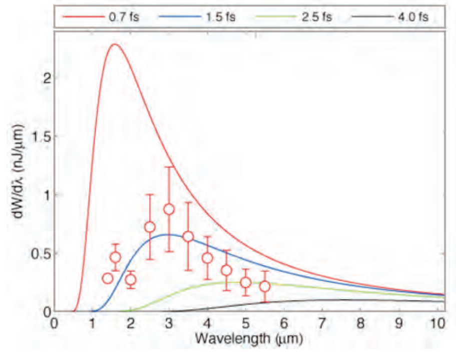
The Max Born Institute, Berlin, Germany pursues an energetic path toward the 1 Joule/100 Hz milestone with its thin disk CPA DPSSL system. Within this first period, 470 mJ/100 Hz have already been achieved. In Jena, Germany, at the Friedrich Schiller Universität, efforts are concentrating on improving efficiency of DPSSL by cooling down to cryogenic level the gain media. This strong impact is illustrated in figure 2.

LAPTECH

The LAPTECH JRA is focussed on investigating and developing methods of accelerating electrons to high energies, using the electrostatic forces of laser-driven plasma waves and the ponderomotive force of intense short laser pulses.

To explore acceleration in the 100-500 TW regime, the Strathclyde team, in collaboration with teams from IST and Glasgow University, have undertaken experiments using preformed plasma waveguides on the ASTRA-Gemini laser. The 5 J, 55 fs duration laser pulse was focussed into a preformed plasma waveguide with a plasma density of 2×10^{18} cm^{-3}. The initial vector potential $a_0 \approx 2$ is enhanced as a result of relativistic self-focussing and longitudinal compression and easily reaches a value 3 times higher, which subsequently leads to self-injection and quasi-monoenergetic electron bunches with energies in the range of 300-850 MeV.

At LOA, with a 40TW laser of "Salle Jaune", the electron injection location and the acceleration length in laser plasma accelerators, have been measured by imaging the betatron radiation at the capillary exit. Using the CTR (Coherent Transition Radiation), it has been shown that the duration of the electron bunch is extremely short with a duration of 1.5 fs RMS to which corresponds a peak current of 4 kA.



Measured CTR spectra. The continuous lines corresponds to theoretical spectra for the case of gaussian bunches for different duration (from O. Lundh et al., Nature Physics 7 (2011).

ALADIN

In the Joint Research Activity ALADIN it is proposed to exploit the recent progress of the new advanced generation of versatile and user-friendly ultrafast sources, to proliferate attosecond technology to a broad user community and to explore the full potential of these magic light sources in innovative science experiments.

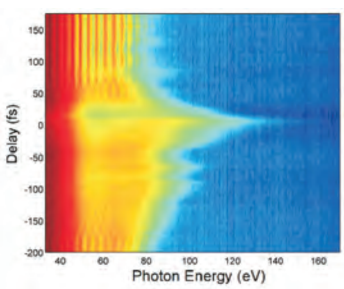
Many outstanding contributions to this goal have been made so far, a few highlights are introduced here.

A temporal gating on the HHG process was achieved at POLIMI by using an intense 20-fs, 1.45- m pulse (IR) in combination with an intense 13-fs, 0.8-μm pulse: a coherent continuous emission extending up to 160 eV using Ar and 200 eV using Ne has been efficiently generated.

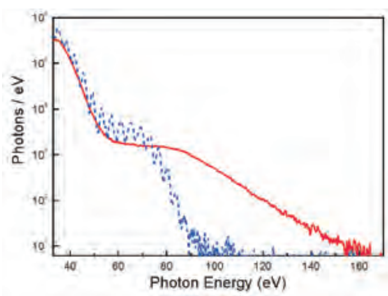
CELIA has developed a setup for harmonic generation at very high repetition rate by using a diode pumped femtosecond system. This allows to generate high order harmonic at adjustable repetition rate ranging from 100 kHz to 1 MHz.

The stereo-ATI phase meter has been improved such that single-shot operation is possible (MPQ, FSU). In addition, further improvements were made which allow in addition real-time performance and phase measurement for pulses up to 10fs (FSU).

