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Laserlab Europe

Laserlab Forum

Newsletter of LASERLAB-EUROPE:
the integrated initiative of European laser infrastructures funded by the European Union's Horizon 2020 research and innovation programme

Lasers for Safety and Security

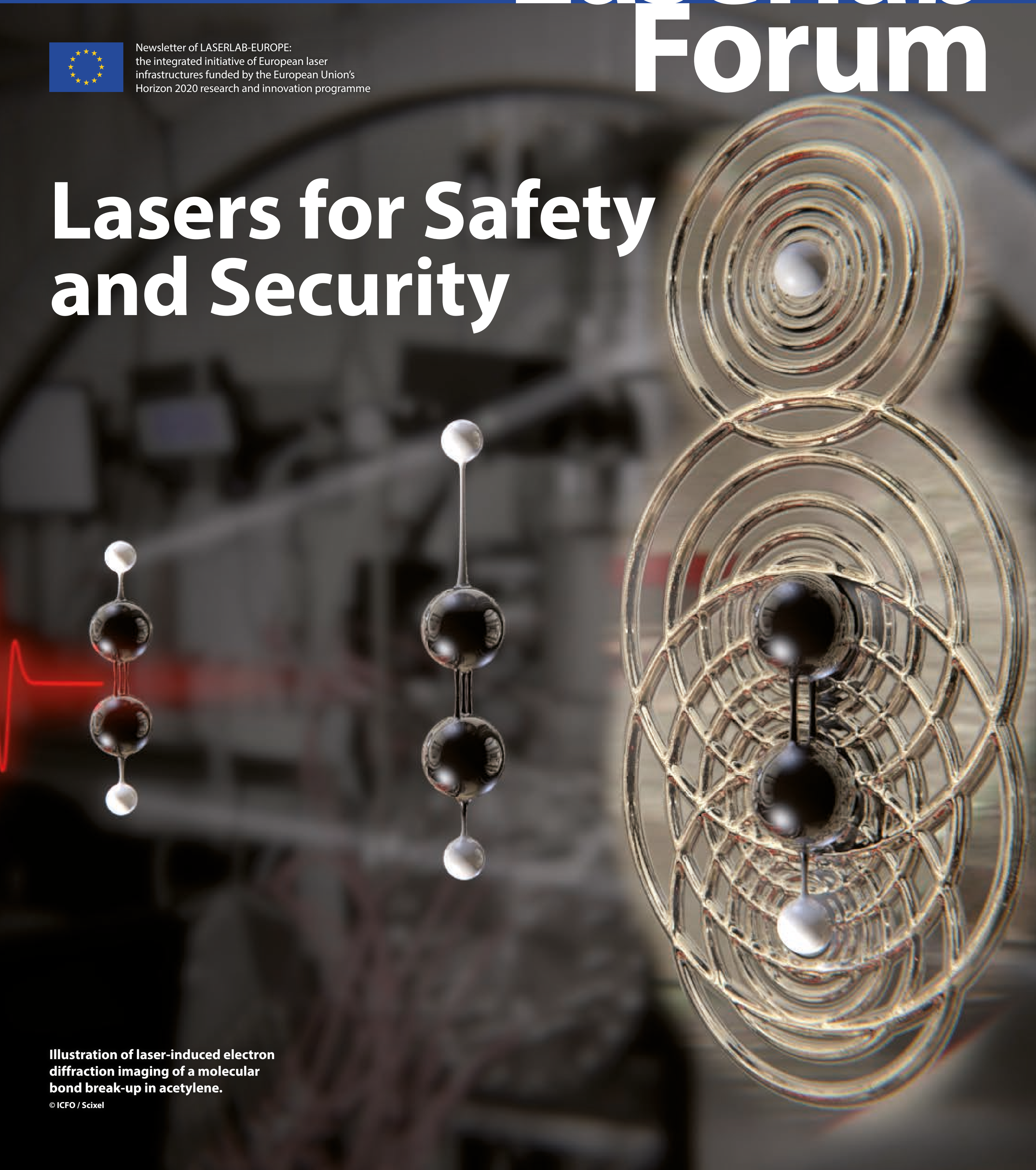

Illustration of laser-induced electron diffraction imaging of a molecular bond break-up in acetylene.

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In this Issue

Editorial

Tom Jeltes

When lasers are mentioned in the context of safety and security, it might not be clear from the start whether the lasers are the problem or the solution. In a way, they are both, and there is definitely a lot to say about laser safety procedures in laboratory environments – even more because lasers are becoming more powerful by the day, and more and more scientists without a background in laser physics are using lasers as an indispensable tool for research.

But lasers also can help make our society a safer place, as becomes clear from this issue's focus section. Examples from Laserlab partners range from lightning protection, testing ballistic protection gear, to assessing the quality of high-voltage insulation from a distance, and identifying speeding perpetrators as well as landmines.

Adding to the variety of the focus section is this issue's Access Highlight, which shows how lasers can also be used as some kind of tweezers to hold tiny strands of DNA, while different lasers are used to visualise the dedicated proteins that our body employs to repair broken pieces of our genetic material. In this way, these novel laser techniques provide insight in how cancer might develop when this repair mechanism fails. All in all, we once again present a nice sample of all the exciting things that are going on in the Laserlab-Europe community. Enjoy!

Tom Jeltes

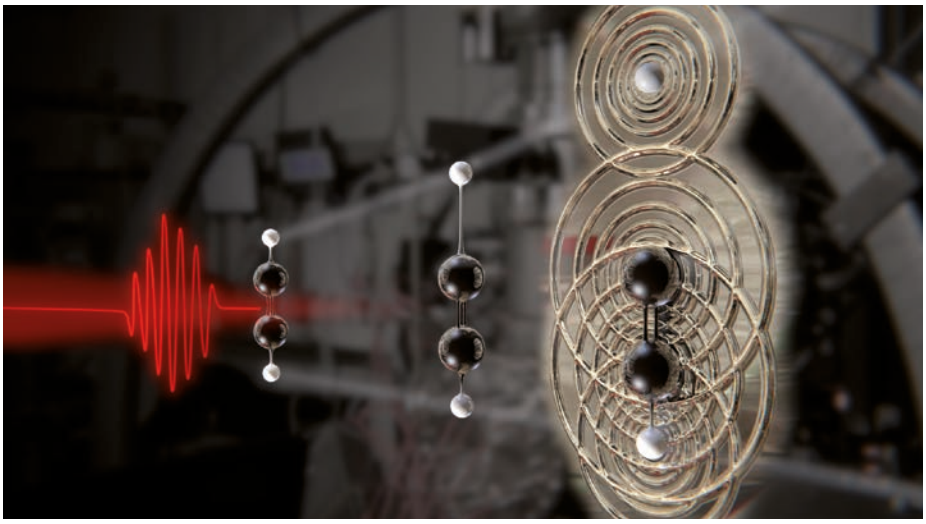
News

ICFO researchers take molecular snapshot

In a study published in Science in October 2016, researchers from the Attoscience and Ultrafast Optics Group at Laserlab-Europe partner ICFO, Barcelona in collaboration with researchers from the USA, the Netherlands, Denmark and Germany, have reported on the imaging of molecular bond breakup in acetylene (C_2H_2) only nine femtoseconds after its ionization.

