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Laserlab Forum

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

International Year of Light

In this Issue

Editorial

Tom Jeltes

Laser scientists are naturally enthusiastic about light as a source of scientific discovery and technological breakthroughs. For the advancement of their field, it is important that this enthusiasm is shared by the public – which, in the end, provides the funding for most laser-based research.

This year has been proclaimed by the United Nations as the International Year of Light (IYL2015), in order to promote the importance of light-based technologies to the public. This provides an ideal opportunity for laser scientists to convey their passion for light to schoolchildren, teachers, representatives of industry, and the general public alike. A comparatively easy task, seeing the spectacular visual effects that can be brought about by lasers. A flavour of contributions to IYL2015 by partners of Laserlab-Europe can be found in the focus section of this issue of Laserlab Forum.

The second step, however, is to make people aware that there is more to lasers than pretty colours. They are at the basis of many important devices and technologies, and as such will be a major force in economic and societal development. Creating this awareness and investing in (laser) science and technology is therefore, as Costas Fotakis states elsewhere in this issue, the best warranty for the future. Not only for his home country in peril, but for Europe as a whole. **Tom Jeltes**

News

Graphene pushes speed limit of light-to-electricity conversion

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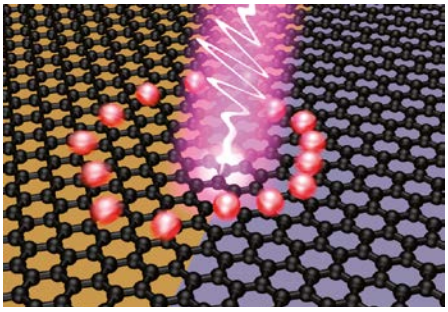


Illustration of ultrafast photovoltage creation after light absorption at the interface of two graphene areas with different Fermi energy.

Researchers from Laserlab-Europe partner ICFO, MIT and UC Riverside have developed a graphene-based photodetector capable of converting absorbed light into an electrical voltage at femtosecond timescales. The ICFO team was led by Frank Koppens and Niek van Hulst. Details about the ultrafast photodetector were recently published in Nature Nanotechnology.

The efficient conversion of light into electricity plays a crucial role in many technologies, ranging from cameras to solar cells. It also forms an essential step in data communication applications, since it allows for information carried by light to be converted into electrical information that can be processed in electrical circuits. Graphene is an excellent material for ultrafast conversion of light to electrical signals, but so far it was not known how fast graphene responds to ultrashort flashes of light.

The new device is capable of converting light into electricity in less than 50 femtoseconds (a twentieth of a millionth of a millionth of a second). To demonstrate this, researchers used a combination of ultrafast pulse-shaped laser excitation and highly sensitive electrical readout. The results obtained from the findings of this work, which has been partially funded by the EC Graphene Flagship, open a new pathway towards ultrafast optoelectronic conversion.

IESL-FORTH partner in Cultural Heritage project

Laserlab-Europe partner IESL-FORTH (Crete) participates in a new research infrastructure funded by the EU: IPERION CH (Integrated Platform for the European Research Infrastructure on Cultural Heritage). The consortium, a continuation of the CHARISMA project, aims to establish a unique European research infrastructure for restoration and conservation of Cultural Heritage. The kick-off meeting was in Florence, Italy in June 2015.

IPERION CH integrates national facilities of recognized excellence in Heritage Science. It connects researchers in the Humanities and Natural Sciences, from universities, research institutes and museums, and fosters a trans-disciplinary culture of exchange and cooperation for the growth of the European Research Area. The ultimate goal of the consortium is inclusion in the ESFRI roadmap.

IESL-FORTH will bring to IPERION CH its expertise in restoring and analysing works of art using advanced laser techniques. The project also includes other research groups working with lasers, as well as synchrotron (SOLEIL and the Louvre's AGLAE in France) and particle and neutron facilities (MTA-Atomki and Budapest Neutron Center in Hungary). In all, 23 partners from 12 EU member states and the US are involved.

Tracking nanoparticles for cancer treatment

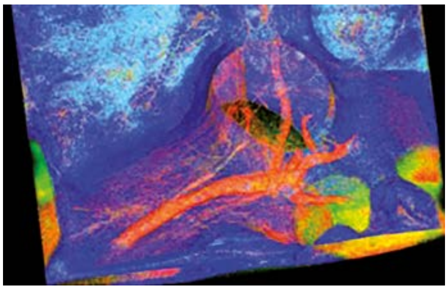
A group from Laserlab-Europe partner ISMO (Orsay, Paris) has developed a combination of techniques to track the position of unmarked nanoparticles, used to amplify the destruction of human tumour cells. The techniques allow scientists to study the effect of these nanoparticles in cancer treatment. The results were published in the journal Cancer Nanotechnology.

To improve radiotherapy techniques, several studies have looked at the possibility of adding nanoparticles, especially when treating certain aggressive tumours, such as glioblastoma cells (the most common brain tumour). The nanoparticles could be used in diagnosis or in therapy, as their presence in cells increases the radiation effect.

However, these particles are difficult to locate precisely inside the cells. Until now fluorescent markers were used to follow the path of these nanoparticles. The problem was that these markers could directly influence their location, thus skewing the study. The ISMO team used for the first time synchrotron radiation deep ultraviolet (SR-DUV) microscopy available on the DISCO beamline of the SOLEIL synchrotron to observe unlabelled nanoparticles in tumour cells.

X-ray camera for 3D body imaging

A new European consortium, VOXEL, aiming to develop a new X-ray camera for 3D imaging of the inside of the human body, will be led by Marta Fajardo from Laserlab-Europe partner IST (Lisbon). The VOXEL consortium also includes Laserlab-Europe partner LOA



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3D X-ray phase contrast tomography image of a vascularisation network (red) inside a porous scaffold (blue) seeded with ostoprogenitor cells in a mouse

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 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.