At MBI, a new XUV/IR pump-probe beam line has been set up that is coupled to a reaction microscope. It now allows for using the whole generated harmonic spectrum beyond ~17 eV for pump-probe experiments.



Sequence of harmonic spectra generated in Argon as a function of the delay between the two-color pulses (logarithmic color map).



High-order harmonic spectra (number of photons) generated in argon by VIS pulses (dashed curve) and two-color pulses at zero delay (solid curve).

African Laser Centre

Supporting economic prosperity through light

The African Laser Centre (ALC) was established in 2002 by 19 founding members from all over Africa with the aim *"to enable African nations to collaborate both with each other and internationally; and ultimately contribute to a mutual goal of uplifting the lives of the continent's people"*. The ALC is a NEPAD recognised flagship programme of the African Union. Through consistent South African Department of Science and Technology funding support since inception, the ALC has emerged as a virtual network of centres of excellence dedicated to research and the development of laser technologies for the African continent. Like LASERLAB-EUROPE, the ALC promotes shared use of laser facilities to conduct research and training programmes.

This venture is a prime example of the success that can be achieved through collaborative effort and partnership-building in the development of scarce science, engineering and technology skills. Since its inception, we have seen the African Laser Centre move in leaps and bounds in its quest to propagate and develop laser-based research on the African continent.

The ALC has a number of objectives, including promoting research and training programmes of the continent's major laser research facilities, ensuring technology transfer among members and industry, providing equipment loans and technical support to researchers, and stimulating collaboration among researchers throughout Africa as well as with their international counterparts.

KEY NODES OF THE AFRICAN LASER CENTRE

The ALC research projects conducted across Africa are laser-based and multi-disciplinary. Research fields include nanotechnology, materials processing, spectroscopy, biophotonics, etc. Research is under taken at facilities situated in the key nodes, research institutes and any laboratories on the continent to which members have access.

The facilities below constitute the strategic key nodes:

Facility	Country	Field of specialisation
CSIR National Laser Centre	Pretoria, South Africa	Laser Physics and Technology, Laser Based Manufacturing, Biophotonics, Quantum Optics and Applied Photonics
University of Cheikh Anta-Diop	Dakar, Senegal	Atomic and Molecular Physics and Laser Spectroscopy and Processing
Laser and Fibre Optics Centre	Cape Coast, Ghana	Agricultural and Environmental Science
National Institute of Laser Enhanced Science	Cairo, Egypt	Medical and Biological Applications of Lasers
Tunis el Manar University	Tunis, Tunisia	Plant and Environmental Science and Molecular Spectroscopy
Advanced Technologies and Development Centre	Algiers, Algeria	Laser Spectroscopy and Surface Studies

The Research Programme is well-established and growing, and is geared towards establishing collaboration networks. Research projects are peer reviewed by an independent international panel of experts. The ALC support grant is used to cover independent peer review, mobility, researcher/student exchange and consumables necessary for projects.

The ALC's Education and Training Programme aims to improve and hone the skills of young researchers and technicians involved in laser based science in various institutes on the African continent. This programme's main focus is on three young researcher and technician training schools/conferences/workshops/symposia and scholarship support for MSc and PhD level study.

The African Laser Centre is growing from strength to strength and currently boasts a membership of 31 institutes across the African continent (north, west, east central and southern Africa). The ALC's main objective is to grow laser-based research through collaborative networks with human capital development as the key driver.

Several pockets of collaborative interaction between the ALC and LASERLAB-EUROPE already exist in fields such as ICT and metrology, biophotonics, novel laser sources development, and climate science studies. In addition, both continental photonics networks would like to cement formal ties leading to potential collaborative programmes in aspects such as:

1. Human Capital Development (international exchange of expert research staff; hosting joint photonics courses; conferences/workshops, etc.)
2. Joint Research projects (collaborative research in identified flagship projects with impact on socio-economic development)
3. Joint response to international research calls (e.g. FP programmes)
4. Photonics enterprise development and nurturing.