The team was able to track the individual atoms of the isolated acetylene molecule with a spatial resolution as small as 0.05 Ångström – less than the width of an individual atom – and with a temporal resolution of 0.6 femtoseconds. They succeeded in triggering the breakup of only one of the bonds of the molecule and saw how one proton left the molecule.

The scientists developed an ultrafast mid-IR laser source and combined it with a reaction microscope to detect the 3D momentum distribution of electrons and ions in full kinematic coincidence. In the experiment, a single isolated acetylene molecule was oriented in space with a short laser pulse. A strong, follow up, infrared pulse liberated one electron from the molecule,



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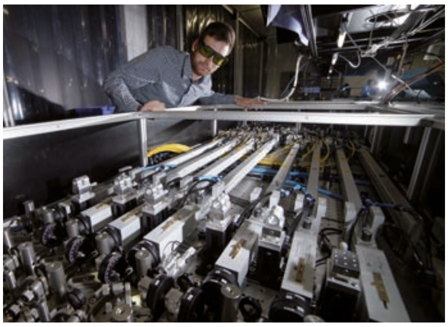
Artists' impression of the ICFO-experiment published in Science.

accelerated it on a returning trajectory and forced it to scatter off its own parent molecular ion, all within only nine femtoseconds.

After some clever data processing, the team was able to extract the entire molecular structure and, moreover, they could show that orienting the molecule along the electric field of the laser, or perpendicular to it, completely changed its dynamics. In one case, the molecule underwent vibrational motion with the laser field, while in the other case a C-H bond was clearly broken. The experiment is the first direct visualization of bond cleavage and observation of the proton during its departure from the $[C_2H_2]^{2+}$ ion.

Record tabletop XUV source from Jena

© Jan-Peter Kasper, FSU Jena



PhD student Robert Klas with the laser setup.

Researchers from Laserlab-Europe partner Helmholtz Institute Jena have developed a table-top source of extreme ultraviolet (XUV) radiation with an average output power at a wavelength of 57 nanometer of 0.8 milliwatt, which is almost an order of magnitude higher than previously reported for sources based on high harmonic generation. The Jena team reported on their new XUV source in the journal Optica in October 2016.

Ultrashort, coherent pulses of extreme ultraviolet radiation can be used to study chemical reactions in real-time, or observe the movement of charge carriers. Such XUV pulses are usually generated in giant particle accelerators, such as the XFEL in Hamburg, whose 3.4 kilometre long underground facility has just been put into operation, or in ring accelerators, so-called synchrotrons, of several hundred metres in diameter. Since access to these large-scale facilities is limited, laser scientists are trying to develop more handy, table-top XUV systems.

In order to create the ultrashort XUV radiation, the Jena researchers focus an infrared laser pulse in a birefringent crystal to double its frequency. The resulting green laser light is then refocused in a second step of the so-called cascaded frequency conversion, which results in even higher-frequency pulses in the XUV.

New Science Center Aurelium in Bratislava

© Dusan Chorvat, ILC

New Science Centre opens in Bratislava

A newly established hands-on science centre has opened in Bratislava, Slovakia. The Aurelium Science Centre was inaugurated in the presence of the Minister of Education, Science, Research and Sports of the Slovak Republic, Mr. Peter Plavčan, on 7 November 2016.

A team from the Slovak Laserlab-Europe partner International Laser Centre (ILC) assisted in developing the Aurelium exhibits related to optics, photonics, imaging and lighting. The new science centre will be playing an important role in photonics outreach activities of ILC in Slovakia, based on the successful European projects GoPhoton! and Photonics4all.

Aurelium is an initiative of the Slovak Centre of Scientific and Technical Information (CVTISR), which aims to promote science, technology, engineering and mathematics (STEM) to young people and students, encouraging them to focus their careers on natural sciences, physics and engineering.
http://aurelium.sk/

UNESCO International Day of Light

Following the highly successful International Year of Light and Light-based Technologies 2015 (IYOL), the Executive Board of UNESCO has endorsed a proposal for an enduring follow-up in the form of an annual International Day of Light to be celebrated on 16 May every year from 2018.

The purpose of an International Day of Light will be to provide an annual focal point for the continued appreciation of the central role that light plays in the lives of the citizens of the world in areas of science, culture, education, sustainable development, and in fields as diverse as medicine, communications and energy. The broad theme of light will allow many different sectors of society to participate in activities around the world that will raise awareness of science and technology, as well as art and culture and their importance in achieving the goals of UNESCO in promoting education, equality and peace.

Laserlab-Europe has been an official Collaborating Partner of IYOL and many Laserlab-Europe members contributed to the success of the initiative, organizing exhibitions, workshops, lectures and festivals for the broad public.

Laserlab-Europe Industrial Advisory Committee

The Industrial Advisory Committee (IAC) is a new body in Laserlab-Europe that provides advice on promoting the collaboration of Laserlab with industry and the medical sector for the benefit of European competitiveness. The IAC is composed of eight industry representatives and Laserlab scientists with vast experience in industrial relations, elected by the General Assembly, and will evolve during the coming years to match future needs.

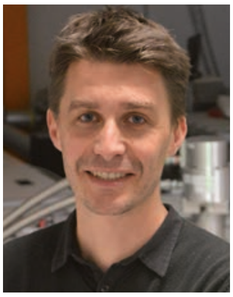
What is Laserlab-Europe?

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 33 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 laboratory in order to perform world-class research.

ERC Grants

Three Laserlab-Europe researchers received ERC Consolidator Grants, each of up to 2 million euros, this year. David Grojo of LP3 (Marseille, France) will use his grant to exploit extreme light for material processing; Frank Koppens (ICFO, Barcelona, Spain) is planning to create nanoscale optical fields in novel quantum materials; and Gerasimos Konstantatos (also from ICFO) aims to develop a solution processed solar cell platform based on environmentally friendly materials. In addition, Sébastien Corde of LOA (Palaiseau, France) has been awarded an ERC Starting Grant of 1.5 million euros, which he will use to develop a new plasma particle acceleration technology.

David Grojo (LP3): Extreme light for micro-fabrication



High peak power compact femtosecond lasers can be used for high-precision laser micro-fabrication. So far, however, the 'extreme light' (ultrashort pulses, X-rays and terahertz radiation) produced inside the exposed matter remains unexploited for nano/microfabrication because of the low intensity.