(Palaiseau, Paris). VOXEL is one of the 26 FET (Future Emerging Technologies) proposals selected in the latest call of this Horizon2020 programme, out of 643 proposals that were submitted.

VOXEL's approach is based on plenoptic image technology, which entails using a special photographic sensor that registers both the image and the direction of the light rays. The data is then processed to reconstruct a three-dimensional image, which has voxels (3D) rather than pixels (2D).

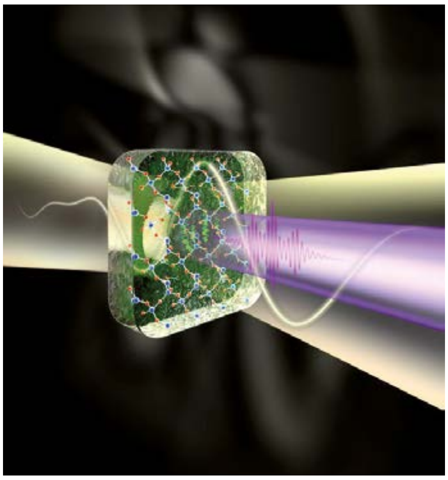
The new camera will be an upgraded alternative to traditional X-ray imaging, with a wide range of potential applications, from dentistry, traumatology and cancer detection to materials study. According to Marta Fajardo, this new technology will allow X-ray images to be obtained using lower radiation exposures than with the current technologies, which are used only in the most serious cases.

Solid-state photonics goes extreme ultraviolet

Using ultrashort laser pulses, scientists in Max Planck Institute of Quantum Optics (MPQ, partner of Laserlab-Europe) have demonstrated the emission of extreme ultraviolet radiation from thin dielectric films and have investigated the underlying mechanisms. The study was published in Nature on 28 May 2015.

Researchers of MPQ's Attoelectronics Research Group have been able to generate radiation in the extreme ultraviolet region of the spectrum by sending an intense ultrashort laser pulse on thin quartz films. Because solid state media cannot stand the intense laser pulses conventionally used in gaseous media to generate ultraviolet and X-ray radiation, the scientists had to use ultrashort pulses of merely a single oscillation of the light wave cycle.

The experiment not only produced radiation with a more than twenty times higher frequency than the original laser beam, but also allowed the MPQ researchers to unveil information about the structure of the solid which had so far been inaccessible to solid-state spectroscopy. The scientists claim to have a strong indication that the laser pulses force the electrons to perform extremely fast oscillations of tens of Petahertz, which would be the fastest electric currents ever generated in a solid.



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Ultrafast lasers drive the motion of electrons inside silicon dioxide to generate extreme ultraviolet radiation.

Laserlab-Europe lighting the way ahead

In a very competitive call the Laserlab-Europe consortium has been successful in securing EC funding of 10 million euros in Horizon 2020.

In the upcoming four-year phase, starting in December 2015, Laserlab-Europe will comprise 33 of the leading European laser infrastructures and, together with subcontractors and associate partners, involve coordinated activities in 21 countries. The laboratories cover advanced laser science and applications in most domains of research and technology, with particular emphasis on areas with high industrial and social impact, such as bio- and nanophotonics, materials analysis, biology and medicine. The consortium offers free access to key complementary laser facilities in Europe with performances at the international forefront of laser technology, including two Free Electron Lasers (FELs).

ERC Grants

Each year, a significant number of Laserlab-Europe researchers are awarded prestigious personal grants from the European Research Council. On the following pages, we highlight a total of ten recently granted Starting and Consolidator projects – worth up to 1.5 and 2 million Euros, respectively – for a period of five years.

ERC Consolidator Grants

Romain Quidant

Romain Quidant (ICFO): Quantum Optomechanics with a Levitating Nanoparticle

Micro- and nano-mechanical oscillators with high quality (Q)-factors have gained great interest for their capability to sense very small forces, and their related potential to contribute to our further understanding of quantum effects with large objects. So far, the Q-factor of these oscillators has been limited because of their physical contact to a support. A very attractive alternative to conventional mechanical resonators is based on optically levitated nano-objects in vacuum. In particular, a nanoparticle trapped in the focus of a laser beam in vacuum is mechanically disconnected from its environment and hence does not suffer from clamping losses.

With his Consolidator Grant project, Romain Quidant is planning to use the unique capability of optically levitating nanoparticles to create a nano-mechanical oscillator closer to the ground state at room temperature. This will allow him to explore new physical regimes whose experimental observation has so far been hindered by current experimental limitations.

Reinhard Kienberger

Reinhard Kienberger (MPQ): Attosecond Electron Dynamics in Molecular Systems

Time-domain investigations of ultrafast microscopic processes are most successfully carried out by pump/probe experiments. Direct access to electron motion on the atomic scale has been made possible by intense waveform-controlled few-cycle near-infrared laser pulses combined with isolated sub-femtosecond XUV (extreme UV) pulses. These tools, along with the techniques of laser-field-controlled XUV photoemission ('attosecond streaking'), and ultrafast UV-pump/XUV-probe spectroscopy, have permitted real-time observation of electronic motion in experiments performed on atoms in the gas phase and of electronic transport processes in solids.

With his Consolidator Grant, Reinhard Kienberger is planning to apply attosecond spectroscopy to electronic processes in molecules. By combining attosecond tools and techniques with their experience in UHV technology and target preparation in a new beamline, his team aims at investigating charge migration and transport in supramolecular assemblies, ultrafast electron dynamics in photocatalysis, and dynamics of electron correlation in high-TC superconductors.