Paul Motalane, Manager of the ALC
pmotalane@csir.co.za

Visit the ALC website: http://www.africanlasercentre.org

Non-linear simultaneous removal of two electrons becomes more efficient than taking them away one-by-one

In a recent experiment at LASERLAB-EUROPE partner FORTH-IESL (Greece), conditions have been reached at which two-photon two electron ejection occurs "simultaneously" rather than one-by-one. This has led to the first 2nd order autocorrelation measurement of broadband coherent XUV continuum radiation, revealing isolated XUV pulses with duration of $1.5^{+0.2}_{-0.8}$ fs, and the first successful XUV-pump-XUV-probe experiment tracking 1fs scale dynamics.

When the interaction of coherent radiation with an atom lasts for only a short while, the physics of the interaction changes. For many years the simultaneous two-(or few)-photon removal of two electrons from an atom remained hidden because sequential ejection of electrons was the dominant process. The efficiency of two-photon double ionization, direct or sequential, is determined by the cross-sections involved and the duration of the interaction with the coherent field.

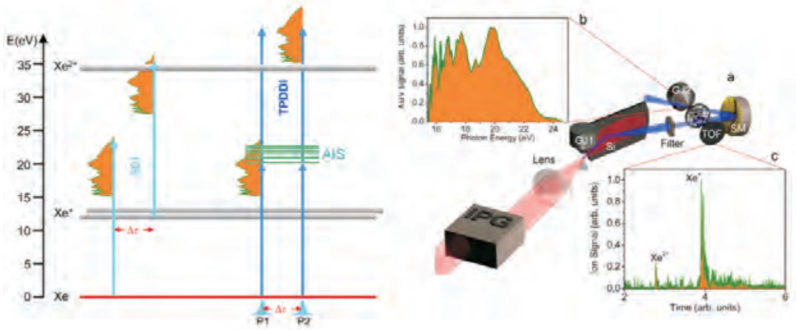
It was recently shown theoretically [P. Lambropoulos, *et al.*, *Phys. Rev. A* **78**, 055402 (2008)] that reaching ionizing pulse durations close to 1fs or shorter, the traditionally "hidden" process may take over. Technically speaking, this is because the direct process depends linearly on the pulse duration, while the sequential one goes with the square of it.

Cross-sections are atomic parameters over which we have essentially no control. Pulse duration, though, is a parameter over which we have direct control. At FORTH-IESL we can impose conditions at which coherent broadband continuum XUV radiation sufficiently energetic to induce two-XUV-photon processes is produced. The emission is based on the Interferometric Polarization Gating technique recently developed at FORTH-IESL [P. Tzallas, *et al.*, *Nature Phys.* **3**, 846 (2007)].

Exploiting these pulses, in collaboration with Dr. G. D. Tsakiris from MPQ, two-XUV-photon double ionization of xenon has been observed, allowing the recording of a 2nd order autocorrelation trace. The measured width and peak-to-background ratio of the trace gave clear evidence that the double ionization process occurs predominantly through simultaneous ejection of two photons that share the excess energy (direct double ionization). The measured pulse duration lies between 700 and 1700 attoseconds. Lack of CEP (Carrier-Envelope Phase) stabilization is the source of the large uncertainty. Thus the measured trace is the accumulation of data resulting from shot-to-shot varying pulse forms from single to double peak structures. Shot-to-shot CEP selective measurements are possible applying the recently developed CEP monitoring technique of high power many cycle laser pulses [P. Tzallas *et al., Phys. Rev. A* **82**, 061401 (R) (2010)], an ongoing project completing the present work.

In the same experiment single-XUV-photon absorption occurred in the vicinity of a rich and dense manifold of doubly and inner-shell excited states, exciting an ultrafast evolving electron wave-packet undergoing multi-oscillatory motion and multi-exponential decay. The wave-packet motion could be traced absorbing a second XUV -photon, delayed with respect to the first pulse, that leads to double ionization. A Fourier transform of the measured trace reveals the energy differences of the auto-ionizing states.

Pulse duration measurement and the tracking of the wave-packet dynamics result from one and the same measured trace. Since the pulse duration and the decay time of the wave packet are very different, pulse duration and wave packet dynamics are imprinted in different regions of the measured trace. A pronounced autocorrelation peak appears around zero delay while the oscillatory motion is visible at longer delays.



Left: Sequential vs direct double ionization scheme. Right: Experimental set-up (a); the broadband XUV continuum spectrum (b); and the Xe ion mass spectra (c).