The main objective of David Grojo's Consolidator Grant project EXCEED is to overcome the intrinsic limits of ultrafast laser material processing by exploiting extreme light pulses. In the proposed concept, the energy required for optical breakdown (local ionisation of the medium) comes mainly from the primary high-power laser source, whereas the desired interaction is initiated by the much weaker secondary pulse of extreme light. Consequently, this method provides the freedom to control the spatial resolution and deposited energy density independently.

Frank Koppens (ICFO): Topological nano-photonics

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Topological nano-photonics is a new paradigm for novel quantum materials and will enable future applications in miniaturised photonic isolators, diodes and logic circuits, possibly leading to completely new concepts for communication systems, optical transistors and optical information processing.

In his Consolidator Grant project TOPONANOP, Frank Koppens aims to exploit the extraordinary topological properties of novel quantum materials in order to control light at the nanoscale in a radically new way. One of the main objectives is to generate non-reciprocal nanoscale optical fields (plasmons) that propagate in only one direction and implement topologically protected plasmons such that they move around defects and corners. At the same time, visualizing and controlling electromagnetic excitations will be used as a tool to unravel extraordinary phenomena in exotic quantum materials.

Gerasimos Konstantatos (ICFO): Green nanocrystal solar cells

Solar cells made of nanocrystals have the potential to combine the best features of plastic solar cells and conventional silicon-based cells. Like plastic solar cells, they can be created from solution using a cheap and flexible technique called spin-coating. In addition, with nanocrystals much higher efficiencies could be reached in principle than with either plastics or silicon.

Gerasimos Konstantatos' Consolidator Grant project HEINSOL aims to develop the first highly efficient, robust solution processed solar cell platform based on environmentally friendly, Earth-abundant materials. To achieve this, HEINSOL undertakes a hierarchical approach to tailor the opto-electronic properties of inorganic nanocrystals, starting from the control of composition and their properties at the atomic level, and following up with further tailoring their optoelectronic properties via interactions at the supra-nanocrystalline level.

Sébastien Corde (LOA): Miniature beam-driven plasma accelerators

© Ecole Polytechnique

As conventional accelerator techniques are reaching their limits, new concepts are emerging. Using an ionised gas – or plasma – the energy gained by the accelerated particle per unit length can be increased by several orders of magnitude.

In his Starting Grant project M-PAC (Miniature beam-driven Plasma ACcelerators), Sébastien Corde proposes to power plasma accelerators with laser-accelerated electron beams based on 100-TW-class laser systems, in order to miniaturise the so-called 'beam-driven plasma accelerators'. He will try to generate and preserve the beam quality required for high-energy colliders and hopes, among other things, to address challenges relevant for the acceleration of positrons, the antimatter counterparts of electrons.

EUCALL: Creating synergy between the X-ray sources of Europe

The European Cluster of Advanced Laser Light sources (EUCALL) has completed the first year of its three-year project period. The project successfully met all its milestones for the year, producing a new open-source tool for experiment simulations and developing specifications for several pieces of new scientific equipment. In its first report, EUCALL's Scientific Advisory Committee stated that the project's successful approach should be continued beyond its initial three-year scope.

Within the European Union-funded EUCALL project, which was launched in October 2015 and is coordinated by European XFEL, the accelerator-driven and the laser-driven X-ray sources of Europe collaborate for the first time in a comprehensive way on technical, scientific, and strategic issues.

EUCALL involves approximately 100 scientists from European XFEL, DESY and Helmholtz Zentrum Dresden-Rossendorf in Germany, ESRF in France, Elettra Sincrotrone Trieste in Italy, MAX IV Laboratory/Lund University in Sweden, PSI in Switzerland, and ELI in the Czech Republic, Hungary, and Romania. The project also involves the previously established scientific networks FELs of Europe and Laserlab-Europe.

A first result is a simulation platform called SIMEX. Compiled from existing simulations, SIMEX integrates different steps of many types of X-ray investigations. Such simulations allow scientists to try out different settings and to optimise their procedures before their experiments, so they can make the most of their valuable beamtime.

Other EUCALL milestones reached in the past year were a design report for a new transparent X-ray intensity monitor, as well as specifications for a sample holder to be used at all participating EUCALL facilities. The X-ray monitor is based on the design of a xenon-based intensity monitor that is currently used at the German research centre DESY's FLASH X-ray free-electron laser and will be capable of dealing with both the hard X-rays to be delivered by the European XFEL as well as the ultrashort soft X-ray and ultraviolet pulses to be generated at the ELI facilities. The first prototype will be tested during 2017.

Further activities included the organisation of a workshop dedicated to development of a target fabrication and characterisation network for high repetition rate laser experiments, which has been identified as an important joint foresight topic for EUCALL. Finally, travel bursaries were organised for young scientists to attend the ELI Summer School 2016 and the Science@FELs Conference 2016, in an effort to promote cross-community experience exchange. This programme will continue in 2017 and 2018 for selected meetings and events.

EUCALL's synergy work package is developing new concepts for its facilities to collaborate, including the organisation of several targeted workshops, which aim to provide experience exchange from EUCALL's operational light sources like DESY and ESRF, to the facilities in preparation such as ELI and European XFEL. These workshops will focus on best practices and mistakes to avoid, addressing for example issues related to user access, to technology transfer and innovation, and to the application of synchrotron, free-electron laser and high-power laser-driven X-ray radiation to a single field such as structural biology.

For further exchange between the communities, the EUCALL webpage provides links to the newsletters of EUCALL's partners, to their social media channels and to any upcoming events (see 'Outreach').

www.eucall.eu **Graham Appleby**

Project participants gathered at the EUCALL Annual Meeting 2016 at HZDR, Germany.

Lasers for Safety and Security

Safety and security is one of the key areas of attention for the European Commission. To show how laser science and technology can contribute to a safer world, in this focus section we give some examples of recent safety and security related initiatives within Laserlab-Europe. In previous issues of Laserlab Forum, we already reported on a number of similar projects related to safety and security. In 2011, in a transnational access project conducted at LaserLaB Amsterdam, Spanish forensic experts were for the first time able to detect the presence of DNT, a material found in many explosive materials, through layers of non-transparent plastics. To accomplish this, they used time-resolved Raman spectroscopy, a laser technique extensively researched at LaserLaB Amsterdam, which provides 'molecular fingerprints' to identify chemical compounds. In 2014, CLF spin-out Cobalt Light Systems received the MacRobert Award, the UK's most prestigious engineering prize, for their application of Spatially Offset Raman Spectroscopy (SORS) in an airport security scanner that allows airports to remove the existing hand-luggage liquid ban. The technique identifies explosive threat materials inside containers in seconds without opening them. More recently, IOE-MUT (Warsaw, Poland) created a multifunctional lidar system for stand-off detection of biological clouds at distances up to several kilometres, which can be used as an early warning device for biological warfare. The bio-lidar system is also able to classify the type of detected species by making a comparison with a database. More generally, several partners of Laserlab-Europe have developed laser-based detection techniques that can be used to distinguish between toxic and non-toxic varieties of the same molecule, for example, and to measure pollution levels that can be considered a threat to our health and as such a safety risk as well. Finally, we should also mention the many laser techniques applied to biomedical cases that have been highlighted in Laserlab Forum over the years. Those, in a way, can also be seen as concerning issues of safety, especially when these techniques reduce the risk of dying of life-threatening diseases like cancer.