Dario Polli (CUSBO): Very Fast Imaging by Broadband Coherent Raman

Real-time non-invasive imaging of cells and tissues promises to have revolutionary impact on various fields in biology and medicine. The ability to detect the chemically specific vibrational signatures of molecules inside the cell would allow us to develop reliable bio-markers to, e.g., follow cell differentiation and to identify crucial properties of tissues, such as whether a tumour is benign or malignant. In this way tumours can be located and their borders with normal tissue traced for surgery.

Dario Polli

The goal of Dario Polli's Consolidator Grant project is to combine the most detailed molecular information over the entire vibrational spectrum with the highest acquisition speed. In order to achieve this, his team will develop a complete coherent Raman microscope for near-video-rate broadband vibrational imaging. The aim is to validate the vibrational imaging system by studying two important biomedical problems: cancerous cell differentiation and detection of neuronal tumours.

Peter Baum

Peter Baum (MPQ): Direct Visualisation of Light-Driven Atomic-Scale Carrier Dynamics in Space and Time

The regime of lightwave electronics, where atomic-scale charges are controlled by few-cycle laser fields, holds promise to advance information processing technology from today's microwave frequencies to the thousand times faster regime of optical light fields. All materials, including dielectrics, semiconductors and molecular crystals, react to such field oscillations with an intricate interplay between atomic-scale charge displacements (polarizations) and collective carrier motion on the nanometer scale (currents). This entanglement provides a rich set of potential mechanisms for switching and control.

In order to be able to exploit these potential mechanisms, Peter Baum's Consolidator Grant project aims at measuring electronic motion within and around atoms. Drawing on their expertise covering electron diffraction and few-cycle laser optics, his team will replace the photon pulses of conventional attosecond spectroscopy with freely propagating single-electron pulses, compressed in time by sculptured laser fields. They will use stroboscopic diffraction/microscopy to provide a direct visualisation of fundamental electronic activity in space and time.

ERC Starting Grants

Edouard Berrocal (LLC): Detailed Characterization of Spray Systems Using Novel Laser Imaging Techniques

When using a beam of visible light to probe a scattering medium composed of droplets, smoke, powders or other aerosols, photons interact several times with the randomly distributed particles. This multiple scattering of light induces strong blurring of images and introduces severe errors in laser-based measurements of particle size and concentration. Because of this problem, for example, detailed characterization of spray systems is still lacking.

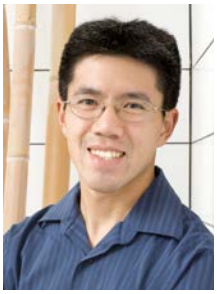

Edouard Berrocal

In 2008, Edouard Berrocal revealed that with a technique called Structured Laser Illumination Planar Imaging (SLIPI), many aspects of this problem can be overcome. In his ERC Starting Grant project, he aims to develop three novel imaging techniques to probe spray dynamics, droplet size and concentration, and spray temperature, respectively. The main goal is to find better injection strategies for combustion engines in order to reduce emission of pollutants.


Francesca Calegari

Francesca Calegari (POLIMI): Steering Attosecond Electron Dynamics in Biomolecules with UV-XUV Light Pulses

One of the challenges facing science is to understand the chemical origin of DNA damage-induced mutations. Upon exposure to UV light, DNA nucleobases become electronically excited. This process potentially favours mutagenic miscoding of the DNA sequence. The main target of Francesca Calegari's Starting Grant project is to study the electron dynamics occurring in UV photo-excited biomolecules with unprecedented temporal resolution. Electron dynamics will be resonantly activated in biomolecules by few-optical-cycles UV pump pulses and subsequently probed by attosecond XUV pulses or few-femtosecond UV pulses. Through time-resolved measurements of the molecular photo-fragmentation, gas-phase spectroscopy will be used to elucidate the role of electrons in the photo-reactivity of the molecule in a solvent-free environment. Aromatic complexes including DNA nucleobases (and ultimately DNA) will be investigated with the aim of tracking in real time the electron dynamics preceding structural changes potentially leading to damage.


Darrick Chang

Darrick Chang (ICFO): Frontiers of Quantum Atom-Light Interactions

The key to the success of atomic physics and quantum optics relies on our understanding and ability to control the way that light and matter interact with each other at the level of their constituent particles – single atoms and photons. From fundamental tools such as laser cooling and trapping or cavity quantum electrodynamics come potentially powerful applications, e.g., quantum simulation and quantum information processing. However, these same techniques have clear limitations which preclude many parameter regimes or paradigms for the utilization of cold atoms.

In his Starting Grant project, Darrick Chang aims to completely re-define our ability to control light-matter interactions at the quantum level. In order to accomplish this feat, his team will exploit control over the dimensionality and dispersion of light, engineering of quantum vacuum forces, and the strong optical fields and forces associated with confining light to the nanoscale.

Carlo Sias (LENS): An Ultracold Gas Plus One Ion


Carlo Sias

The concept of impurity is of fundamental importance in condensed matter physics, since impurities play a central role in the description of most materials. A physical system made of a single localized impurity in a many-body system is a paradigm that lies at the base of some of the most celebrated impurity models.

The aim of Carlo Sias' ERC Starting Grant project is to perform novel quantum simulations using an ultracold gas of alkali atoms as a many-body system, and a single trapped ion as a localized impurity. The first goal is to reach the ultracold regime in the atom-ion interactions, which has never been accomplished so far. The idea is that studying this unknown collisional physics at ultralow temperatures will open fascinating new prospects for this hybrid quantum system of atoms and ions.

Matteo Zaccanti (LENS): Superfluidity and Ferromagnetism of Unequal Mass Fermions with Two- and Three-body Resonant Interactions


Matteo Zaccanti

Superfluidity and magnetism characterize a wealth of interacting fermion systems encompassing solid-state, nuclear and quark matter environments. Despite decades of interdisciplinary investigations on these topics, several important questions about these phenomena are still unanswered.

