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Laserlab Forum

Newsletter of LASERLAB-EUROPE:
the integrated initiative of European laser
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Laserlab and Industry

Impression of the novel photodetector envisioned by Frank Koppens and Gerasimos Konstantatos. Colloidal quantum dots (red) on a layer of graphene (honeycomb structure). © ICFO

In this Issue

Editorial

Tom Jeltes

Though much can be said against unrestricted involvement of industry with science – many scientists may even feel that their sacred scientific endeavour could be tainted by commercial thinking – it is also clear that much can be won by sensible collaboration between the people in the laboratory and those who know what kind of products society is willing to pay for.

In many cases, both worlds can benefit from close collaboration: commercial companies might turn a scientist's idea into a marketable product, or, the other way around, they may provide input for scientific research in the form of essential laboratory equipment.

To illustrate the importance of collaboration between science and industry, we dedicated several pages of this issue of Laserlab Forum to an 'Industry Focus', describing several ways in which business and academia can interact to the benefit of both.

To some extent, even researchers who operate in a purely academic environment have to think commercially, because they have to get funding to be able to buy equipment and hire junior researchers to pursue their scientific goals. Writing attractive funding proposals is a way of advertising yourself and your research. Evidently, this skill has become of paramount importance for the professional survival of scientists in the past decades and some do much better than others.

Still, I was surprised to see that all three ERC Advanced Grants awarded within the Laserlab-Europe community in 2013 go to researchers who also received this same grant at the first opportunity some five years ago. I would like to congratulate these outstanding researchers with their ability to convince 'the market' to buy their 'product'. More about their exciting new plans can be found in this sixteenth issue of Laserlab Forum.

Tom Jeltes

News

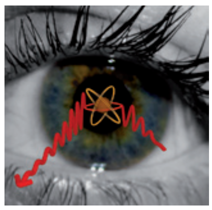
Herbert Walther Award for Massimo Inguscio

Massimo Inguscio, professor of Atomic Physics and Structure of Matter at Laserlab-Europe partner LENS (Florence, Italy) will receive the 2014 Herbert Walther Award for his 'groundbreaking experiments in modern atomic, molecular and optical physics, and for his scientific leadership world-wide'. Inguscio will get the award, which entails a plaque, a certificate, and 5000 euros, at the Spring Meeting of the Deutsche Physikalische Gesellschaft (DPG).

The Herbert Walther Award is a joint award by DPG and the Optical Society (OSA), and presented by each society in alternate years. Established in 2007, the Award recognizes distinguished contributions in quantum optics and atomic physics as well as leadership in the international scientific community. Inguscio will join the list of esteemed past recipients including Alain Aspect, Marlan O. Scully, Serge Haroche and David J. Wineland.

Inguscio is considered a leader in AMO physics thanks to his many cutting-edge experiments with ultra-cold atomic gases. Notably, he was among the first to research the possibilities of sympathetic cooling to cool atoms such as potassium.

Non-destructive detection of optical photons achieved at MPQ



© MPQ, Quantum Dynamics Division.

Scientists from the Quantum Dynamics Division of Prof. Gerhard Rempe at Laserlab-Europe partner MPQ (Garching, Germany) have for the first time realised a device with which an optical photon can be detected without destroying it. The new method, an important breakthrough for quantum information experiments, was reported in Science Express on 14 November 2013.

Up until now the only way to detect photons, quanta of light, was via absorption by a sensitive medium. In the process, the photon is destroyed. The MPQ device, though, allows researchers to 'see' the light particle while keeping it intact. They use a single rubidium atom locked inside an optical cavity. By preparing the atom in a so-called superposition of two states, a photon of the right energy, impinging on the cavity, will have an effect on the atom (it causes a phase-shift), without being absorbed by it.

So far, the chance of detecting a single photon is 74%; two out of every three photons survive the detection process, but according to the researchers, these values are not fundamentally limited. Repeated detection of photons allows construction of a deterministic quantum gate for photons, which would be an essential building block for optical quantum computers.

New laser-plasma research centre at Strathclyde

A new research centre devoted to the exploitation of laser-plasma based accelerators is being built at the campus of the University of Strathclyde, partner of Laserlab-Europe. The Scottish Centre for the Application of Plasma-based Accelerators (SCAPA), a facility of 10 million euros and 1200 m², is a project of the Scottish Universities Physics Alliance. SCAPA is scheduled to begin operation at the end of 2014 and will be led by Strathclyde's Professor Dino Jaroszynski.

The centre will house three shielded areas and seven laser-accelerator beam lines that will provide a range of very high energy particle beams (electrons, protons, ions) and very bright bursts of incoherent and coherent radiation (from terahertz to hard X-rays) for a wide range of applications. Two high power femtosecond laser systems will be used to produce the secondary sources of radiation. Relativistic electron beams with energies exceeding one GeV will be used as drivers of betatron, synchrotron and free-electron laser light sources. In addition, proton and ion beams with energies of 100's MeV will be produced using solid targets.

These radiation and particles beams will enable the study of a wide range of applications, including particle beam therapy, isotope generation, imaging, detector development, and damage of material in harsh environments such as fusion reactors and in space.

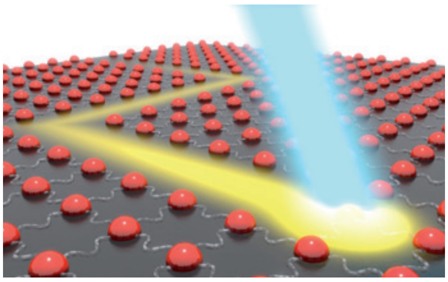
SCAPA will also host a Centre for Doctoral Training to train PhD students (new intake of ~12-14 per year) in advanced applications and the development of laser-based radiation sources. This should help with ultimately providing trained personnel for the ELI and other EU facilities. Furthermore, industrial partnership is expected to play a key role in SCAPA.

What is Laserlab-Europe?

Laserlab-Europe, the Integrated Initiative of European Laser Research Infrastructures, understands itself as the central place in Europe where new developments in laser research will take place in a flexible and co-ordinated fashion beyond the potential of a national scale. The Consortium currently brings together 30 leading organisations in laser-based inter-disciplinary research from 16 countries. Its main objectives are to maintain a sustainable inter-disciplinary network of European national laboratories; to strengthen the European leading role in laser research through Joint Research Activities; and to offer access to state-of-the-art laser research facilities to researchers from all fields of science and from any European laboratory in order to perform world-class research.

LaserLaB Amsterdam partner in nanolithography institute

Laserlab-Europe partner LaserLaB Amsterdam will participate in a new institute for fundamental and applied research on extreme ultraviolet lithography. The Advanced Research Centre for NanoLithography (ARCNL) will be located at the Science Park Amsterdam and is partially funded by ASML, the leading manufacturer of photolithography systems for the semiconductor industry. The ARCNL will host around one hundred researchers and has been given a budget of 100 million euros for a period of ten years.