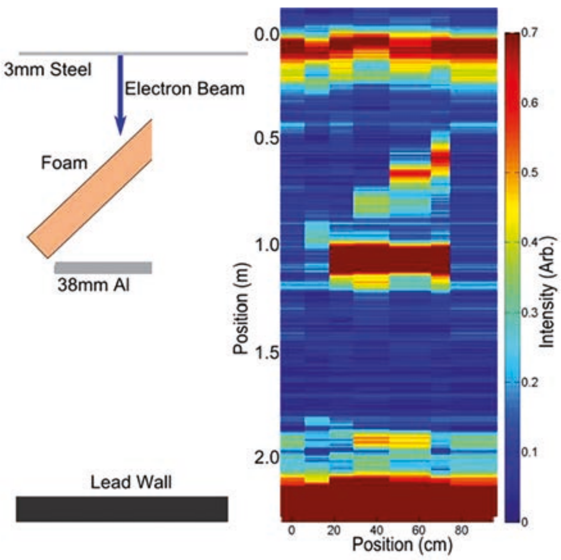
Detection of hidden objects by X-ray imaging using a laser-generated electron beam

For detection of objects through barriers such as items smuggled in a container crate or buried landmines, standard X-ray detection techniques are inadequate. In collaboration with the UK's Defence Science and Technology Laboratory, scientists from Laserlab-Europe partner the Central Laser Facility (CLF) have developed and demonstrated a new approach to probe for hidden objects or items surrounded by sand or soil.

X-ray backscatter imaging is currently used in a range of technologies, from portal security, where it is used to scan airline passengers, vehicles and containers, to industrial inspection, studying the internal structure of low density materials, and applications requiring single sided imaging. Currently, the application of this technique to the detection of landmines is limited due to the surrounding sand or soil strongly attenuating the 10s to 100s of keV X-rays required for backscatter imaging.

In collaboration with the UK's Defence Science and Technology Laboratory the CLF have developed and demonstrated a new approach using a high energy 140 MeV short-pulse (<100 fs) electron beam, generated by laser-driven acceleration, to probe the sample. High energy electrons are able to penetrate to greater depths in a sample; these electrons will then produce X-rays via bremsstrahlung emission, which then backscatter and travel back through the sample before being detected. The backscattered X-ray pulses coming from deeper within the sample will take longer to reach the detectors, therefore a depth profile can be formed. Scanning across the sample allows one to generate a full 3D like image.

An experiment carried out using the Gemini laser system generated the electron beam by focusing the laser pulse in a supersonic gas jet. A variety of detector and scintillator configurations were used to measure the backscattered X-ray pulses coming from various depths within the sample, with the main challenge being the capability of the detectors to resolve pulses that hit the detector, only billionths of a second apart. Despite this extreme challenge, an X-ray backscatter image of an array of different density and atomic number items was demonstrated and is the first time a backscatter image with



Left: A diagram of the set-up of the array of test objects. Right: Example of an X-ray backscatter image of the object array shown left. An array of objects including 38 mm thick aluminium and 0.14 m thick insulation foam are shown. For more details see: R. Deas et al., J. X-ray Science and Technology 23, 791-7, 2015.

depth information has been acquired using a laser-driven electron beam to generate X-ray emission in the imaging target itself.

Although this research is in its very early stages, it is hoped that it will ultimately lead to a deployable system that can be used to help detect buried or hidden objects such as landmines or contraband.

David Neely (CLF)

Laser lightning protection

French Laserlab-Europe partner LOA will lead a new FET-OPEN programme called Laser Lightning Rod, aimed at developing a new type of lightning protection. The goal of Laser Lightning Rod is to investigate and develop a new type of lightning protection based on the use of upward lightning discharges initiated by a high-repetition-rate, multi-terawatt laser.

The feasibility of the novel technique is based on recent research providing new insights into the mechanism responsible for the guiding of electrical discharges by laser filaments, as well as on cutting-edge high-power laser technology, and the availability of the uniquely suitable Säntis lightning measurement station in Northeastern Switzerland, located at an altitude of 2500 metres.

Because of the optical Kerr effect, a terawatt ultrashort laser pulse propagating in air will self-organise into thin light channels called filaments. This process results in long-range propagation of a pulse with multi GW/cm^2 peak intensity. Due to ionisation, a plasma track and a low-density channel are left in the wake of the pulse.

Such long-lived low density channels form a preferential path for lightning precursors, as has been demonstrated in laboratory experiments where guiding of electric discharges has been obtained over distances of 4 metres. Using a powerful kHz laser in conjunction with a new type of focusing system should allow the formation of a long and permanent low-density channel able to initiate upward lightning discharges in real conditions.

LOA will collaborate with Swiss institutions of higher education Université de Genève, École polytechnique fédérale de Lausanne (EPFL), and Haute Ecole Spécilisée de Suisse occidentale (Hes-so), as well as laser company Trumpf Scientific Lasers, and aircraft manufacturer Airbus GI. The Laser Lightning Rod programme has a budget of 3.9 million euros.

Aurélien Houard (LOA)

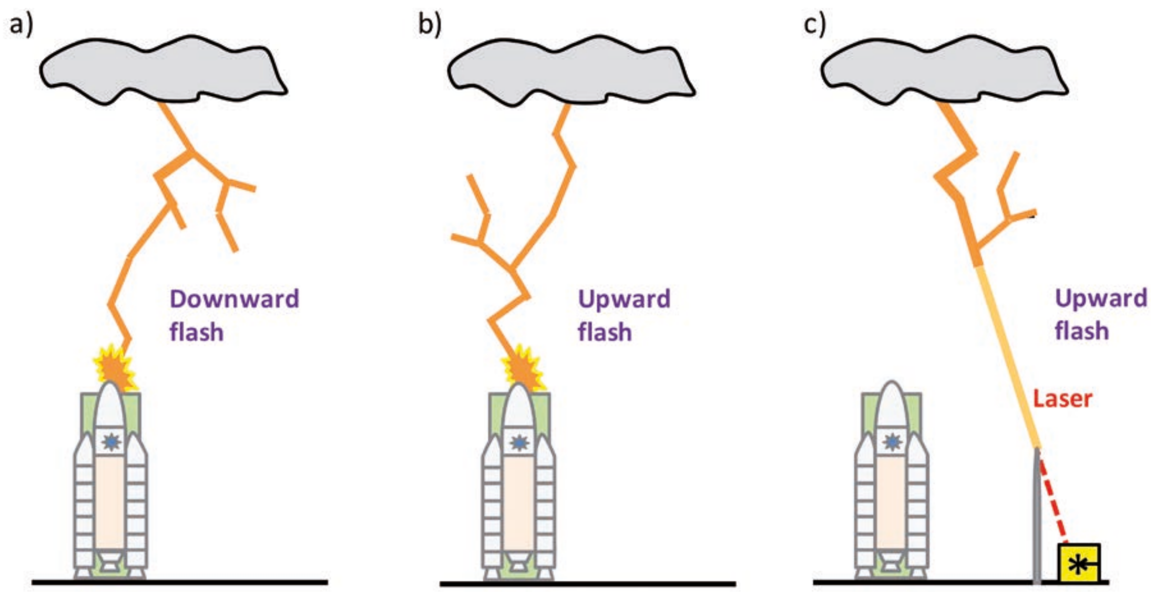
Laser speed gun velocimeter with integrated camera