Within his ERC Starting Grant project, Matteo Zaccanti wants to use a new, ultracold mixture of two fermionic atoms (Lithium6 and Chromium53) to address some of those questions experimentally. The special mass ratio between the two atoms will allow him to obtain tuneable three-body interactions, whereas so far people only have been able to create tuneable interactions between two atoms. Furthermore, the prediction is that atom recombination into paired states of the species used will be suppressed to a high degree. Zaccanti will disclose the predicted exotic superfluid and magnetic phases using high-resolution imaging and state-of-the-art spectroscopy.

Stefan Witte (LLAMS): High-resolution Microscopy without Lenses


Stefan Witte

While imaging technology is one of the most widespread diagnostic techniques in science and industry, the need for specialized optical components can often be problematic. Lensless imaging is an elegant answer to the problem with optical components, which may be large, costly and sensitive to alignment.

Recently, Stefan Witte has shown that the amplitude and phase of an object field can be reconstructed with high contrast and resolution by detecting wavelength-dependent differences in wave propagation. Using this method, a high-resolution image can be reconstructed using only a light source, an image sensor, and a computing device. Witte's aim with his ERC Starting Grant is to develop lensless microscopes for extreme-ultraviolet radiation, as well as to image many cell cultures in parallel. In addition, he plans to develop smartphone-based lensless microscopes for low-cost point-of-care diagnostics in developing countries.

International Year of Light

By proclaiming 2015 the International Year of Light and Light-based Technologies (IYL 2015), the United Nations recognises the importance of raising global awareness about how light-based technologies can be used to tackle global challenges in energy, education, agriculture and health. Across the world, IYL2015 programmes are promoting public and political understanding of the central role of light in the modern world, bringing together stakeholders including scientific societies, educational institutions, non-profit organisations and industry. Naturally, several partners of Laserlab-Europe are involved in activities related to the International Year of Light – on these pages we highlight a few of their contributions.

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Incredible Power of Light roadshow

The science and technology of British Laserlab-Europe partner Central Laser Facility (CLF) is heavily featured in the Incredible Power of Light roadshow celebrating the International Year of Light. In its first 44 days, the roadshow already captured the attention of around 38,000 visitors on a 2,800 km tour, which brought the exhibit to the first ever Northern Ireland Science Festival in Belfast, the Big Bang Fair in Birmingham, and the foyer of the Scottish Parliament building during Edinburgh's International Science Festival.

The Incredible Power of Light roadshow features demonstrations, information and hands-on exhibits. Visitors are able to discover the central role that lasers play in the modern world and are able to chat to scientists and students from STFC's Central Laser Facility, as well as PhD students from university laser departments across the UK.

Within a reconstruction of the laser bay of the Vulcan facility, visitors can use a model of a Vulcan mirror bench and amplifier to adjust mirrors in a smoke filled chamber, allowing a laser beam to travel through the mirror unit and onto a target in the amplifier unit – if the laser beam hits the centre of the target a noise sounds and the amplifier unit lets out a flash of light briefly.

Also popular is the 'adaptive optics' apparatus, made up of a laser being reflected around a number of mirrors to a camera unit linked to a monitor. Other demonstrations include a 'laser tweezers' exhibit, a demonstration of laser transmission of images through the air, and Raman spectroscopy applied to airport security. As well as these hands-on demonstrations, there is a glasses-free 3D screen showing 3D films from around the main Research Complex and inside the CLF experimental areas, a plasma ball, a laser-based board game and diffraction gratings.

Mark Wells and Ceri Brenner

GoPhoton! conquers Europe

GoPhoton! is an EC-funded project aiming to make photonics a household word. Throughout 2015, so-called PhotonicSplashes are traveling from city to city, featuring activities for students, teachers, industry and the general public. GoPhoton! is organised by the European Centres for Outreach in Photonics (ECOP), involving Laserlab-Europe partners ICFO (Barcelona), ILC (Bratislava) and POLIMI (Milan).

GoPhoton! activities include a travelling exhibition 'The Power of Light: from Fiction to Society' and a congress for young students (Girls, Boys and Photonics) that features workshops and hands-on experiments, as well as vocational and academic guidance. Furthermore, there are LIGHTtalks, a series of talks about careers in photonics and future applications of light, where you can meet experts in an informal setting, and the participating research centres open their doors to the general public to share their fascination for light.

Events and places visited by GoPhoton! include the Imperial Festival in London, the Atomium in Brussels, the Innovation and Science Festival in Barcelona, and the 6th Girls' Technology Congress in Berlin. Special opening events involve dance, poetry, raps, a laser harpist, as well as special effects, 3D animations and light painting.

Tom Jeltes
www.gophoton.eu

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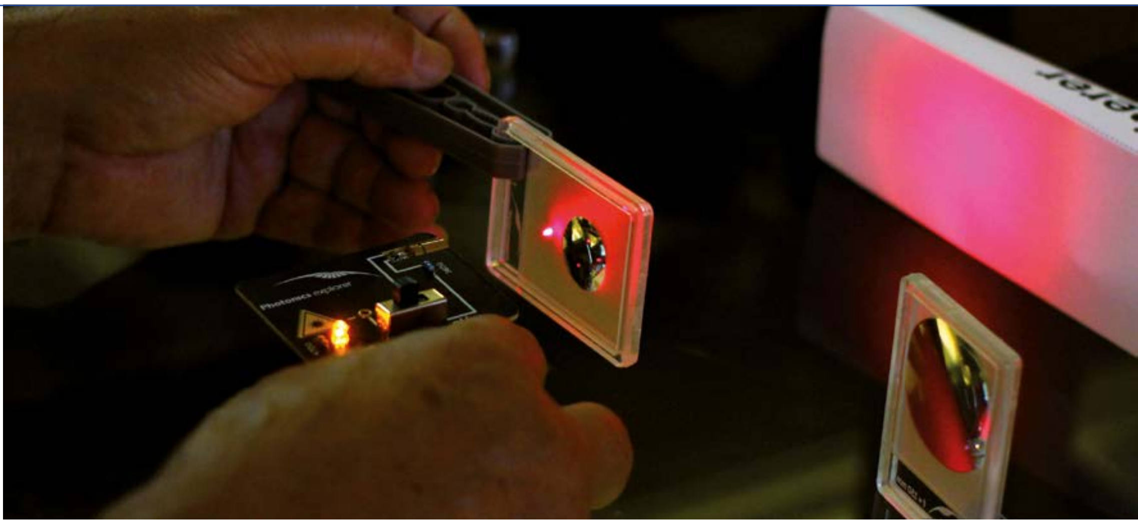

Demonstration of the photonics toolkit.