The institute will focus on the physics of EUV light, infrared-laser physics, (surface-)physics of clusters and radicals and nanophotochemistry. LaserlaB Amsterdam's extensive experience in the field of EUV physics has contributed to the election of the Amsterdam consortium as a partner in the ARCNL; LaserLaB Amsterdam professors Wim Ubachs and Kjeld Eikema will contribute key expertise to the scientific problems associated with EUV lithography.

ERC Starting Grant Thibault Cantat

Recycling CO_2 might provide an alternative to fossil resources as a feedstock for organic chemicals. However, CO_2 is difficult to transform; only a handful of chemical processes recycling CO_2 have been industrialised so far. Thibault Cantat from SLIC (Saclay, France) will use the ERC Starting Grant he was awarded this year to design novel catalytic transformations in which CO_2 reacts with so-called functionalising reagents and reductants to produce a large spectrum of molecules.

Thibault Cantat (SLIC)

In 2012, Cantat and his team established a proof of concept of what they call the 'diagonal approach' by co-recycling CO_2 and PHMS (a chemical waste of the silicone industry), converting amines to formamides. The goal of Cantat's project is to synthesise amines, esters and amides, which are currently all obtained from fossil materials. Cantat also envisions that his project will increase the understanding of CO_2 activation and will provide invaluable insights into the basic modes of action of organocatalysts in reduction chemistry.

ERC Starting Grant Melike Lakadamyali

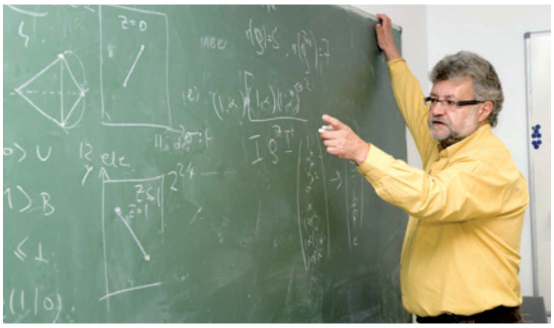
Melike Lakadamyali (ICFO)

Intracellular transport plays a key role in many processes inside cells and its breakdown can have catastrophic consequences. For example, transport failures are an early indicator and a likely cause of many neurodegenerative diseases. Understanding what goes wrong with intracellular transport during disease, requires knowledge of how so-called motor proteins work together to transport cargo, but those proteins are difficult to visualise due to their small size and complex environment.

Melike Lakadamyali from ICFO (Barcelona) received a Starting Grant from the ERC to try and overcome this visualisation problem by combining several advanced techniques (such as single particle tracking, quantitative single molecule counting, genetic manipulation, and fluorescence labelling) with 'nanoscopy' – a branch of fluorescence microscopy in which the diffraction limit is overcome. Lakadamyali believes that this multidisciplinary approach will for the first time provide a detailed picture of how motor proteins function inside living cells.

ERC Advanced Grants 2013

In the sixth round of the Advanced Grant competition of the European Research Council (ERC), three prominent scientists from LASERLAB-EUROPE partners have been awarded this prestigious grant of up to 3.5 million euro. For each of them it is their second Advanced Grant, after a first successful application in 2008.



Maciej Lewenstein (ICFO)

Maciej Lewenstein (ICFO)

Systems that interact with their environment play an important role in many areas of physics, chemistry, and biology. In recent years, considerable attention has been drawn to such 'open systems'. For example, recent advances in bio-photonics have allowed to observe Brownian motion of biologically functional particles in cells, and ultracold atoms have been proved to be eminently suited for building quantum simulators and basic quantum computers. In both systems, interaction with the environment plays a significant role. Many aspects of these open systems, however, are not well understood.

With his second ERC Advanced Grant, Maciej Lewenstein, Professor of quantum optics theory at ICFO (Barcelona), intends to develop a theory of classical Brownian motion of biological molecules on the surface of the cell membrane and in the cell, as well as a theory of quantum Brownian motion in an inhomogeneous environment. Furthermore, he aims at formulating new models of classical many-body open systems, and hopes to develop a theory of open-system quantum simulators. According to Lewenstein's expectations, investigating the connections between these seemingly disparate project goals will lead to a unified theory of open systems.

Victor Malka (LOA)

Victor Malka (LOA)

In free-electron lasers (FEL), coherent electromagnetic radiation is produced by a relativistic electron beam moving through a periodic magnetic field structure. This rather special type of laser can be used to generate a particularly broad spectrum of radiation, ranging from microwaves to X-rays. As such, free-electron lasers are part of the so-called *fourth generation* of light sources. With his new ERC Advanced Grant, Victor Malka intends to demonstrate the feasibility of a *fifth generation* light source: free-electron lasers injected with electron beams produced with laser-plasma accelerators.

In recent years, Malka's group at LOA, Palaiseau, has been able to produce very intense electric fields (in the order of hundreds of Gigavolts per metre) by controlling the collective motion of electrons in a plasma medium. Using different injection schemes, they have shown that local injection of electrons allows fine-tuning of the electron beam parameters. Combined with the fact that laser-plasma accelerators can nowadays deliver high-quality particle beams in ultra-short bunches (of a few femtoseconds) and high peak currents (of a few thousand amperes), laser-plasma accelerators seem a natural candidate to reduce the size and cost of future free-electron lasers.

The project, called *X-five,* aims at delivering bright X-ray beams at a repetition rate of 10 Hz, and will be especially of interest for applications which do not require very high average brightness. Malka foresees applications in, for example, medicine, radiation biology, chemistry and security.

Anne L'Huillier (LLC)

Anne L'Huillier (LLC)

As the field of attosecond science is entering the second decade of its existence, scientists are ready to move from merely mastering the generation and control of attosecond pulses to application in the emerging scientific field of 'ultrafast atomic physics', where one- or two-electron wave packets are created by absorption of attosecond pulse(s) and analysed or controlled by another short pulse.

With her second ERC Advanced Grant, Anne L'Huillier from Lund Laser Centre, will try to answer a number of basic questions: how long does it take for an electron to escape its potential, how long does it take for an atom to become an ion once the electron has left the atom, and where, how and when do the electrons leave the atom?

In order to answer the first of these questions, L'Huillier will measure photo-emission time delays for several atomic systems, using a tuneable attosecond pulse system. To study the ionisation process, XUV pump/probe experiments are required to find the transition between so-called non-sequential double ionisation (where photons are absorbed simultaneously and both electrons emitted at the same time) and sequential ionisation (where the electrons are emitted one at a time). Finally, L'Huillier wants to combine coincidence measurements with angular detection, allowing to characterise (two-particle) electronic wavepackets in both time and momentum.