These developments establish the era of XUV-pump-XUV-probe experiments at the 1fs temporal scale, along with isolated pulse metrology in this temporal scale, based solely on NL-XUV processes. The rich and dense structure of the studied auto-ionizing manifold signifies applicability of the method to complex systems. In this sense the present experiment opens up a new chapter in time domain studies of realistic complex systems, at ultra-high temporal resolution.

Dimitris Charalambidis

P. Tzallas, E. Skantzakis, L.A.A. Nikolopoulos, G. D. Tsakiris, D. Charalambidis, "Extreme-ultraviolet pump-probe studies of one-femtosecond-scale electron dynamics", Nature Physics, published online 3 July 2011, doi:10.1038/nphys2033

Ultrafast electronic delocalization

Mott insulators show interesting behaviour when probed with laser pulses on an ultrafast timescale. A recent collaboration between groups from Oxford, Hamburg, Japan and LASERLAB-EUROPE partner CUSBO (Milan), carried out in the framework of the LASERLAB Transnational Access Programme, sheds light on this phenomenon.

The conducting or insulating nature of most materials is dictated by their band structure. Electrons in bands are delocalized over the material and their mutual interactions can be neglected. This results in material properties that are only dictated by the filling of the bands. If a band is full, and the next available state is separated by a band-gap, the material is an insulator; if the band is partially filled, then electrons can easily move to unoccupied states and the material is a conductor. However, the interactions between electrons can be significant and even dominate a material's properties. In these so-called "strongly correlated" materials a band-theory based prediction of the properties is often in complete contradiction to what is observed.

Electron-electron interactions can be described by the Mott-Hubbard model. In this picture each lattice site contains two states (spin up and spin down) and donates an electron. From a band-structure point of view, this material would be considered half filled, and therefore a metal. However, the Mott-Hubbard Hamiltonian consists of two terms, one in which the electrons can gain an energy *t* by hopping between lattice sites and which favours delocalized states, and a second term, *U*, which represents the Coulomb repulsion energy penalty when two electrons occupy the same lattice site, favouring localization. The conducting or insulating nature of these materials is dictated by the relative strength of *U* vs. *t*; in the limit of $U >> t$, electrons localize on individual lattice sites and the material is insulating.

Mott insulators are particularly sensitive to changes in filling. In a band material, adding or removing charges via chemical doping only affects the position of the Fermi level and not the band structure, thus the charges already present do not feel the effects of the doped charges. In Mott insulators, the interactions between electrons result in additional perturbations to the electronic structure and can have a dramatic influence on the physical properties.

This sensitivity is also observed in the response to laser excitation, which redistributes charge, where large changes in the reflectivity are observed over a wide range of wavelengths. Photo-doping often induces a transient 'metallization' of the sample, with a Drude-like response observed at low wavelengths and a suppression of the charge-transfer resonance, the energy cost to overcome the electron-electron interaction, see figure 1.

To date, little is known about the processes that trigger the collective response and delocalization of charges in photo-excited Mott insulators and to tackle this problem a collaborative approach between groups in Oxford, Hamburg, Tsukuba and Milan (CUSBO), in the framework of a project sponsored by LASERLAB-EUROPE, was required.

The timescale for electrons to delocalize is proportional to Planck's constant divided by the inverse of the hopping energy. Therefore, to probe dynamics on these materials, light pulses shorter than this timescale are needed. In many materials hopping times are of order 1 fs, too short for current experiments. However the organic salt ET-F_2TCNQ, supplied by the Tsukuba group, has a low hopping energy of ~0.1 eV corresponding to timescales of a few tens of femtoseconds. The next step was to measure the effects of photo-doping on the charge transfer resonance, as this is a probe of the localized electrons. In ET-F_2TCNQ, this resonance is centred at 0.7 eV or 1.7 μm. Generating sub-10 fs pulses in this spectral region is particularly challenging, as the optical cycle period at this frequency is ~5 fs. Fortunately, a novel optical parametric amplification and an adaptive-optics based compression technique, recently developed by the CUSBO researchers, produced pulses in the required spectral range together with 9 fs duration. This facility enabled the Oxford-Hamburg group to perform high time-resolution pump-probe experiments on ET-F_2TCNQ.