Year of Light in Slovakia

Slovak partner of Laserlab-Europe ILC is involved in various activities presenting the crucial and irreplaceable role of photonics in our world, as part of the European projects GoPhoton! and Photonics4All.

An 'Exhibition of Photonics' will be launched at the Festival of Light in Bratislava, explaining the principles and applications of light. Throughout the year, various activities for young students are taking place in Slovakia. Several presentations and science shows are presented within the framework of the 'Superschool of Bratislava' and a 'Children's University', where young students will learn about light and light-based phenomena. Furthermore, ILC is creating an interactive educational tool, the OmniLight Laboratory, presenting many experiments using light and lasers to the public.

Several personalities from Slovak history will be commemorated during IYL2015, bringing photonics closer to the Slovak people. One of these personalities is M.R. Stefanik who was not only one of the founders of the Czechoslovak Republic, but also a Slovak spectroscopist, who launched the first astronomy observatory on the Pacific Island of Tahiti.

The IYL2015 activities in Slovakia will culminate in October at the two 'Weeks of Photonics' organized by ILC with the support of the European Centers for Outreach in Photonics (ECOP) alliance. Since the beginning of the year secondary schools all around Slovakia received Photonics Innovator Toolkits from Eyest, which allowed them to experiment with light and better understand this phenomenon. One of the highlights of the 'Weeks of Photonics' will be a 'Student Congress on Photonics' (October 14-15) where young students will have the opportunity to experience light-based phenomena and to present their own projects related to light.

Alzbeta Marcek Chorvatova
and Dusan Chorvat
http://photonics4all.eu

Royal support for International Year of Light 2015

The UK's Orion laser facility, associated partner of Laserlab-Europe, is playing its part in supporting the International Year of Light. So much so that His Royal Highness Prince Andrew, the Duke of York, visited the Orion laser facility at AWE in Aldermaston, Berkshire, UK, in his capacity as UK Patron of the International Year of Light.

Orion is taking part in the celebration of the International Year of Light through a series of community events and outreach activities giving local people an insight into its leading-edge science and access to its technical experts. During his visit, the Duke stressed the importance of Orion's outreach activities. In his view, Orion presents an exciting opportunity for young people interested in a career in science and technology.

Colin Danson

© Orion

UK Patron of the International Year of Light, the Duke of York (centre), visiting the Orion laser facility.

Jena celebrates the International Year of Light

The Helmholtz Institute Jena, partner of Laserlab-Europe, and the Leibniz Institute of Photonic Technology (IPHT), associated partner of Laserlab-Europe, are celebrating the 'International Year of Light' together with Jena's universities, research institutes, and technology companies. The opening event on 17 January included a science show entitled 'LIGHT Phenomena' starring the TV anchorman Ralph Caspers.

The opening ceremony in a sold-out concert hall was attended by 2,700 guests. In addition, 600 spectators followed the show at a public screening area in downtown Jena and 500 other viewers followed the show live on the

Live performance by "Laserman"

internet. TV host Caspers answered questions, submitted by schoolchildren, based on exciting experiments performed live on stage. The two-hour show of experiments also included acts by the French Laserman and the performance group Feeding the Fish.

IPHT and the University of Jena will participate in several other activities that will take place around Jena as part of the Year of Light. They will co-organise a summer school entitled 'Biophotonic – Visions for better health care', and the institute will be presented during the 'Highlights of Physics' theme week. At this event alone, organized together with the German Physical Society, thousands of visitors are expected.

Daniel Siegesmund
www.lichtstadt-jena.de

LIGHT2015: bringing photonics to students and entrepreneurs

Laserlab-Europe partners ICFO (Barcelona) and POLIMI (Milan) are partners in LIGHT2015, a European project funded under Horizon 2020, which aims to promote the importance of photonics to young people, entrepreneurs and the general public in all member states of the EU during the International Year of Light (IYL).

A highlight of LIGHT2015 will be a community experiment on smartphone photonics, where thousands of participants from throughout the EU will carry out optical measurements of the sky to yield information related to air pollution. Further LIGHT2015 activities build on the GoPhoton! project and include a series of inspirational events, taking place throughout the European Union in different cities at different times for the whole duration of the project. To aid teachers and to inspire students, 'photonics kits' will be distributed to schools around Europe to support the scientific education at secondary schools.

A specific series of events targeted to local industry and entrepreneurs, will take place during the period 25-28 September 2015 to take advantage of the international '100 Hours / Weekend of Light' of the global IYL 2015 programme.

Tom Jeltes
www.europe.light2015.org
www.ispex-eu.org

Focus session Year of Light at Dutch physics conference

At FYSICA, the annual meeting of the Netherlands Physical Society, a special focus session was devoted to the International Year of Light 2015 on April 10. The organisers at the Eindhoven University of Technology invited researchers from industry and academia to talk about the past, present, and future of light in science and technology.