Workshop on characterisation of ultra-short high-energy laser pulses

On 23-24 September 2013, a two-day workshop was held in Abingdon, UK, on the characterisation of ultra-short high-energy laser pulses. The workshop was hosted by the Central Laser Facility (CLF) on behalf of Laserlab-Europe and attended by over thirty participants from eleven institutions. It enabled the delegates to discuss the challenges surrounding the characterisation of laser pulses used in laser-matter interactions, which is fundamental to the understanding and interpretation of the resultant data.

The workshop was attended by delegates from established facilities and those that are developing their own systems. The sentiment throughout the presentations and discussions was one that enabled common problems to be aired and potential solutions identified. The format of the workshop was arranged so that the overall topic was divided into sessions, with a series of talks that were then used as discussion points for the rest of the session.

The first session concentrated on measuring the pulse durations of high energy Nd:Glass lasers, where the biggest problem is to ensure that there is a reliable pulse length measurement on a shot-to-shot basis. The discussion revolved around the issues of the B-integral (the nonlinear phase shift along the beam's optical axis, ed.) and its impact on the pulse shape and pulse length tuning and on pointing stability into the measuring devices. The methods used to attenuate the incident energy on the shot to reduce the B-integral for the diagnostics arms fell into two camps, with the relative merits of reflective and transmissive schemes being discussed. In addition, the technique of using a sub-aperture sample beam to measure the pulse length was explored.

The second session was targeted at Ti:Sapphire laser systems; since those have higher repetition rates than Nd:Glass lasers it was felt that the average pulse length measurement was appropriate for diagnosing the laser. With the shorter pulse lengths operated on these systems, the pulse-front tilt is an additional problem and the talks in the session led to discussions on the use of inverting interferometers for pulse-front tilt measurements and the availability and reliability of commercially available diagnostics. There was a later session dedicated to different techniques for measuring the pulse-front tilt, and this enabled a thorough discussion as to the limitations and advantages to the different schemes being developed by the speakers.

The third session discussed the difficulty associated with measuring the contrast of laser pulses. The talks from the session showed that whilst there are reliable schemes for determining the nanosecond contrast 'on the shot', the contrast within picoseconds of the arrival of the pulse still requires the use of a scanning device for stable measurement. It was also discussed that with the difficulty measuring the pulse duration on high-energy systems, measuring the contrast would be an even greater challenge.

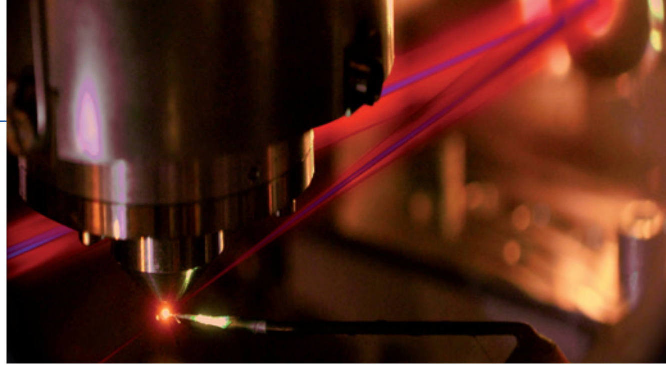
Measurement of the spatial beam quality on the shot was also an area that brought together a consensus that it was a difficult measurement to make; the best approach seemed to be an equivalent-plane measurement or one that recreated a spot from a wave-front measurement.

With the advent of multi-PW laser systems, the diagnostics challenges associated with these schemes led to an interesting discussion on the relative merits of using parabolas for beam expansion for very broad bandwidths and how to maintain their alignment. Techniques for measuring and characterising damage to the final gratings were also discussed.

The problems associated with higher repetition rate laser systems led to a discussion about automated processing of diagnostics and the potential problem with large amounts of laser diagnostic data and whether an average or sampling approach should be taken. Other highlights from this discussion included the use of reflective optical systems for polarisation control and the potential benefits of a dark-field imaging system for damage detection.

Ian Musgrave (CLF)

Science and industry: a two-way street



View inside a vacuum chamber at UFI.

Technological inventions, whether originating from the academic world or created in industry's research labs, are an essential ingredient for our modern economy. Close collaboration between science and industry increases the odds that such findings will eventually benefit society. In these collaborations, knowledge can flow in two directions.
On the one hand, to be able to answer a specific scientific question, scientists often create methods and machines that could also be used for applications outside their field. Generally, these scientific devices are difficult to use for others than those who built them. The step towards a user-friendly marketable product can either be made by creating a spin-off company with heavy involvement of the scientists themselves, or by contacting an established company with a relevant background.
On the other hand, scientific progress is greatly enhanced by dedicated companies supplying components and even fully functioning systems (e.g., frequency combs and other laser systems) to the scientific world. Close ties to relevant research groups, which can provide feedback about those products and can come up with new ideas and inventions, are essential for these high-tech companies.
In this 'Industry Focus', Laserlab Forum presents a short overview of some high-tech companies, both recent spin-offs and independent businesses, associated with several Laserlab-Europe partners. In addition, two new ERC Proof of Concept projects – from LaserLaB Amsterdam and ICFO – are presented, illustrating how the European Research Council stimulates development of scientific results into profitable products. **Tom Jeltes**

Ultrafast Innovations – MPQ

ULTRAFAST INNOVATIONS

Ultrafast Innovations GmbH (UFI) was founded in 2009 as a spin-off from the Ludwig-Maximilians-Universität München (LMU) and the Max Planck Gesellschaft (MPG), Germany, which are also the stockholders of the company. The objective of UFI is to provide commercialized solutions developed at LMU and the Max Planck Institute for Quantum Optics (MPQ), especially by the groups of Ferenc Krausz and Ulf Kleineberg, to the growing ultra-short-pulse laser community.

UFI does this with success, as is shown by recent projects such as the installation of a beamline for attosecond streaking experiments for the King Saud University in Saudi Arabia, and the design and development of a new enhancement cavity for the Friedrich Schiller University in Jena, Germany. In general, UFI provides optical elements suited for ultra-short laser pulses, ranging from the infrared to extreme ultraviolet and x-rays.

"The idea is to use the technological and research expertise for industrial projects in a straight-forward way", says Hans Koop, UFI's current CEO. According to him, much of the success of the company should be credited to the vision and engagement of Ferenc Krausz who initiated the founding of UFI.

UFI, which has 10 employees, takes care of engineering, product development, and customer relations, whereas science remains the main task of the research groups of Ferenc Krausz and Ulf Kleineberg. Koop: "That means that UFI is basically working at the fount of new products and that UFI has access to passionate coworkers who made their profession their hobby. We really hope that UFI is beneficial for the people and all research institutions of the Garching research campus.

http://www.ultrafast-innovations.com/

Light4Tech – LENS

light4tech high tech solutions

Light4Tech was founded as a joint venture between a group of academic researchers from the European Laboratory for Non-linear Spectroscopy (LENS) in Florence and several industrial partners in 2005. The company itself stands halfway between the worlds of research and industry, and it offers prototyping and technology transfer services mainly in the fields of photonics and (bio)physics. As such, it intends to fill the gap between basic research and industrial research. The company's know-how includes microscopy, biological imaging, machine vision, and image and data analysis. It employs five people.