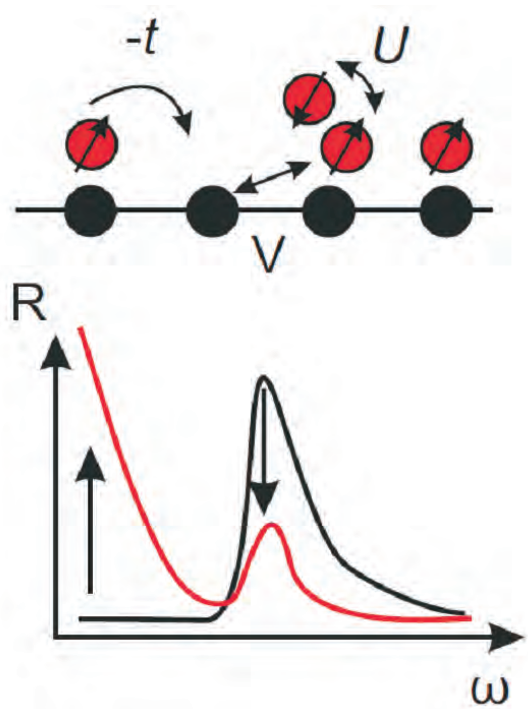


Fig. 1: (upper) Cartoon of a Mott insulator. Electrons (red) can hop between lattice sites gaining an energy t. However, if a lattice site is occupied by two electrons, there is an energy penalty U. This interaction is felt by nearest neighbours with strength V. (lower) Reflectivity of a Mott insulator (black line), the peak corresponds to the charge transfer resonance, the energy cost to create a lattice site with two electrons. After photo excitation (red line) the peak is reduced and a Drude like response at low wavelengths is observed.

In the measurements, a strong pump pulse excites electrons within ET-F_2TCNQ, and the effects are measured by a weak probe pulse. By controlling the delay between the pump and probe pulses the dynamics of the material can be resolved. In addition, by spectrally resolving the probe pulse in a spectrometer, the frequency-dependent reflectivity changes can be obtained.

The high temporal and spectral resolution obtained in these experiments enabled the dynamics of the charge transfer resonance to be probed in unprecedented detail and allowed the extraction of the time dependent optical conductivity. As expected, the charge transfer resonance decreased after excitation due to the delocalization of the charges. However, also observed was a near single cycle 25 THz oscillation of the resonance position (see figure 2).

In order to understand these phenomena the Oxford group performed numerical simulations of the time-dependent Mott-Hubbard Hamiltonian. These simulations, normally performed to model dynamics in the highly controlled environment of optical lattices, were able to accurately describe the observed physics. Firstly, the Hubbard parameters *U* and *t* were obtained by fitting the profile of the charge transfer resonance under static conditions. It was found that an addition *V* term was also required which extends the Coulomb interaction to include nearest neighbours. With these parameters held fixed, a charge transfer excitation was introduced and the numerical simulation was allowed to evolve.

Remarkably, without any additional parameters or tuning, the same 25 THz oscillation in the peak position was reproduced. These simulations allow important insights into the charge delocalization processes. A charge transfer excitation in a Mott insulator creates lattice sites with two electrons, a doublon, and a neighbouring lattice site with no electrons, a holon. During the delocalization process, the holon and the doublon evolve between bound and ionized states, giving rise to the observed oscillations, before finally delocalizing.

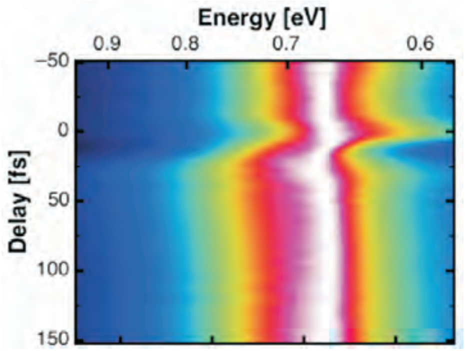


Fig. 2: The measured time dependence of normalized charge transfer resonance (positive delays correspond to times after the pump pulse) showing an oscillation in the peak position at 25THz.