Since Poland joined the EU, the country has seen a rapid increase in the number of modern, double belt highways. This, together with increasing demand among drivers for indisputable prove of their traffic offense, led to an urgent need for new methods of measuring speed of the vehicles. Accordingly, the Institute of Optoelectronics (IOE) of the Military University of Technology (MUT) in Warsaw developed a handheld laser speed gun velocimeter for law enforcement on public roads.

Widely used Doppler radar devices are becoming obsolete because they do not allow precise beam aiming. The answer to that problem is a pulsed laser diode. Combined with the right optics it can generate a narrow light beam with milliradian divergence, sufficient for accurate targeting.

As a result of joint work of IOE MUT and the ZURAD company from Ostrów Mazowiecka, a prototype named 'Rapid Laser' was built based on lidar technology. IOE took the role of R&D department and ZURAD – the future manufacturer of the device – contributed its experience in the law enforcement market.

The presented device is based on a 905 nm semiconductor pulsed laser diode. The energy of the emitted pulse



In the Laser Lightning Rod project, upward lightning flashes will be initiated by a high-repetition-rate, multi-terawatt laser, directing lightning away from vulnerable objects.

is 0.5 mJ, an upper limit for class 1 laser products operating within a pulse width range of one to one hundred nanoseconds. The device emits a series of pulses in order to increase the accuracy of the measurement. Receiving and transmitting optics are based on a single aspheric lens which creates a 3 mrad divergence of the transmitted beam and a 4 mrad field of view for the receiver.

The device is meant to measure the speed of vehicles traveling within a range of 1250 metres. It can also measure the distance to a vehicle, record photos and videos, and is immune to laser jammers and other laser devices aiming for the same vehicle. It has features like a 'distance gate' when measurement results are marked and classified only when the vehicle is located in the specified range away from the device.

Aiming unambiguity is achieved by displaying the targeting point in the live video image. The device has two displays: a high-resolution touch display serving as data output and user interface, and a near-eye display meant to ease aiming. Performance of the device was proven in field trials against laser jammers available on the Polish market, and against crosstalk between various laser devices.

Michal Muzal (IOE MUT)

'Rapid Laser' handheld speed gun prototype

© IOE MUT and ZURAD)

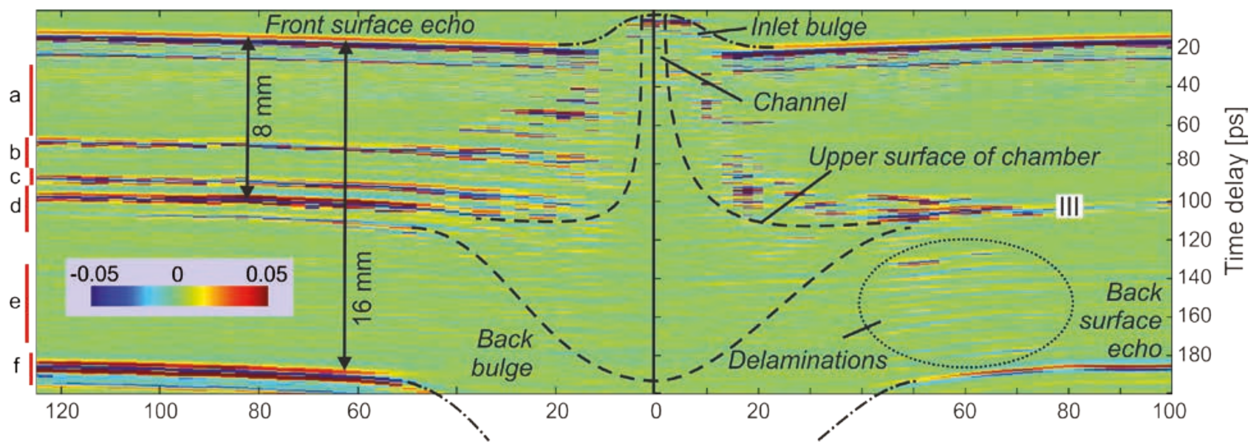
Terahertz imaging of polyethylene bullet protection plates

To improve ballistic protection plates, detailed study of the material after impact is essential. At the Institute of Optoelectronics (IOE) of the Military University of Technology (MUT, Warsaw), laser-generated terahertz radiation is used to image the effect of the impact of a bullet on polyethylene fibre plates.

Polyethylene composites, which are manufactured as plates with a thickness of approximately 10-20 mm, are used as material for the ballistic protection of vehicles, helmets and bulletproof vests. They consist of a number of about 50 mm thick layers of fibres made of ultra-high-molecular-weight polyethylene (UHMWPE). The fibres are arranged in successive layers perpendicular to each other. During interaction of a projectile with the structure, a chamber is created and the composite will delaminate.

Knowing the location, size and thickness of these delaminations is essential to determine the quality of the material and further research. Terahertz radiation in the range of 0.1-3 THz perfectly passes through the polyethylene structures and facilitates their accurate analysis and three-dimensional visualisation.

To measure the sample, we used a time domain system (TDS) operating in the reflection configuration. In the TDS setup, a femtosecond laser and two photoconductive antennas are used to generate and detect a short pulse of electromagnetic radiation lasting about 1 ps. A THz pulse propagating in a multilayer structure encounters the interfaces between the layers with different refractive index and is partially reflected. The remaining part propagates further in the structure. As a result, one obtains a series of pulses delayed relative to each other by twice the propagation time in the individual layers. Scanning the sample point by point allows reconstruction of the internal structure and the position of delaminations.



THz B-scan of the sample in reflection along axes: PeO (left part) and GeO (right part). The scan was performed from the front side of the sample. The image is saturated to emphasise delaminations. Reproduced from N. Palka et al., Composites Part B 92 (2016) 315-325.

Vertical and horizontal cross sections of the structure present the inlet channel of the projectile, the centrally located chamber, radially spreading delaminations, and other features. By means of signal processing of ambiguous THz waveforms reflected from the interior of the sample, we can unambiguously determine the distribution of delamination and size of the chamber.