Light4Tech is a versatile company: it not only works for high-tech companies that would like to develop a new product, but it is also hired to create products based on ideas from academic groups. It owns state-of-the-art labs, says Domenico Alfieri: "Our laboratories consist of two experimental rooms with a very accurate air control system. That's a prerequisite for advanced optical research. The labs are equipped with optical tables and related optical and electrical tools and chemicals." These labs are not only used by Light4Tech: the company also offers private and public researchers access to their labs.

"A typical approach with L4T starts with a joint technical discussion about the idea or product to be developed", says Alfieri. "This is then followed by a technical and economic feasibility study, which is performed by L4T."

Which ideas from the labs of LENS, the University of Florence, and other academic partners are eligible for the 'L4T treatment' is decided by a Scientific Committee together with an Industry Panel. Alfieri: "They evaluate the most promising research in terms of results and devices, looking at the potential market, to see which ideas can be patented or industrialised by L4T. Our motto is: we give legs to ideas."

http://www.light4tech.com/

Optics11 – LaserLaB Amsterdam

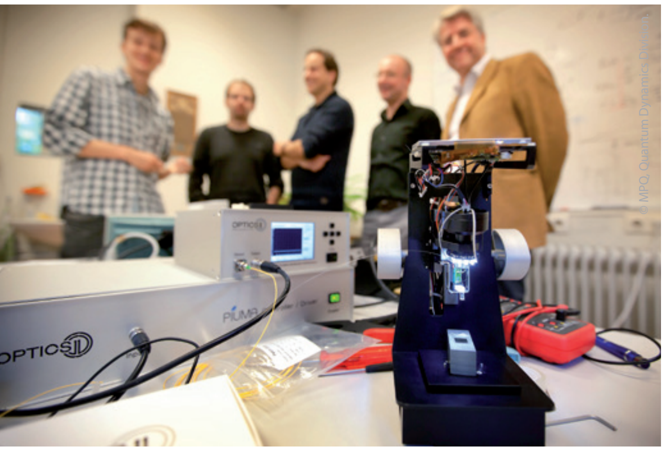
OPTICS11 ideas on the top of a fiber

In 2011, Davide Iannuzzi, University Research Chair Professor at LaserLaB Amsterdam, teamed up with serial entrepreneur Hans Brouwer to found Optics11. The company markets the 'fibre-top' technology Iannuzzi invented. This technology allows producing an atomic force microscope probe at the end of an optical fibre, which can be used at a distance in harsh and wet environments. The method uses a tiny cantilever at the tip of the probe, which reflects light back into the fibre.

The idea dates back to 2005. At the time, Iannuzzi tried to solve a technical problem related to one of his nanoscale experiments when he sketched the design of a new device based on an optical fibre. The Italian realized that using this design he could not only overcome the particular problem he was trying to solve, but that it had the potential to become a new platform for all kinds of miniaturised optomechanical sensors. After building a prototype for his laboratory, Ianuzzi decided he wanted to transform his idea into a mature technology.

Since then, among other grants, Iannuzzi collected a Starting Grant, a Proof-of-Concept and a Consolidator Grant from the ERC to develop his fibre-top technology, which is now being used in ten different countries.

"Academic entrepreneurship is a healthy exercise: it has been teaching me the difference between *doing* and *delivering*, while still widening my scientific horizon", Iannuzzi said about his commercial adventure on the recent occasion of his inaugural lecture as University Research Chair Professor. "Going outside the comfortable rooms of my own laboratory required a change of mindset. The focus had to shift from what we were doing for us to what we wanted to deliver to others. But the effort had its payback. Thanks to the spread of my technology, I am meeting scientists from the widest range of disciplines, which leads to many enlightening discussions."
http://www.optics11.com/

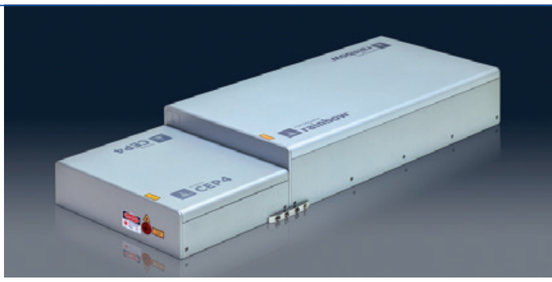


The 'fibre-top' atomic force microscope by Optics11.

Femtolasers – MBI

The group of Günter Steinmeyer from the Max Born Institute for Nonlinear Optics and Short-Pulse Spectroscopy (MBI, Berlin) developed a method to stabilise the Carrier-Envelope Phase (CEP) of laser pulses. MBI had a patent filed, which was later transferred to Femtolasers Produktions GmbH in Vienna. Femtolasers now sells the CEP4™ method as an add-on to their FEMTOSOURCE™ rainbow™ series of ultrafast oscillators.

Since MBI's research is mostly directed at fundamental science, patents are more an exception than a rule. Nevertheless, the institute strongly supports patenting of relevant ideas and some of them are sold or licensed.



Femtolasers' rainbow oscillator with CEP4 module.

According to Steinmeyer, MBI was already an important customer of Femtolasers. "MBI has one of the biggest installations of Femtolasers' products in Europe. When we contacted them about the CEP stabilisation method, they immediately showed great interest. We then demonstrated the idea in the presence of several people from Femtolasers. The result was published in Nature Photonics in 2010, with an equal number of co-authors from MBI and Femtolasers."

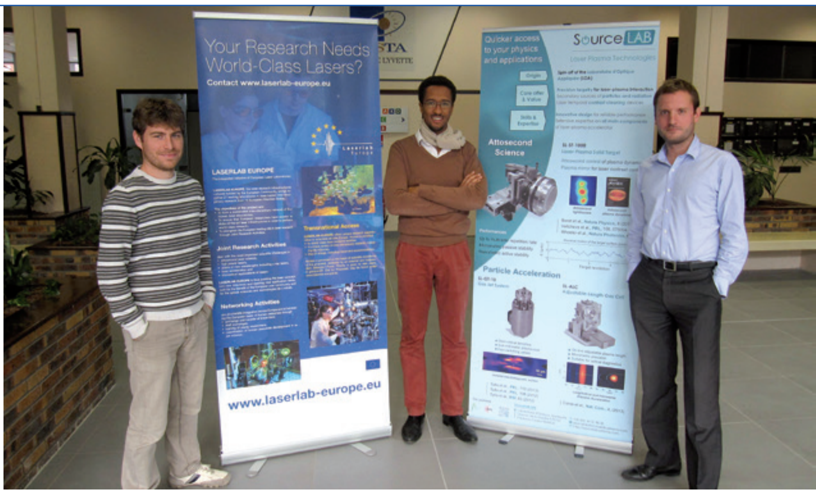
Next, Femtolasers took over and developed the lab demonstration into a product, while MBI agreed to support this process in any way possible. "There were a lot of technical questions and solutions, which we mostly discussed on the phone or via email; the payback has been a few more shared publications", says Steinmeyer. MBI wants to show that their ideas are not only of theoretical nature, but that they really enable superior stabilisation, he says. "We had to make it very clear that the feed-forward scheme is not just a cheap and inferior work-around for the proven feedback technology. And this can only be done by peer-reviewed publication in some of the top journals. In turn, this is the best advertisement that Femtolasers can get."
http://www.femtolasers.com/

SourceLAB – LOA

SourceLAB is a spin-off from the Laboratoire d'Optique Appliquée (LOA) in Palaiseau near Paris. It was founded in February 2011 by Antonin Borot and François Sylla based on their thesis works at LOA during the previous years. The company provides innovative targets and complete systems (laser, target, and detector) to generate and manipulate beams of particles and high-energy radiation.

