LA3NET

Newsletter
March 2014
Issue 8

Special Interest Articles

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- **Partner News**
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Individual Highlights

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- 3rd LA³NET Workshop

Laser Plasma Accelerators to the Horizon of 2020

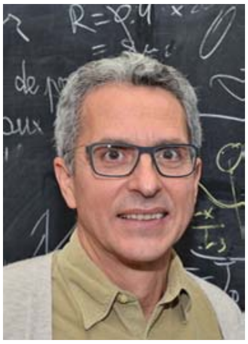
Victor Malka, Laboratoire d'Optique Appliquée (CNRS, ENSTA, Ecole Polytechnique)

The advances made in the collective control of the motion of electrons in a plasma medium with intense laser pulses has allowed the emergence of novel concepts for efficiently accelerating charged particles. The tremendous progress in the development of Laser Plasma Accelerators is opening new perspectives for major applications in science, technology and healthcare. By focusing intense laser pulses onto a target it is possible to produce high quality, energetic particle beams with adjustable parameters. This is thanks to the local control of electron motion in the plasma accelerating field which has a phase velocity close to the speed of light. Electron beams are currently generated with low percentage energy spread at energies in excess of few GeV with a peak current of a few kA and emittances at less than one π.mm.mrad. By comparison, proton beams are accelerated in a static electric field using high-density targets (for example thin foils targets) reaching energies in the 100 MeV level.

The route for applications is now well paved in medicine with radiotherapy, radio-isotope production for PET and ion implantation. Other future aspirations are for the realization of compact free-electron lasers, for the generation of compact light sources of relevance for imaging such as HHG, betatron and Compton sources and in material science for the non-destructive inspection of dense matter. For each of these applications the required particle beam parameters differ (high average or high peak current, high average or high peak brightness etc). Consequently, specific laser systems are needed for each of these applications with parameters optimized appropriately. Thanks to growing activity and awareness, the applications are attracting interest from the many European laboratories that have advanced laser systems with unique parameters.

The emergence of this field of research is due to the number and the quality of groups in Europe, their globally-recognised expertise and dynamism and the networks that support strong collaborations such as European projects LaserLab, EuCARD and LA³NET. The synergy between accelerator, laser and plasma communities with other scientists from particular applications is the natural step that needs to be pursued and is now underway in the H2020 programme. These efforts will contribute to the rapid development of these technologies and the ultimate success of this venture. This will enable dedicated facilities to be built orientated for the demonstration of one or two major applications by identifying the most important topics with societal applications, by reinforcing the networking activities and by concentrating effort and resources in an appropriate number of projects. In doing so, it will encourage the scientists involved to solve all the technological challenges that have been neglected or given low priority to date. These aspects will prove to be of greater importance as the benefits are realised and further applications discovered. This will pave the way for the design of more advanced laser plasma accelerators in the future. The priority is then to unite efforts to generate excellence and open novel perspectives for particle and radiation beam users across Europe. This will allow the present leadership in this field to be maintained in Europe and enable applications with significant impact on science and society.

At the forthcoming workshop on Novel Acceleration Techniques at HZDR, Dresden at the end of April Victor Malka will lead the Electron Acceleration session giving an overview of laser-driven electron acceleration. Registration is currently open but is approaching capacity, for more details see www.liv.ac.uk/la3net/events/...

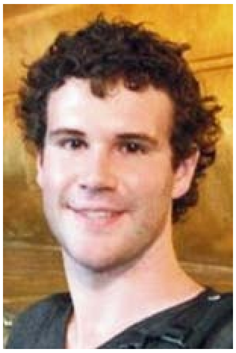


About the author

Victor Malka is a CNRS researcher and lecturer in the physics department of Ecole Polytechnique working at ENSTA in a team that he set up in 2001 to study laser-plasma particle acceleration. In July 2008, he was awarded an Advanced Grant by the European Research Council of €2.2 million for his many scientific works and for his ability to create new fields of research. This helps to fund Victor's team in collaboration with various other groups in innovative experiments in Palaiseau at the interface of different scientific domains. The research has great potential for society: laser-plasma accelerators can have applications in medicine for treating cancer, in materials science, radiobiology and rapid chemistry. In pursuit of this his work includes an exploration of new laser plasma accelerator blueprints for the production of energy electron beams and very strong peak point currents. These electron beams will be used in a variety of domains, including life science and materials science. They will also be used to study the blueprint of compact free electron lasers (FEL) for the production of intense X and XUV beams for which he was awarded this year a second ERC Advanced Grant.