Norbert Palka (IOE MUT)

Remote LIBS for assessing the safety of high-voltage outdoor insulators

Insulators are crucial for the reliable performance and safety of high-voltage (HV) systems. In the project POLYDIAGNO, scientists from IESL-FORTH (Crete), together with Greek partners, developed a laser diagnostics system which can be used to remotely assess the condition of outdoor high-voltage insulators, thereby reducing the risk of electrocution or fire.

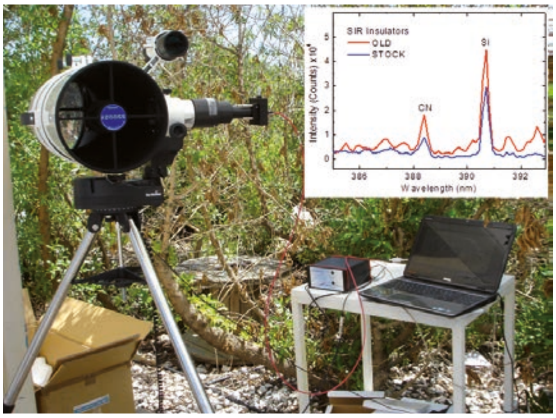
Polymer-based composite HV outdoor insulators have been introduced in HV power systems technology more than thirty years ago, as an alternative to conventional insulators, made of porcelain or glass, due to their excellent long-term performance and reduced installation and maintenance costs. They consist of a fibre-reinforced epoxy rod, which is covered with an elastomeric housing. In particular, silicone rubber insulators are commonly used in overhead transmission lines of most electric power distribution stations due to their unique properties, such as low weight, high heat resistance, chemical stability and long-term hydrophobicity.

However, these insulators are subject to ageing and/or degradation processes, which are often attributed to prolonged exposure to unfavourable environmental conditions and/or the occurrence of electric discharges. Contamination of salts, dust, moisture and biological growth on the insulator's surface contribute to the formation of conductive layers, which serve as ideal paths for leakage current flow, which, under certain conditions, may cause a complete flashover.

In order to avoid such complications and secure the high efficiency of an electrical energy system, it is important to develop suitable non-destructive diagnostic techniques, which would enable the remote and real time evaluation of the insulator's performance, without detaching them from the network. To this end, Laser-Induced Breakdown Spectroscopy (LIBS) has been found to be promising as a field-deployable technique for the efficient and reliable assessment of the operational state of HV outdoor insulators in service.

Remote LIBS measurements were performed successfully on site, at the TALOS High Voltage Test Station in Heraklion, Crete, a unique facility dedicated to the research of outdoor insulator systems operated by HEDNO (the Hellenic Electricity Distribution Network Operator).

In brief, focusing a high-intensity pulsed laser beam on the insulator's surface, from a distance of over 5 metres, results in plasma formation. Plasma light is collected via a telescope, which is approximately 10 metres away, and is transferred into the spectrometer for analysis and recording of the spectrum, which provides information



Laser-induced plasma emission is collected through a telescope, placed at a distance of almost 10 metres away from the target insulator. An optical fibre is aligned at the focus of the telescope and transmits the plasma light into the spectrometer. The inset shows two typical spectra obtained upon irradiation of stock and old (field) insulators (Nd:YAG laser; λ=1064 nm, τ = 10 ns). Image courtesy of IESL-FORTH and HEDNO SA.

on the elemental composition of the silicone rubber housing.

Correlation of Si, C and CN emission intensity ratios obtained from field insulators with reference intensity ratios, corresponding to unused (stock) insulators, shows that their values differ systematically reflecting the extent of chemical modifications, induced to the polymeric housing of the insulators, as a result of ageing and/or structural deterioration. Therefore, using the emission peak intensity ratios as spectral indicators was found to be satisfactory for remotely evaluating the operational quality of silicone rubber insulators.

Based on the value of the percentual difference of the spectral indicators between field and stock insulators, a straightforward classification of the operational quality of the insulators can be made. Likewise, by use of proper spectral parameters, also extracted from LIBS spectra, it has become possible to differentiate different types of synthetic insulators as well as to detect environmental deposits on their surface.

Costas Kalpouzos and Demetrios Anglos (IESL-FORTH)

Photo: Kreuzschnabel/Wikimedia Commons, Licence: Cc-by-sa-3.0 (http://creativecommons.org/licenses/by-sa/3.0/legalcode)

How protein bridges assist in DNA repair

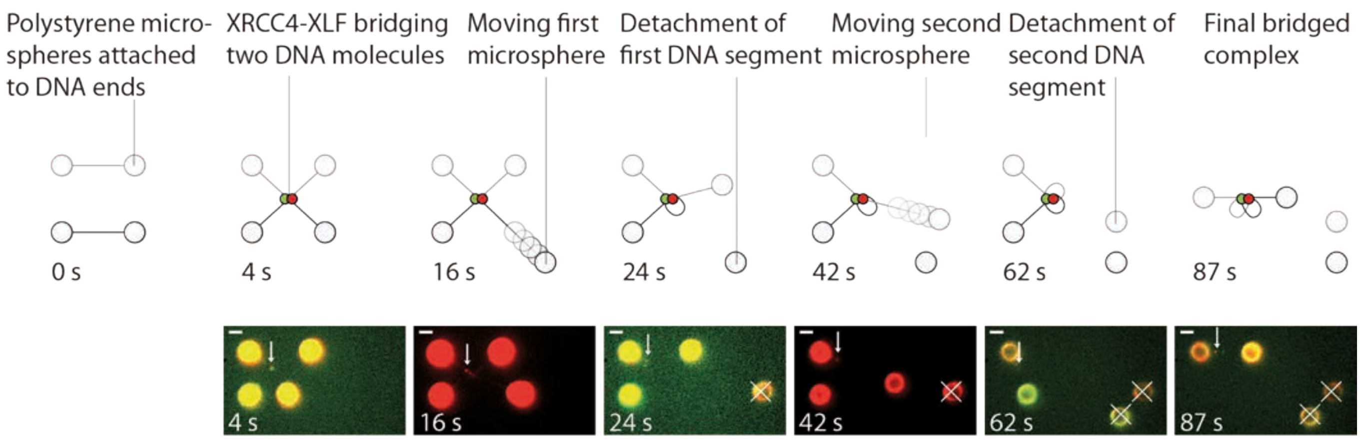
Every day, thousands of the DNA strands hidden in our body's cells are damaged. Usually, the DNA is quickly repaired with the help of dedicated proteins, but sometimes we are not so fortunate and a rupture does lead to cancer. Now, as part of the Laserlab-Europe transnational access programme, scientists from Laserlab-Europe partner LaserLaB Amsterdam and colleagues from the Cancer Research Center of Marseille have for the first time been able to make a movie of a part of the DNA repair process. Their work, which contributes to our understanding of DNA repair processes and the origin of cancer, was published in Nature last summer.