CEO François Sylla recounts about the earliest stages of the conception of the company: "One year before the defense of my PhD thesis, I decided to start an entrepreneurial adventure in parallel to the scientific work I was carrying out. The company I intended to create, SourceLAB, should bring the technological fruits of four years of developments in the lab to the market, with the help of the technical expertise I acquired at LOA." Sylla therefore decided to spend the last year of his thesis work not only on the scientific side of the field of laser-plasma interaction, but to explore also the economic and societal side.

"Laser-plasma interaction in the so-called 'underdense regime', implemented by focusing an intense laser onto a gas jet, can be used to create relatively cheap and very compact accelerators delivering beams of very energetic electrons and ions", explains Sylla. "These beams have very interesting properties for scientific, industrial and medical applications." They could be used for such different applications as cancer radiotherapy, electron



The SourceLAB team presenting their company together with Laserlab-Europe. In the middle CEO François Sylla.

beam etching of integrated circuits, irradiation sterilisation of food, non-destructive testing of dense materials, and dating works of art.

Sylla's thesis work paved the way towards compact and energy-efficient laser-plasma accelerators, he says, allowing investigation within a wide range of plasma and laser parameters. In its first year, 2011, SourceLAB had two patents filed, and it was awarded an ERC Proof of Concept grant in the same year.

http://www.sourcelab-plasma.com/

Menlo Systems – MPQ

Menlo Systems is a spin-off from the Max Planck Institute of Quantum Optics (MPQ) in Garching, Germany. It was founded by MPQ Director Theodor Hänsch and his co-workers Ronald Holzwarth and Michael Mei in 2001. Menlo's products are based on the frequency comb technology that brought Hänsch the 2005 Nobel Prize in Physics. The company currently employs more than seventy people.

A Nobel Prize being awarded for the technology you are trying to sell, does not hurt the business, says CEO Michael Mei. "But, actually, we managed to be profitable since early on, after collecting a small amount of private money and a grant from the German government for spin-offs. Also, some of our earliest customers pre-paid for the first units. But I am happy that we already started the business before the Nobel Committee decided to give the prize to Hänsch; the day the prize was announced our web statistics went out of the roof. And, more important, Ted Hänsch has been the best advisor you can think of from the very first day and he is exposed to many potential customers."

Another reason for Menlo's success lies, according to Mei, in the company's attitude. "We always try to make life as easy as possible for our customers. With every frequency comb and other products we also share some of our knowledge with the customers. Indeed, most of the time this is a two-way interchange; we get many things back from them as well."

It helps that he and Menlo's CTO Ronald Holzwarth are both scientists, Mei thinks. "In most places I have been you encounter incredibly smart people, and often it is such a pleasure to work with them that you forget how hard you actually work. If our employees feel the same, I think we do things right."

http://www.menlosystems.com/

Proof of Concept: bridging the gap to the market

The European Research Council actively stimulates its grantees to explore whether any ideas arising from projects funded by Advanced or Starting Grants might be developed into a profitable commercial product. For this purpose, the ERC established the Proof of Concept of up to 150,000 euros in 2011.

This year, Frank Koppens, together with Gerasimos Konstantatos, and Gijs Wuite, from Laserlab-Europe partners ICFO (Barcelona) and LLAMS (Amsterdam), respectively, received Proof of Concept grants to further develop products related to their Starting Grants.

Low-cost and extremely sensitive photodetector

Sensing and imaging in the short-wave infrared is used in such different areas as automotive vision systems for driver safety, food and pharmaceutical inspection, civil and military surveillance, night vision applications and environmental monitoring. The market is currently only limited by the high cost associated with the existing technology.

Frank Koppens' and Gerasimos Konstantatos' Proof of Concept project aims to develop a new type of cheap and extremely sensitive photodetector platform based on graphene and colloidal quantum dots. Graphene is a novel, Nobel Prize winning two-dimensional material with a wide palette of unique properties, including extremely high electronic conductivity. Colloidal quantum dots offer high absorption and bandgap tunability from ultraviolet to short-wavelength infrared. Combined, these two materials form a hybrid photosensitive system with high sensitivity and high gain, which can be integrated on thin, transparent, and flexible substrates – thereby strongly reducing its production costs.

Manipulation of single strands of DNA

The team of Gijs Wuite at LaserlaB Amsterdam has pioneered an experimental technique in which a single molecule of DNA can be manipulated and stretched while individual proteins interacting on it can be filmed in real-time under physiological conditions. For this purpose, a combination of microfluidics, optical tweezers (where micrometre-sized beads are captured and moved by laser beams) and fluorescence microscopy are combined in a single apparatus. The technique allows researchers to study the interaction of proteins with DNA in detail, which can help us increase our understanding of the genetic basis of diseases.

With the Proof of Concept grant, the team will establish a venture to market the apparatus and know-how. In this project, market research, intellectual property, possible establishment of a spin-off company and development of prototypes for launching customers will be investigated. Andrea Candelli, who recently obtained his PhD in this area of research, will take on the challenge to move the venture forward and render this technology commercially available to life scientists.

Networking Events

Laserlab users meet in Marseille

The Laserlab-Europe annual User Meeting of 2013 took place in Marseille, France on September 26 and 27. The meeting was organized by LP3 laboratory (Lasers Plasmas and Photonics Processing) and hosted by Aix-Marseille University at its beautiful administration site Palais du Pharo. The meeting was chaired by Marta Castillejo (CSIC, Spain) and Marc Sentis (LP3).

During these two very busy days, more than sixty people were present to listen to 27 scientific talks related to the main topic of the meeting: 'Using laser sources and secondary sources as diagnostic tools for science'. Of these presentations, 25 were given by Laserlab users coming from sixteen countries who had performed their research in 14 different Laserlab access facilities (CELIA, CUSBO, FORTH, HIJ-FSU, LASERIX, LaserLaB Amsterdam, LLC, LOA, LP3, LULI, PALS, SLIC, USZ and VULRC).