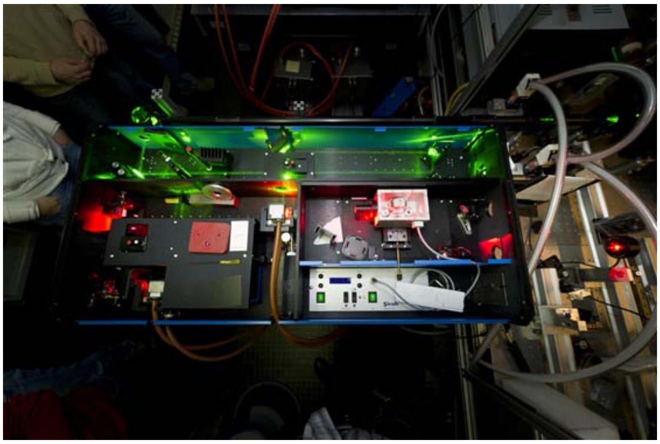
Research News from LA^{3}NET Fellows

Tom Day Goodacre: Research update from RILIS



The Resonance Ionization Laser Ion Source (RILIS) is part of ISOLDE: CERN's radioactive beam facility. The RILIS is an element selective ion source which relies on the resonant excitation of atomic transitions using tuneable laser radiation. More information can be found on the new RILIS website that has been developed and compiled by Tom Day Goodacre. The website brings together information from previous RILIS talks and papers to give an introduction and overview of the installation.

After an 18 month shutdown, during which time extensive renovations, upgrades and development work have taken place, ISOLDE is scheduled to come back online for physics experiments in July 2014. During the start-up, an extended period of off-line tests with the RILIS lasers is foreseen. This will enable the verification and characterization of the ionization scheme development already performed during the shutdown period. If successful, these developments will extend the RILIS capabilities, enabling new experiments to take place at ISOLDE.



One of the Sirah Dye lasers of the RILIS installation.
Image courtesy of CERN.

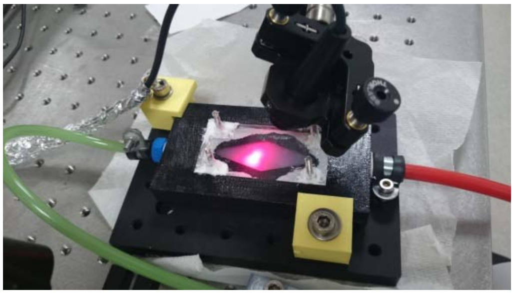
Alexandra Alexandrova to present latest results at SPIE Photonics Europe

Alexandra is going to present the results of her work at the SPIE Photonics Europe conference in Brussels, Belgium in 14th-17th April. The poster is entitled 'Self-mixing Diode Laser Interferometry for Velocity Measurements of Different Targets.'

Gas targets are used for a number of accelerator based experiments as well as for beam diagnostic purposes. In the case of supersonic gas jets, they combine low internal temperatures with high directionality and as a result they are very interesting as experimental targets in different fields of science. For the optimisation and verification of the properties of such a monitor the gas jet needs to be characterised with high accuracy, in particular with regards to its velocity and density profile. In these applications, gas jet velocities can be up to 2,000 m/s with inhomogeneous distribution across the jet. However, all currently used methods for such characterisation are either not reliable or require a powerful laser system.

A diode laser velocimeter based on the laser self-mixing method is currently being developed by the QUASAR Group as an easy-to-build and compact solution when compared to alternative measurement techniques. The technique has the potential for complete characterisation of the gas jet parameters. The laser velocimeter could provide detailed information about the velocity, density and temperature of any jet with micrometer-resolution. Such a sensor would allow for unambiguous measurements from a single interferometric channel and could be installed even in radiation-exposed environments.