These experiments show some of the interesting physics that can be observed in Mott insulators when probed on the ultrafast timescale. From these experiments further observations can be predicted, for example, charge delocalization on a timescale which is fast also compared to *U* as well as *t* will reveal the effects of the on-site Coulomb repulsion, suggesting interesting physics to be observed in attosecond condensed matter.

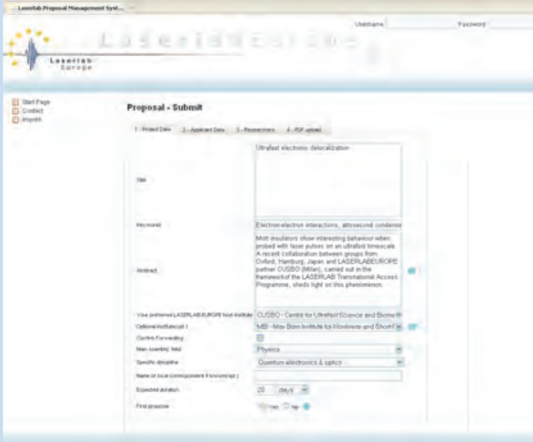
Simon Wall

S. Wall, D. Brida, S.R. Clark, H.P. Ehrke, D. Jaksch, A. Ardavan, S. Bonora, H. Uemura, Y. Takahashi, T. Hasegawa, H. Okamoto, G. Cerullo, A. Cavalleri, "Quantum interference between charge excitation paths in a solid-state Mott insulator", Nature Physics 7, 114 (2011)

Laserlab Proposal Management System 2.0

A new online system for the submission and management of Access proposals to the Laserlab facilities was launched in March 2011. The system of 2004 had shown its age coping with the increasing number of Access facilities and applications in Laserlab during the past years, so that the need for a replacement was evident. However, developing a new and flexible software system is a complex task which tends to take longer than anticipated. The system now offers a new design and improved web interface with secure access over https protocol. A new feature for the proposal submission allows to indicate an additional institute where the research project might be performed in case the execution is not feasible at the first choice lab. Applicants have the possibility to monitor the status of the processing of their proposal and receive an automatic email notification about the final decision. The Laserlab partners now find the incoming proposals and all related management and reporting tools in one unified system.

Applicants may find the new forms in the Transnational Access section of the Laserlab homepage or directly at the new address:
https://laserlab.mbi-berlin.de/access



ELI on its way to implementation

The Extreme Light Infrastructure (ELI) is getting ready for implementation. Over the last few months, the three countries that will host the infrastructure have been working on the final arrangements necessary for the establishment and organisation of the ELI Delivery Consortium. As the successor to the ELI Preparatory Phase Consortium, this new structure will be entrusted with two essential objectives: on the one hand, it will ensure coordination and consistency in the implementation activities carried out by the local project teams based in the Czech Republic, Hungary and Romania; on the other hand, it will organise the discussions and negotiations with partner countries on the establishment of the future pan-European consortium that will operate ELI. Established as a legal entity, the ELI Delivery Consortium will be served by a fully dedicated international team, whose recruitment is about to start.

Meanwhile, significant progress has also been achieved in the three host countries. On April 20th, the European Commission officially approved the grant application of the ELI Beamlines, thereby allowing the launch of the implementation activities in the Czech Republic. In Hungary and Romania, official support to the funding of the ELI Attosecond and ELI Nuclear Physics facilities was confirmed earlier this year at the highest governmental levels; all efforts are now being made to complete the preparation and design activities and submit the applications for funds to Brussels in the second half of the y ear. The conference "Light at Extreme Intensities" (15-18 November 2011 in Szeged, Hungary) will be an excellent opportunity to exchange on ELI's science and report on the development of the three sites.