The various talks gave a stimulating overview of experiments in a broad range of research themes, reflecting the diversity of opportunities offered by the Laserlab access programme. Two very interesting and enlightening invited talks were given by John Tisch (Imperial College, UK) and Klaus Sokolowski-Tinten (University of Duisburg-Essen, Germany) on attosecond science and ultrafast X-ray sources to probe solids, respectively.

A lively round table discussion between users, facility operators and members of the Laserlab Access Board was organized by Laserlab User Representatives in order to collect feedback from users and to improve and enlarge access to the different facilities.

Besides these scientific exchanges, social events were organized around the wonderful old harbor of Marseille taking advantage of Marseille being the European Capital of Culture 2013. Thus, participants could visit the new museum MuCeM and share some typical Provençal cuisine. In addition, a visit of the LP3 laser facilities provided an opportunity for users to discover the new and unique ASUR Platform (10 TW, 25 fs, 100 Hz). **Marc Sentis**

User meet in Marseille.

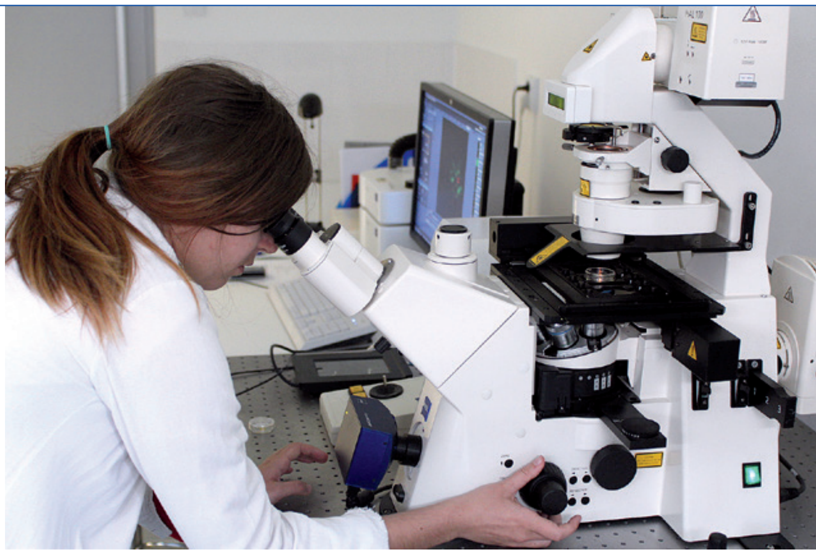


Photo: courtesy of W. Kautek

Practical training at the biophotonics workshop.

User Training Workshop on Biophotonics, Košice

In the last two weeks of June 2013, a User Training Workshop was held in Košice, Slovakia. The workshop, organized at the Pavol Jozef Sfarik University in Košice in collaboration with Laserlab-Europe partner ILC (Bratislava, Slovakia) and Université P. et M. Curie (UPMC, Paris), served to improve the theoretical and practical knowledge of doctoral students in advanced methods of biophotonics.

The two-week course provided students with a set of lectures on recent advances in biophotonics research, namely optical spectroscopy, imaging and time-resolved techniques. The lectures were coherently supplemented with practical demonstrations of the respective experimental techniques. Moreover, interdisciplinary teams, each of 3-4 students, were formed which had to select and develop their own individual projects, related to the focus of the school. The projects were publicly defended and evaluated during the last day of the school and prizes were awarded during the closing ceremony for the best student contributions.

The school of biophotonics was attended by eighteen PhD students and young researchers from five countries, and the lectures and practical trainings were imparted by fourteen internationally recognised experts in the field of biophotonics. Invited foreign speakers included Jürgen Popp (IPHT Jena), Marco Capitanio (LENS), Lorand Kelemen (BRC Szeged), Santiago Sanchez Cortes (IEM Madrid), Franck Sureau (UPMC Paris), and Wolfgang Becker (Becker-Hickl GmbH Berlin).

Information on Laserlab-Europe and the opportunities offered by the project was provided in the form of a 45 minute lecture given by Alzbeta Chorvatova from ILC, while opportunities for access to the Laserlab facilities and for user training events were advertised throughout the whole school. The students also benefited from dedicated lectures on safety and good laboratory practice as well as on ethical issues in biophotonics.

Finally, with the aim to evaluate feedback from the participants, a user training questionnaire was distributed and analysed. In summary, the school of biophotonics in Kosice was highly appreciated by all participants, students as well as lecturers. The student teams presented high-quality research that we believe can lead in future to new collaborative proposals for the Laserlab-Europe access programme.

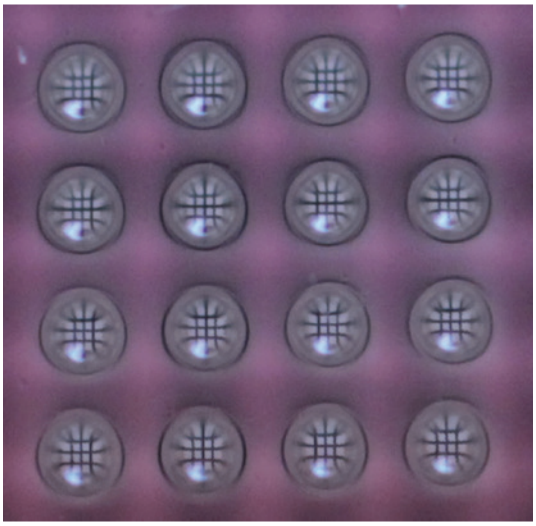
Dusan Chorvat and Pavol Miskovsky

Access Highlight: Slicing Microlenses by Nonlinear Imaging Microscopy

A novel method for microlens characterization and 3D imaging has been investigated in collaboration between Laserlab-Europe partner IESL-FORTH (Institute of Electronic Structure and Lasers, Heraklion, Greece) and the Photonics Center of the Institute of Physics, University of Belgrade (Serbia), granted through the Transnational Access Programme of Laserlab. In this Access project, nonlinear imaging microscopy was used to 'slice' the lenses at different depths, and with the obtained data 3D images of the microlenses were reconstructed. In addition, important characteristics of microlenses – such as surface profile, diameter, volume, and in-depth changes – could be determined.

In our joint research project, we used microlenses manufactured in a novel material and with a well-examined technology developed in recent years at the Photonics Center of the Institute of Physics in Belgrade [1]. On the sunny island of Crete, not very far away from Belgrade, our colleagues at IESL-FORTH developed a prototype experimental setup for nonlinear microscopy [2]. The main property of this method is that it allows micro-objects to be sliced, in an optical manner, at very thin and closely separated layers. Subsequently, the object can be reconstructed in three dimensions using the obtained slices. The microlenses were taken to the laboratory for nonlinear microscopy in Crete in order to show that this advanced non-destructive technique is suitable for microlens characterization.