In the SPIE contribution, the heterodyne principle and design of the laser diode velocimeter will be discussed. The laser velocimeter is a self-aligning device, based on the self-mixing method where the laser is both a transmitter and receiver of the signal. It should be pointed out that laser self-mixing is usually used for measurements of low velocities and vibrations. The theoretical analysis to be presented shows the possibility of also extending these measurement capabilities to high velocities by altering the design.



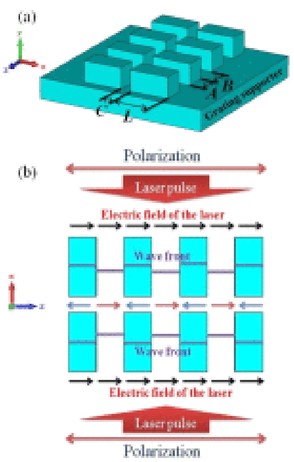
Set-up for testing the laser velocimeter as a flow sensor on fluids passing through a chamber

Experimental results from measurements with different targets, including white paper and fluids will be presented. The initial calibration and verification of the accuracy of the method showed that the velocity of a white paper target can be measured with an accuracy better than 2% and micrometer spatial resolution over a velocity range from 0.5 mm/s to 50 m/s. The set-up for testing the sensor allowed investigations into the limitation of the method as well as into the amount of feedback which is needed for a detailed study of a gas jet. In order to verify the possibility of using the velocimeter as a flow sensor, measurements of local velocities were performed on fluids with externally-imposed flow profiles. The sensor's capability to measure higher target velocities is also discussed.

Aimierding Aimidula's work published in Physics of Plasmas

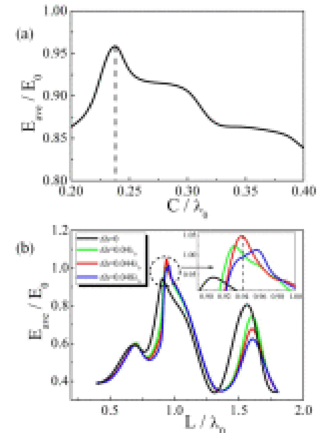
The LA³NET research carried out by Aimierding Aimidula in the QUASAR Group at the University of Liverpool has now been published in Physics of Plasmas. The paper presents numerical simulation results for a dielectric asymmetric dual-grating accelerator which show an increase in the average acceleration gradient by around 10% in comparison to symmetric structures.

Novel accelerators based on lasers have great potential to substantially reduce the size and associated costs of future accelerators. Micro-fabricated dielectric laser accelerators (DLAs) are an attractive approach due to the high damage threshold of dielectric materials and because they offer continuous acceleration to relativistic as well as nonrelativistic charged particles. DLAs are also able to deliver nm-beams of sub-fs pulses, since the transverse dimensions of the acceleration channel are on the operating laser wavelength scale. These beams have unique advantages for investigating basic radiobiology processes as they are able to target single DNA strands.



The paper describes studies of the properties of a fiber laser based dielectric asymmetric dual-grating accelerator structure. Acceleration is achieved by decreasing the phase velocity of the electric field, thereby synchronizing it with relativistic or nonrelativistic electrons. Figure on the left shows the proposed structure cross section geometry and dimensions (a) along with the working principle of the dual-grating accelerator structure (b).

The accelerating field gradient was determined by particle tracking simulations with CST Particle Studio. Figure 2 shows the average accelerating gradient for different structure dimensions. The Figure below (a) shows that a maximum gradient with a value close to 0.95 E_0 can be achieved when the vacuum channel width $C \sim 0.24\ \lambda_0$. In this calculation, the pillar height L was 0.9 λ_0. (b) shows that the average accelerating gradient depends not only on the pillar height L, but is also affected by the asymmetry level Δh of the dielectric pillar length A.