The DNA in our cells is continually being damaged, both by regular processes in the cell, and by external factors like sunlight. One of the severest kinds of damage is a so-called double strand break, where both strands of the DNA double helix are simultaneously broken. The body's repair mechanism for the double strand breaks relies on the formation of protein bridges between the broken pieces of DNA. In order to perform their task in the repair process, it is thought that these bridges should be strong and flexible at the same time. So far though, no one had been able to see directly how the bridges are being formed.

In the transnational access project, a team of physicists from LaserLaB Amsterdam, led by Erwin Peterman and Gijs Wuite, collaborated with a visiting team from the Cancer Research Center of Marseille directed by Mauro Modesti. In the Amsterdam lab, a unique combination of techniques is available which allowed the scientists to take hold of and manipulate the ends of two separate pieces of DNA, while measuring the forces exerted on the DNA. Simultaneously, the proteins bound to the DNA can be visualized using fluorescence microscopy. This technology is currently being made available for researchers around the world by the spin-off company LUMICKS.

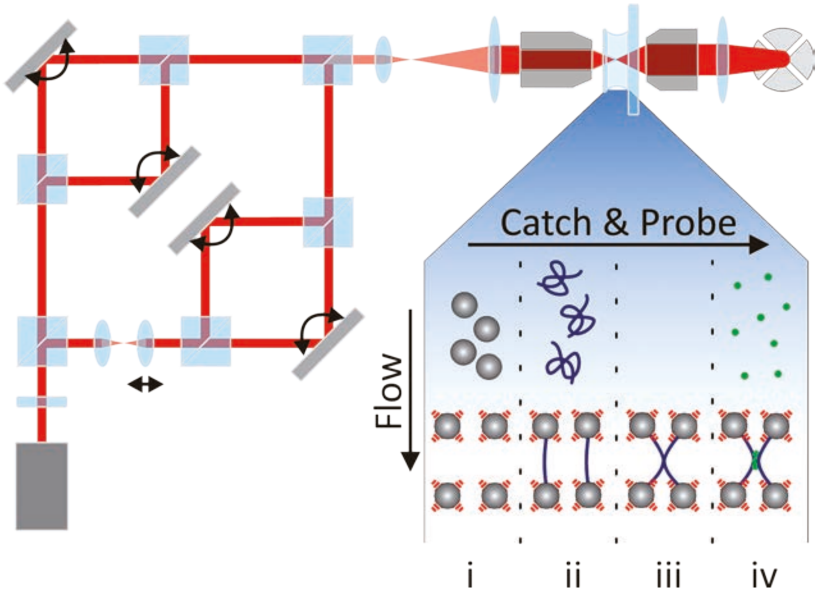
The single-molecule instrument used for the experiment employs so-called quadruple-trap optical tweezers, Ineke Brouwer from the LaserLaB Amsterdam team explains. "The instrument is custom-built onto an inverted microscope and consists of four independently steerable optical traps. These are used to hold polystyrene microspheres that can be tethered to the four ends of two DNA molecules, enabling full control over the tension in the DNA molecule and the positions where the two DNA molecules can interact. The optical traps are generated from a single trapping laser with a wavelength of 1064 nm, which is split into four traps using beam-splitter cubes. Force detection is possible on two of the traps, as one trap has a unique polarization and a different trap is co-aligned with a laser of a slightly different wavelength. In this way the tension on both DNA molecules can be monitored. For direct visualization the DNA-bound proteins are fluorescently tagged with fluorophores of different colours, which are excited by two excitation lasers."

At the Cancer Research Center in Marseille, Mauro Modesti studies the 'nanomachines' that detect and repair DNA double-strand breaks in cells, he explains. "When these nanomachines are defective, chromosomal aberrations arise that can lead to cancer. Furthermore, many cancer therapeutic strategies consist of inducing DNA double-strand breaks to kill cancer cells. It is therefore important to understand how these nanomachines function at the molecular level. My team uses biochemical approaches and cell-based assays to study these mechanisms, but it remains very difficult to directly assess the dynamics aspects of the reactions involved. In our collaborative work with Erwin Peterman and Gijs Wuite, we use a single-molecule approach to study these mechanisms. It is a much more direct route to unravel reaction dynamics because we can directly watch the nanomachines at work as they interact with the DNA substrate."



Single-molecule bridging experiments: *Fluorescence images (bottom) and cartoons (top) of two bridged dsDNA molecules after wrapping, incubating in a solution containing XRCC4 an XLF, and unwrapping. The DNA molecules are held together purely by a protein bridge, and, when tension is exerted on the complex by moving the microspheres (as indicated in the figure), the DNA detaches from the microsphere, showing that the protein bridge is stronger than the DNA-microsphere attachment. (Reprinted from Brouwer et al., 2016).*

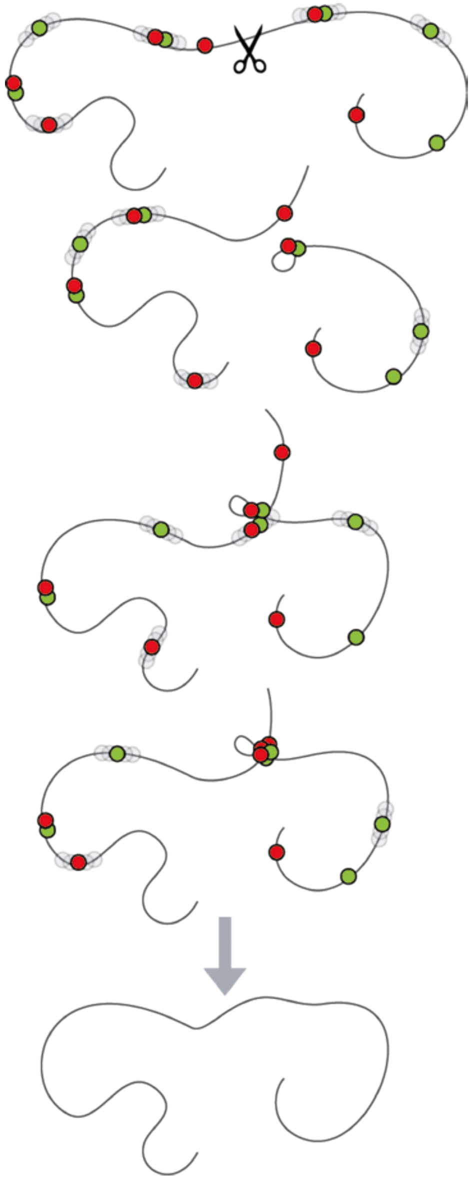
Modesti stresses that the Nature publication is the result of a long-standing scientific relation. He recounts how he got in touch with the Amsterdam team. "I met Erwin Peterman and his student Joost van Mameren at the Dutch annual biophysics meeting in 2005, I believe. Joost had a poster where he described the setup he was building, which consisted of a dual optical trapping system that he wanted to use to catch a single DNA molecule and study its elasticity. I immediately told myself that it would be great if we could directly watch the DNA repair proteins that I study acting on these single DNA molecules. So, I asked Joost whether it would be possible to couple his system with fluorescence



Schematic of the instrument. *A single laser is used for generation of four traps, each movable by rotation of a steerable mirror. The flowcell is placed on a movable stage between the objective and the condenser of the microscope. Within this flowcell, four laminar buffer flows are present, allowing fast buffer exchange and easy assembly of DNA-protein complexes. (Adapted from Laurens et al., 2012).*

microscopy and he said that this was exactly his plan. This is how it all started. With the advice of Erwin, I generated fluorescently labeled RAD51, a DNA repair protein, and a couple of years later we published our first study together. Over the years, and thanks to Laserlab-Europe, we kept collaborating on different projects, with my students and myself visiting the Amsterdam team regularly. We are fortunate because the Amsterdam team always keeps us up to date with their new technological advances."