In Eindhoven, the audience learned about the history of lighting, the technology behind it, and the promises of so-called organic light emitting diodes, from three speakers associated with Philips company – one of the first mass producers of incandescent light bulbs in the early twentieth century, and still at the forefront of developments in digital led technology.

In addition to these talks about the technological applications of light, Wim Ubachs from LaserLaB Amsterdam addressed a very different use of light. He explained that in light emitted by quasars in the early epochs of our universe, information is imprinted from atomic and molecular species in galaxies billions of light years away from us. Collecting this light with telescopes, and comparing the spectral information it contains with measurements on the same species in the lab, not only shows us that the early universe contained the same species as today, but can also give clues about possible variations of fundamental constants (such as the electron-proton mass ratio), on cosmological time and length scales.

Tom Jeltes

Research and Innovation in Greece in times of crisis

Costas Fotakis, former Director of Laserlab-Europe partner IESL-FORTH, joined the team of Greek Prime Minister Tsipras as Alternate Minister for Research and Innovation in January 2015. For Laserlab Forum, he reflects on his position as a laser scientist in the current Greek political and socio-economic situation.

This is the first political position I have held. Although not a member of the governing party, my views were well known. When I was asked by the newly elected Prime Minister to undertake the task of Alternate Minister for Research and Innovation (R&I), I had to decide within a couple of hours and that was a great dilemma.

On the one hand, it would involve leaving FORTH, where I have served for many years, as well as my teaching duties in the university. As President of FORTH, I was able to keep in close contact with the research activities in the laser laboratories of FORTH, and I knew this would be very difficult in the new position. On the other hand, the offer was both an honour and a challenge: to keep the research ecosystem standing under the immensely difficult socio-economic crisis the country is encountering. As the Prime Minister told me when he called me, "we cannot avoid the appointment with history during this critical time". This is a new ministry, signifying the emphasis the new government intends to place in Research and Innovation. My previous experience at FORTH, the largest Research Center in the country, and in various EU research policy committees, as for example the Chair of the Advisory Board for Research Infrastructures, is proven useful. I also consider that my involvement in Laserlab-Europe from its very early stages is a positive asset.

A particular feature of this government is the high number of scholars and scientists in cabinet positions. Especially for R&I, having an active scientific background is useful because it enables one to know what is needed on the ground, in terms of policy making. Of course, this has also to be combined with a broader vision for the role R&I may have, socially and economically. To this end, it is my belief that under the unprecedented social and economic crisis prevailing, learning, research and innovation may become a shield against the material, intellectual and moral degradation of society. Even more, they can become a lighthouse for hope and perspective.

In formulating research policies, we have to recognize that the increasingly globalised character of the economy and especially the Knowledge Economy leads to scientific hot spots and deserts. This is imposing new challenges and prioritizations for developing effective R&I policies and especially for crossing the innovation gap from basic and applied research to facilitate wealth creation through the development of innovative products and methodologies. A particular feature of the European landscape in this respect is the so called "European paradox"; in Europe, there is "good science" but weak deployment. In Greece this paradox is even more acute. Despite the crisis, researchers in Greek universities and research organizations rank highly internationally, according to several performance indicators. On the other hand, there is a serious innovation gap. Drastic interventions at different parts of the whole innovation chain are needed. For example, the regulatory and financial frame for R&I is the weakest part of the chain. Simplified, clear and consistent rules adapted to the specific needs of research work have been already planned and put in action. It is our task to inspire confidence and demonstrate political commitment. Overall, a drastic decrease of bureaucracy is needed. This applies in particular to the rules applied for the use of Structural Funds for R&I actions, which is highly ineffectual as it stands.


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Furthermore, boosting the funding opportunities for research, apart from public and EU Framework Programmes, is necessary. The exploitation of emerging risk financing instruments, which have appeared recently at European level, provides several good options.

Another major challenge we are set to tackle is that of reversing the brain drain, which has taken immense dimensions during the last five years due to the ineffectual austerity measures that have been applied. According to recent reports from Bloomberg, during the period 2009-2014, 20.000 young scientists have left the country, which is ten times as much as for similar periods before the crisis. We have been developing a policy which will hopefully help reduce the brain drain and enhance the brain circulation.

A final major challenge is that of pursuing scientific quality and excellence. This is always a major task, particularly during these difficult times. However, preserving the pockets of excellence in the country and providing opportunities for the development of new ones is –in my opinion – the best warranty for the future.

Costas Fotakis

Imaging light-matter interaction with femtosecond resolution

High intensity, ultrashort laser pulses propagating in transparent media can cause permanent material modification, triggered by a light-induced plasma. Material modifications resulting in a variation of the refractive index or in the formation of voids have a wide range of applications in the field of laser-surgery and fabrication of micro/nano-photonics components. The improvement of these applications requires the understanding of the light-induced plasma formation. A recent Laserlab-Europe experiment at VULRC in Vilnius, Lithuania uses time-resolved shadowgraphy to highlight how energy is transferred from light to water on the femtosecond timescale, allowing researchers to update their models of water photo-ionization.

Unveiling the dynamics of energy loss of intense, femtosecond laser pulses propagating in transparent media is of foremost importance for several advanced applications such as laser micro/nano-machining and laser-surgery. From the experimental viewpoint, the in-situ characterization of the optical pulse dynamics poses several challenges, mainly related to the small spatiotemporal scales (microns and femtoseconds) typical of the energy deposition process. In particular, the energy content of the laser-wave packet can usually be measured only at the exit of the material sample, thus cancelling the whole dynamics of the losses.

In a recent Laserlab-Europe experiment (Minardi et al., 2014), we managed to estimate the energy content of the optical wave packet while it propagates in water. The data of the pulse energy content along the propagation coordinate, combined with a direct measurement of the density of the plasma generated in the process, allowed us to update the model of plasma generation in water.