Figure 1: An image of a regular square grid observed through the microlens array. This figure was used for the cover page of J. Phys. D: Appl. Phys. 46, issue 19 (2013).



The collaboration of the two groups dates back to 2008, to a Laserlab User Meeting held in Hersonissos, Crete, where the undersigned went upon invitation by Prof. Costas Fotakis, then director of IESL, and nowadays director of FORTH. One year later, he spent four months in the laboratory for nonlinear microscopy as a Marie Curie fellow, working as an experienced researcher with George Filippidis and George Tserevelakis [3]. The materials and methods for microlens manufacturing were already well established in Belgrade by Branka Murić and Dejan Pantelić, but some novel diagnostic tool was needed in addition to standard ones like electron microscopy and profilometry. Nonlinear microscopy seemed a good candidate, and an application for Laserlab-funded access to IESL was submitted. The results were encouraging. We established another good method for microlens characterization and the number of applications where nonlinear microscopy can be utilized was significantly extended [4].

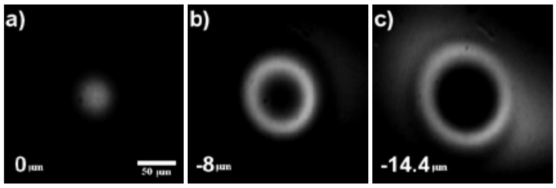


Figure 2: Three THG slice images of a microlens taken at different depths (denoted at the bottom left corner of each picture).

Today, microlenses are used in various high-tech applications and they are rapidly developing. For most applications it is very important to know the exact properties of the microlenses (surface profile, diameter) and to understand the (photo)chemical and physical changes in the material during microlens formation. The microlenses used in our joint research are made by direct laser writing in Tot'hema Eosin Sensitized Gelatin (TESG) layers. Tot'hema is a trade name of a drinkable solution used in medicine for treatment of anemia, while eosin is an organic dye also used in medicine. The resulting material is cheap, easy to use, and biocompatible. Because of the very strong absorption of eosin in the green region, a frequency-doubled CW Nd-YAG laser at 532nm was used for the writing of microlenses. Using precise mechanical stages, we were able to make very fine arrays of microlenses.

Nonlinear microscopy is a scanning technique which utilizes ultra-short laser pulses (1028 nm, 200fs in our case) to induce nonlinear effects, such as Second Harmonic Generation (SHG), Third Harmonic Generation (THG) and Two/Three Photon Excitation Fluorescence (TPEF/3PEF), in the focus of a laser beam inside the volume or at the surface of the micro-object. Whenever any of these nonlinear effects are present, they are detected – usually by photomultiplier – and the signal is recorded by a computer. Scanning the laser beam spot by spot, an image in the focal plane is obtained, which is simply called 'slice' in microscopic terminology. Moving the focal plane up or down through the sample, slices at arbitrary separation can be obtained and used for 3D reconstruction of the sample.

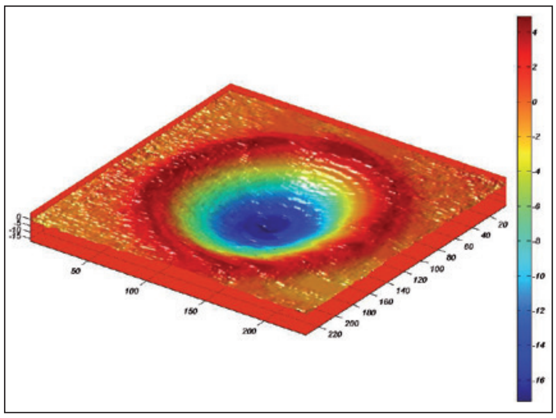


Figure 3: 3D-rendered reconstruction of a microlens obtained with THG microscopy. All dimensions are in micrometres.

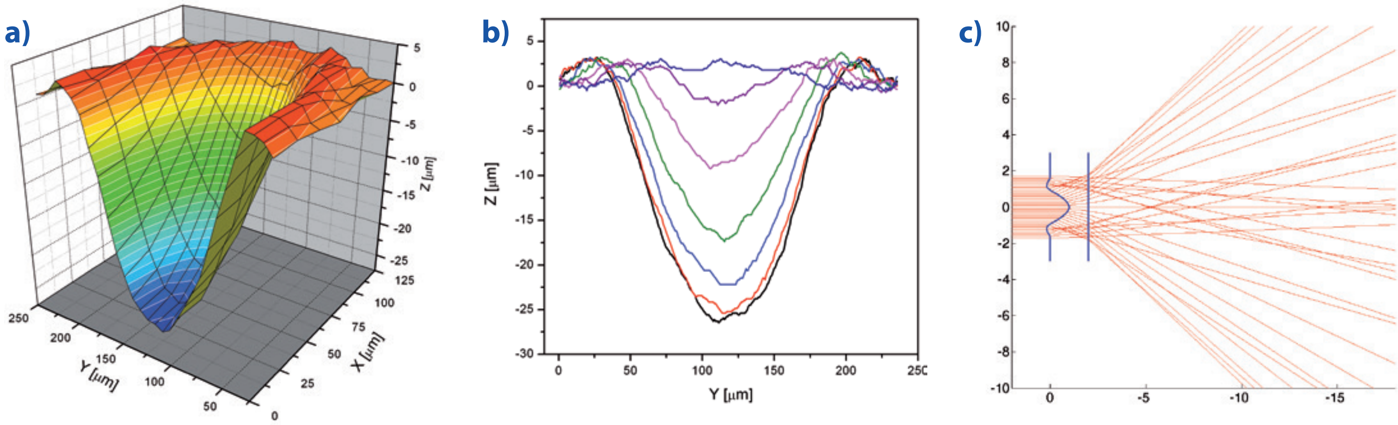


Figure 4: Cross-sectional view of the microlens from Figure 3. a) 3D and b) individual axial cross sections extracted from the 3D reconstruction. The distance between two adjacent cross sections is 25.5 µm. c) Ray tracing analysis performed with the obtained analytical shape (triple Gaussian) of the microlens profile. The distances are given in arbitrary units.

The nonlinear effects detected in this microscopic technique give us different, complementary information about the sample structure in the focal volume. The SHG is produced only in non-centrosymmetric structures and it is not of importance for our story since the material used for microlenses is isotropic. The THG process is highly efficient at the optical interfaces, where the abrupt change of refractive index exists. As a consequence, the signal at the photo detector is maximized whenever the focused laser beam is positioned at the interface of microlens material during the scanning process. Otherwise (if the focal point is inside or outside of the material), the THG process is very weak and there is no signal from the detector. Thus, scanning the laser beam and detecting the THG signal, one is able to reconstruct the 3D profile of the sample surface.

From the 3D model of a microlens it is possible to extract a lot of other quantitative data, such as axial and radial profiles, the volume of the microlens, ray tracing, etc. All of these data are important for microlens design and improvement. Apart from a single microlens, we also performed 3D imaging of a microlens array.