More on the LEI conference:
http://www.eli-hungary.hu/lei2011/

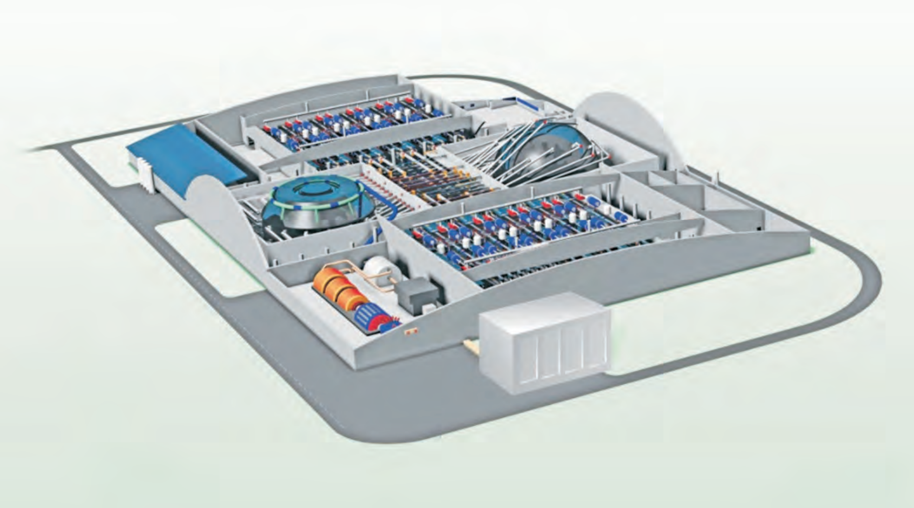
Florian Gliksohn
ELI Delivery Consortium

HiPER

The European Commission has formally approved the extension of the HiPER Preparatory Phase until April 2013. This is a very important decision as it enables the project to maintain the EC funded aspects and therefore to maintain the HiPER 'brand' until NIF ignition, whilst pursuing the national campaigns for funding the 'Technology Development' Phase.

A dedicated HiPER workshop took place as part of the SPIE Optics and Optoelectronics conference held in Prague in April 2011. The workshop consisted of an opening talk describing recent news and progress, a series of technical talks to showcase progress to date and an evening forum where progress with the national funding campaigns was presented.
http://spie.org/x25077.xml

Marie-Anne Clarke



Updated concept of the HiPER facility showing the 'Development chamber' on the right hand side and the 'Power Production' chamber on the left.The Power production capability can be added as an upgrade to the existing facility.

Announcements

Forthcoming events

16 June 2011, 2nd Annual Meeting NAUUL: "New European PW laser facilities: perspectives and challenges", Salamanca, Spain

4-7 July 2011, Laserlab Europe User Community Training: Regional Eastern Europe Training School for Potential Users joined with Workshop on Advanced Optical Techniques in Bio-Imaging

12-16 September 2011, Related event: 7th International Conference on Inertial Fusion Sciences and Applications (IFSA 2011), Bordeaux, France

How to apply for access

Interested researchers are invited to contact the LASERLAB-EUROPE website at www.laserlab-europe.eu/transnational-access, where they find all relevant information about the participating facilities and local contact points as well as details about the submission procedure. Applicants are encouraged to contact any of the facilities directly to obtain additional information and assistance in preparing a proposal.

Proposal submission is done fully electronically, using the LASERLAB-EUROPE Electronic Proposal Management System. Your proposal should contain a brief description of the scientific background and rationale of your project, of its objectives and of the added value of the expected results as well as the experimental set-up, methods and diagnostics that will be used.

Incoming proposals will be examined by the infrastructure you have indicated as host institution for formal compliance with the EU regulations, and then forwarded to the Users Selection Panel (USP) of LASERLAB-EUROPE. The USP sends the proposal to external referees, who will judge the scientific content of the project and report their judgement to the Users Selection Panel. The Users Selection Panel will then make a final decision. In case the proposal is accepted the host institution will instruct the applicant about the further procedure.

Laserlab Forum Contact:

Professor Wolfgang Sandner
Coordinator - LASERLAB-EUROPE
The Coordinator's Office
Daniela Stozno
Assistant to the Coordinator
Max Born Institute
Max-Born-Str. 2A,
D-12489 Berlin, Germany
Phone: +49 30 6392 1508
Email: stozno@mbi-berlin.de

Laserlab Forum Editor: Tom Jeltes
Email: tomjeltes@gmail.com
Layout: Wiebke Metzgen

If you would like to subscribe to this publication or find out more about the articles in this ne wsletter, please contact the editorial team
office@laserlab-europe.eu