The setup of our experiment is based on a pump-probe configuration, where the pump is a 120 femtosecond near-infrared pulse focused in a water cuvette and the probe is a wavelength-tuneable, collimated 50 femtosecond pulse propagating through the cuvette perpendicularly to the pump pulse. When the time delay of the probe is synchronized to the pump, the probe wave front is perturbed by the modification of the complex refractive index of water induced by the pump (Minardi et al., 2008). By setting a microscope to image the probe pulse at the plane containing the trajectory of the pump, we can observe the pump-induced absorption of the probe in the medium (the so-called shadowgram).

Two main structures can usually be seen in the shadowgrams, as illustrated in Figure 1. The most prominent structure is the trace of solvated plasma excited by the pump pulse, which is absorbing light on a 300 nanometer band centred at 750 nanometer and lasts for a few nanoseconds. This absorption band is well characterized (Migus et al., 1987) and transmission measurements on the shadowgram can be used to gauge the solvated plasma density. Additionally to this feature, the shadowgrams can

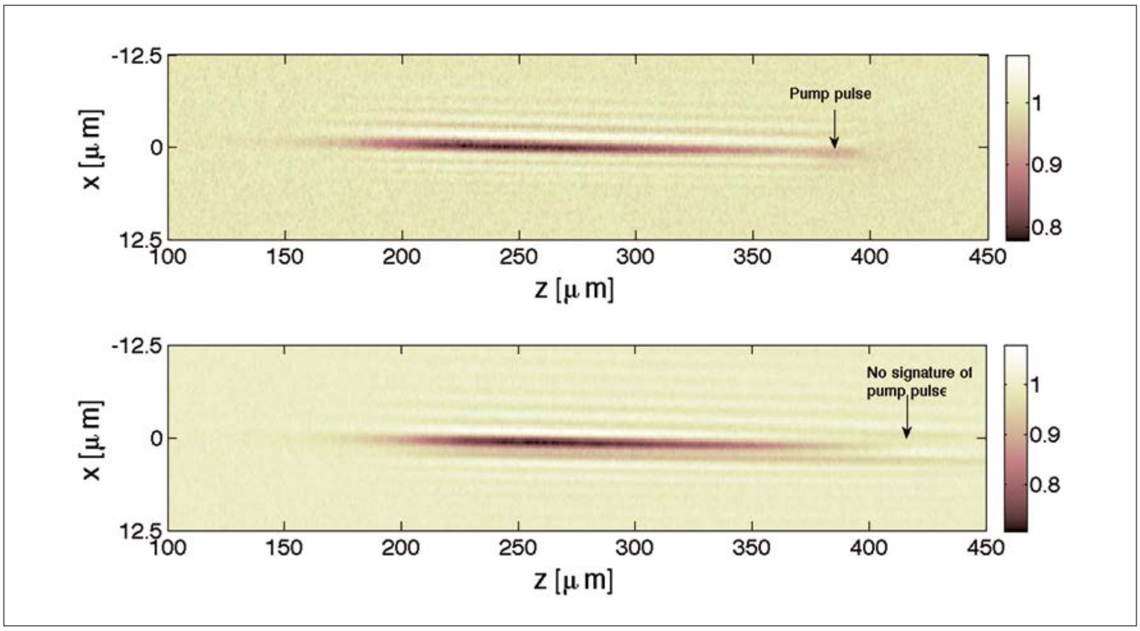

Figure 1: By carefully tuning the probe pulse at the anti-stokes wavelength of the pump pulse, it is possible to detect the pump pulse as an absorption feature of the shadowgram, thanks to an inverse Raman scattering process. The effect is evident from the comparison of the shadowgrams for probe at the anti-stokes (top) and pump (botton) wavelength. In the latter image the signature of the pump pulse is absent (adapted from Minardi et al. 2014).

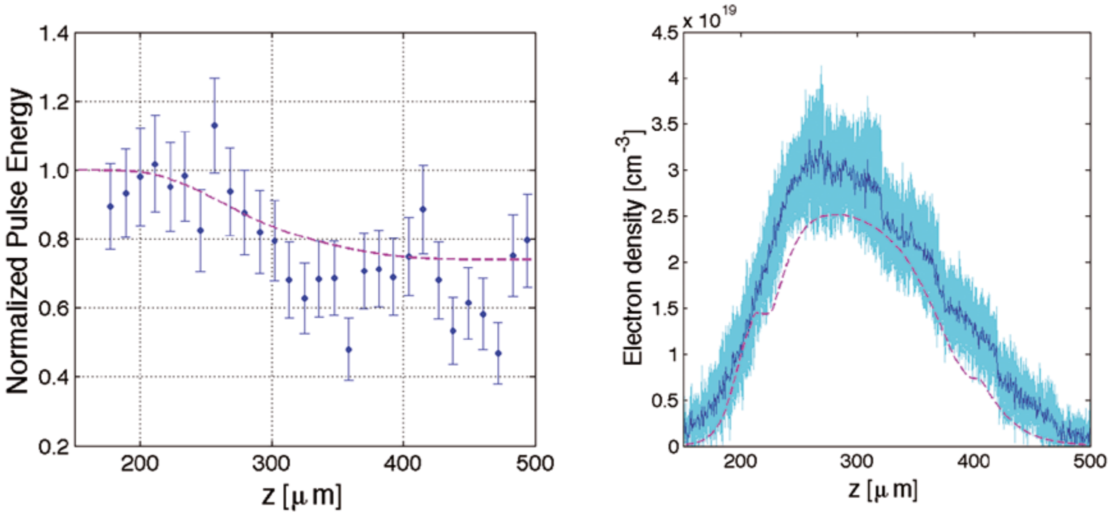

Figure 2: Comparison of experiment with simulation data. Left: the normalized energy content of the pump wave packet as a function of the propagation length. Dots: experimental data. Broken line: numerical simulation. Right: density distribution of the solvated electrons along the propagation coordinate. Blue line: experimental estimate with error (pale blue area). Broken line: numerical simulation (adapted from Minardi et al. 2014).

show a transient absorption due to an inverse Raman scattering (IRS) (Jones & Stoicheff, 1964) process between the pump and the probe, provided the probe is tuned to the anti-stokes wavelength of the pump. IRS is a stimulated absorption of light mediated by molecular vibrations, and can be considered as the complementary effect of the more notorious stimulated Raman scattering. We proved theoretically that IRS absorption as measured on the shadowgram can be used to estimate the energy content of the optical pump wave packet.