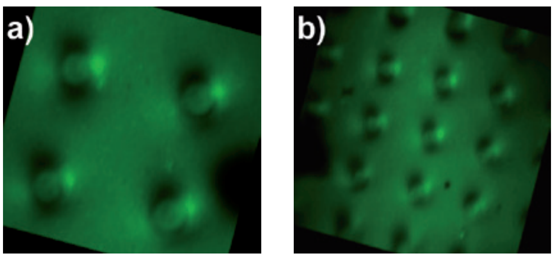


Figure 5: 3D reconstruction of a a) 2x2 and b) 4x4 microlens array, performed using the THG signal.

There is not a single ideal method for microlens characterization. All methods have both advantages and drawbacks and provide different and complementary information about the microlenses. However, only a few methods deal with changes of bulk material during the fabrication process of microlenses. Using nonlinear imaging microscopy, it is possible to obtain subsurface (volume) changes of a microlens by detecting TPEF signals arising mostly due to eosin. Mechanical and photochemical changes and vertical walls (which are not detectable by THG) are clearly visible in 3D models made after TPEF signal recording.

We performed 3D imaging of microlenses by the two modalities, THG and TPEF, of nonlinear microscopy using ultra short (femtosecond) laser pulses. Imaging the surface of microlenses by THG microscopy is a straightforward, rather simple, process that does not require any complicated algorithms for reconstruction of the surface shape from the signal. The proposed method allows 3D imaging of microlenses made from arbitrary materials, since THG is not sensitive to material variations. Whereas the THG signal allows the morphology to be determined, (photo)chemical changes, created during the process of microlenses manufacturing, give rise to TPEF signals. After imaging the microlenses by the two modalities of nonlinear microscopy, we used the data for obtaining other properties, such as the profile at arbitrary cross section, diameter, volume, focal length, astigmatism, etc.

Our results prove that nonlinear imaging microscopy is a powerful diagnostic tool for microlens characterization, since it enables in-depth investigation of the structural properties of the samples in a non-destructive manner. Moreover, the method and experimental set up used in this work are universal, versatile, and widely used, not only for microlens inspection but in a broad range of biophysical and material science problems.

To our knowledge, this is the first time that any researcher from Serbia has used the possibilities offered by Laserlab in order to improve and reinforce their research. The joint research project granted by Laserlab has enabled the symbiosis of the scientific experience and laser infrastructure from both institutions, which has led to high-quality results and publications.

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Much progress for HiPER

There have been extremely positive developments of importance to the European High Power laser Energy Research facility (HiPER) since the last issue of this newsletter.

Review of the ESFRI project portfolio

ESFRI has conducted a review of all projects on the Roadmap to ensure that progress to date and future plans are consistent with the ESFRI objectives. With over 100 refereed publications in the scientific literature arising from the Preparatory Phase of HiPER, technology development in many fields including lasers, materials studies and target fabrication, and the establishment of doctoral and post-doctoral training networks and a high profile COST action, HiPER is hoping for a very favourable outcome.

Launch of UK IFE Network

A network to assess UK capabilities in inertial fusion energy (IFE) has been established with funding from the Engineering and Physical Sciences Research Council. The network, led by Prof. Roland Smith of Imperial College, will conduct a number of meetings and workshops over the next two years to identify areas in which UK could contribute to any future major programme of research and technology development in IFE. John Collier and Chris Edwards are co-investigators of the network, which will ensure that HiPER takes full advantage of the initiative. Prof. Dimitri Batani, HiPER work package manager for fusion experiments, was among the speakers at the kick-off meeting held at the Royal Society in London on November 26th.

Scientific breakeven demonstration at NIF

'Scientific Breakeven' at the National Ignition Facility (NIF) was achieved at the end of September using a new design of target which gives improved hydrodynamic stability during the compression phase. Though HiPER is following 'direct drive', high gain routes to ignition, rather than the indirect drive approach of NIF, success at NIF will play an important role in securing funding for laser fusion in general and for HiPER in particular.

Visit the HiPER website at www.hiper.org for more information and the latest HiPER Project news or send an e-mail to Chris Edwards (chris.edwards@stfc.ac.uk)

Blueprints become reality!

In 2013, the Extreme Light Infrastructure (ELI) has set up huge construction sites for its buildings, procured some of the world's most advanced laser systems from international suppliers, and founded the ELI-DC International Association for coordination of the three sites and preparation of operation after 2017.

Construction activities with volumes of around 50M€ each were launched in both the Czech Republic and Romania at the end of spring. The visits of the European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn to the ELI Beamlines and ELI Nuclear Physics sites in October and November were the opportunity to celebrate these important milestones. In Hungary, ELI-ALPS is following the same track: it is currently completing the selection of its general contractor and will soon start pouring concrete.

On the technological front, two major contracts for the procurement of world-leading laser systems were passed: with Thalès Optronique for the supply of ELI-NP's high-power laser system (2 x 10 PW), and with Lawrence Livermore National Security (LLNS) for the supply of ELI Beamlines' L3 laser (10Hz, ultra-short-pulse, multi-PW diode-pumped laser). Procurement of major technological equipment will continue in the coming months at the three sites.

The local implementation teams have expanded substantially. A total of more than 275 people are currently involved in the three teams (200 in the Czech Republic, 50 in Romania, and 25 in Hungary). Among them should be mentioned in particular the newly appointed scientific directors of ELI-ALPS, Dimitris Charalambidis, and ELI-NP, Sydney Gales.

In April 2013 the *ELI Delivery Consortium International Association* (AISBL) was founded. It will support and coordinate the implementation of the present three ELI pillars, ensure ELI's character as unified pan-European infrastructure, and pave the way towards the future ELI-ERIC consortium, which will govern, operate and finance ELI after 2017. Wolfgang Sandner, Director General of the ELI-DC International Association and former Laserlab-Europe Coordinator, looks forward to welcoming representatives from many Laserlab-Europe countries also within this new organisation.

For more information, please contact Florian Gliksohn (florian-gliksohn@eli-laser.eu) or Wolfgang Sandner (wolfgang.sandner@eli-laser.eu).

Forthcoming events

Joint JRA Meeting
31 March – 1 April 2014, Warsaw, Poland

Laserlab Training School 'Laser Applications in Spectroscopy, Industry and Medicine'
7 – 11 April 2014, Riga, Latvia

Annual meeting NAUUL – 'Target interaction challenges and developments'
28 – 29 April 2014, Abingdon, UK

Laserlab Workshop 'Lasers for Life'
2 – 4 June 2014, London, UK

5th Target Fabrication Workshop
6 – 11 July 2014, St Andrews, Scotland

To find out more about conferences and events, visit the Laserlab online conference calendar.

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 USP. The USP will then take a final decision. In case the proposal is accepted the host institution will instruct the applicant about further procedures.

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