In their most recent collaboration, which led to the publication in *Nature*, the teams have been able to show how complexes of two different proteins (XRCC4 and XLF) are able to keep together two broken strands of DNA by forming bridges between the strands. The properties of the protein complexes and their interactions with DNA appear to be optimized for exactly this purpose: even though they bind stably to DNA, the proteins are still very mobile and they do not influence the mechanical characteristics, explains PhD student Ineke Brouwer, first author of the paper. "It works like Velcro: the connection is pretty strong, but can still easily be adjusted and displaced. That is how the ends of the DNA strands stay accessible for other repair proteins."



Proposed mechanism for XRCC4 and XLF in DNA repair. *XRCC4 and XLF can bind at any location on the DNA. When a DNA break (indicated by scissors) occurs, the DNA fragments will overlap at a random location. Here, XRCC4 and XLF will localize and form very stable, yet mobile protein bridges. These bridges act as a 'cast' to hold the DNA ends in each other's proximity, while leaving the ends accessible for further processing and repair. (Reprinted from Brouwer et al., 2016).*

References:

I. Brouwer et al., Sliding sleeves of XRCC4–XLF bridge DNA and connect fragments of broken DNA, *Nature 535*, 566-569 (2016)

N. Laurens et al., Alba shapes the archaeal genome using a delicate balance of bridging and stiffening the DNA, *Nature Communications 3*, 1328 (2012)

Euro-BioImaging Preparatory Phase II: Full-speed towards operation

Since October 2016, European life science researchers have the possibility to use state-of-the-art imaging technologies, which they do not find at their home institutions or among their collaboration partners. The European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences (Euro-BioImaging, EuBI) provides open physical user access to a broad range of advanced technologies in biological and biomedical imaging for life scientists.

In addition, EuBI will offer image data support and training for infrastructure users and providers. A total of 29 node candidates in 11 countries, among them Laserlab-partners LENS in Italy, ICFO in Spain and ILC in Slovakia, host a range of novel imaging technologies, which scientists can use for study of biological samples from protein to human size. In the scope of the EC call for scientific infrastructure development INFRADEV-2, EuBI was granted 1.5 million euros for its Preparatory Phase II, to take the final steps needed to found the EuBI ERIC (European Research Infrastructure Consortium) and to start full operation for open user access by 2017.

The EuBI consortium members are now establishing the first generation of EuBI nodes to be ready for operation. In this regard, the Preparatory Phase II grant also provides the means to prepare the procedures for including additional nodes in the future and to identify exciting novel imaging technologies that may be suitable for open user access as part of EuBI.

In the Preparatory Phase II, a comprehensive EuBI training programme for researchers of all levels as well as an advanced training for core facility staff will be put in place, and training sites will be prepared for running first courses upon start of the EuBI ERIC. In parallel, the EuBI partners can now develop and test the concepts for future EuBI Image Data Repositories, which will host and offer access to large-scale, high-quality image data sets of common interest for the scientific community.

Laserlab-Europe and Euro-BioImaging, complementing each other in many fields of research and applications, will benefit from close collaboration, now and in the future. Thus, Laserlab-Europe wishes EuBI every success during the Preparatory Phase II.

More information can be found at *www.eurobioimaging-interim.eu*.

Dusan Chorvat

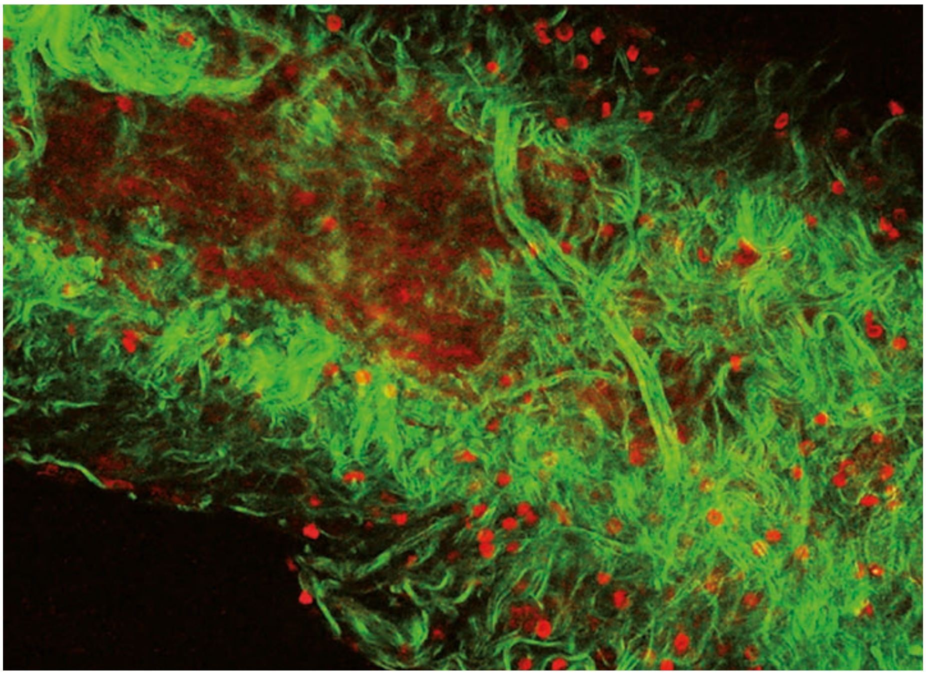


Image of collagen and blood cells in the tissue of a mouse aorta taken by a confocal microscope with nonlinear excitation (courtesy of ILC, Bratislava).

Forthcoming events

Laserlab Workshop on Data Handling and Open Data
March 2017, Berlin, Germany

SPIE Europe's Optics + Optoelectronics symposium
24-27 April 2017, Prague, Czech Republic

Laserlab Joint JRA Meeting
10-12 May 2017, Berlin, Germany

Training School on Laser Applications for Biology and Biomolecular Systems
3-7 July 2017, Coimbra, Portugal

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 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 Access Selection Panel (ASP) of Laserlab-Europe. The ASP sends the proposal to external referees, who will judge the scientific content of the project and report their judgement to the ASP. The ASP 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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