From the analysis of several shadowgrams of a probe tuned at the anti-stokes wavelength of the pump and taken at different pump-probe time delays, we were able to track simultaneously the energy content of the pump wave packet along its propagation path, and the time evolution of the solvated plasma density generated by the pump. The experimental data were then used as a benchmark for a numerical model of the investigated system. The model includes the description of the spatiotemporal propagation of the pump wave packet in pure water, the generation of plasma by multi-photon and avalanche ionization, and the optical properties of the generated plasma (refractive index and absorption).

In the simulations, we fixed the parameters of the input pulse (energy and focusing conditions) to the experimentally measured values and used the band gap of water as a free parameter to fit the energy losses and the solvated plasma data. An additional constraint was given by published data on the solvated electron yield for different photon energies (Bartels & Crowell, 2000). Indeed, only a fraction of all excited photo-electrons can be trapped by water molecules and form the solvated plasma state, and this fraction depends on the (multi)-photon transition energy.

As a result of the comparison, we found excellent agreement between the model predictions (see Figure 2) and the experimental data provided that the band gap of water was set to ~8 electronvolt, rather than the commonly used value of 6.5 electronvolt (Kennedy et al., 1995). This result illustrates the potential of the applied experimental and numerical method to study the very first instants of the energy deposition dynamics of ultrashort laser pulses in Raman-active transparent materials.

The successful accomplishment of the project was possible thanks to the unique combination of experimental and theoretical skills featured by our team. In this context, the excellent preparation and skills of the personnel at the Vilnius Laser Research Centre, Lithuania, were critical to complete the experimental campaign and produce high-quality data within the two weeks of Laserlab-Europe allocated time. Elaboration of the experimental data was carried out by the group at the University of Jena, Germany, which proposed and coordinated the project. The final theory of the IRS shadowgrams and the numerical simulations were developed by the group at the Centre de Physique Theorique in Palaiseau, France, which has a long standing expertise in developing numerical models of high-intensity ultrashort laser pulses propagating in transparent media. An intense opinion exchange between all the participants in the project was key to orient – and develop considerably – the data elaboration procedures and their interpretation.

Stefano Minardi

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HiPER: Workshop on IFE at SPIE Lasers and Optoelectronics Symposium

On 15 and 16 April 2015, the HiPER IFE (Inertial Fusion Energy) Physics and Technologies workshop was held within the SPIE Symposium in Prague. The event included invited presentations from Thierry Massard, CEA Chief Scientist of the Simulation Programme, and John Edwards, National Ignition Facility (NIF) Ignition Program leader from Lawrence Livermore National Laboratory. The event was jointly hosted by UK's Science & Technology Facilities Council (STFC) and Atomic Weapons Establishment (AWE).

Thierry Massard described the progress with installation and commissioning of the Laser MégaJoule (LMJ) facility in Bordeaux and the arrangements for academic access in 2017. Preliminary proposals have been submitted from the community, including HiPER.

John Edwards gave an update on recent experiments at NIF and explained the prospects for progress towards ignition over the coming year. Substantial progress has been made towards understanding the issues which have degraded the ignition performance to date. This new understanding is informing the high priority areas for the experimental and computational programme in the immediate future. Subsequent sessions at the workshop covered laser technology development, theory and simulations of shock ignition and other advanced schemes, chamber design, fusion compatible materials and target design and fabrication.

The possibility of preparing a bid to H2020 for an 'IFE I3' was also discussed. Thierry Massard agreed to consider how CEA might be able to support such a bid.

Chris Edwards, STFC

ELI to organise ICEL conference

The Extreme Light Infrastructure Delivery Consortium (ELI-DC) will organise the first International Conference on Extreme Light (ICEL) to highlight the novel science to be undertaken at ELI, thus contributing to the celebrations of the International Year of Light and Light-based Technologies. The conference will take place in downtown Bucharest, Romania, from 23 to 27 November 2015 and will be co-organised by ELI Nuclear Physics, the Romanian pillar of ELI.

ICEL2015 will be the first of a regular series of conferences, and can be regarded as a follow-up on the tradition of ELI-related conferences established some years ago with LEI2009 and LEI2011. The conference is a unique opportunity to gather together the community of ELI users at large in a single scientific event. Further details will follow shortly on www.eli-laser.eu and can be requested by email: *icel2015@eli-laser.eu.*

Catalin Miron, ELI-DC

ELI presented itself in a dedicated booth at the LASER / World of Photonics Congress and Exhibition held in Munich in June. Visitors were invited to come to the booth to learn about ELI's advanced laser technologies and the current implementation status of the Extreme Light Infrastructure in Hungary, Romania, and the Czech Republic. The exhibition included posters, a video presentation, and a model of the ELI-NP facility under implementation in Romania.

Forthcoming events

Application of Laser Plasma X-ray and EUV Sources in Technology and Science
6-9 July 2015, Warsaw, Poland

User Training Workshop on Light-Based Technologies
2-4 September 2015, Trnava, Slovakia

Laserlab User Meeting 2015
6-8 September 2015, Coimbra, Portugal

Joint JRA Meeting
24-25 November 2015, Milan, Italy

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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