The numerical studies presented in the article show that an asymmetric dual-grating laser accelerator structure made from silica can generate high acceleration gradients greater than 1.3 GeV/m, using structure safety factor of 2. The asymmetry of the dielectric pillar length and adjacent vacuum length distribution helps to optimize the field distribution in the acceleration tunnel and decreases the maximum value of the focused laser field in this structure. The optimum structure dimensions for vacuum channel width C, pillar height L, and asymmetry level Δh, were determined in simulations to be 0.24 λ_0, 0.94 λ_0, and 0.044 λ_0, respectively. Considering the safety factor, it was found that a laser system with an average pulse energy of 2 mJ would be suitable to pump a 1 cm long structure and yield a 13 MeV energy increase. In the current design, electron bunches with an initial energy of more than 500 keV can be synchronized to the electric field in the structure. The geometry of the structure is simple enough to enable further modifications to allow acceleration of nonrelativistic electrons.

The paper can be downloaded for more details and a discussion on the effect of the initial kinetic energy of injected electrons on the acceleration gradient along with the required laser parameters:

Numerically optimized structures for dielectric asymmetric dual-grating laser accelerators, A. Aimidula, et al, Physics of Plasmas, Vol.21, Issue 2 (2014).

Yelong Wei is the latest Fellow to join LA^{3}NET

Yelong Wei has been recruited by the University of Liverpool to work on the 'Development of a compact, fibre-based electron accelerator.' Yelong will build on the published simulation results achieved to date using CST and develop this on site at the Cockcroft Institute with both dielectric and Terahertz studies. The latter will allow to exploit the unique accelerator infrastructure available at Daresbury Lab, UK.

Yelong Wei received his master degree in July 2012 from the University of Chinese Academy of Sciences (UCAS) with a major in Electromagnetic Fields and Microwave Technology, his bachelor degree was awarded in June 2009 from Nanjing University of Aeronautics and Astronautics with a major in Electronics Information Science and Technology. During the period of pursuing his master degree, he devoted himself to research on the design of the superconducting RF accelerating cavity and relevant microwave systems in Shanghai Key Laboratory of Cryogenics & Superconducting RF Technology, Shanghai Synchrotron Radiation Facility. In July 2012, after graduation from UCAS, he joined Tektronix Inc. and worked as an RF Design Engineer. His work mainly focused on RF modules including passive/active circuits design in the RF signal generator.

In March 2014, Yelong joined the QUASAR Group as a Marie Curie Fellow within the LA^{3}NET project at the University of Liverpool. His work will focus on the development of a compact, fibre optics-based electron accelerator. Within this project, the coupling of both laser light and electrons beams into different fibre structures is being studied and optimized to maximize acceleration efficiency and enable quantitative measurements for both process. Studies are being carried out in collaboration with experts from UCLA and the Universities of Tokyo and Manchester.

Fellow Activity

LA^{3}NET reaches out to Schools

This year Jakob Krämer has already completed two school visits to spread the word of science to pupils stimulating their interest for the future. He spoke to pupils in the advanced physics classes at his former school in Oberhausen and another school in Kaiserslautern, both in Germany. He talked about his job as a physicist and his research project in particular. In addition, he raised awareness about opportunities to progress such as the German scholarship programmes and Marie Curie funding, both of which Jakob has benefited from. Jakob confirmed that this was an interesting exercise saying that it was a good chance to combine both the science itself and opportunities available. Positive feedback was received from both pupils and teachers.

Alexandra Alexandrova has been involved in various outreach activities such as the Knowledge Observatory Astronomy Fair in Runcorn and Cumbria and has lined up two schools visits to spread the knowledge further to try to engage children in astronomy and science in general.

Kamil Nowacki has also made arrangements for outreach and will be returning to his home town of Tomaszow Mazowiecki next month to deliver a power supplies workshop to secondary school children. This will give them hands-on experience of building their own DC/DC converter – undoubtedly for most the first practical electronics exercise in their lives. But parents don't worry: it will all be at low voltage.

Kamil explained that he is looking forward to the opportunity to give a lecture in his old secondary school and was confident that it would stimulate the students to start to think about their plans for the future.

Fellows shine in Knoxville

In January the US Particle Accelerator School (USPAS) took place in Knoxville in Tennessee State. LA³NET fellows Alexandra Alexandrova from the University of Liverpool and Thomas Day Goodacre from CERN participated in the two-week course in Accelerator Physics with Eric Prebys from Fermilab as the lecturer. This course covered a comprehensive overview of particle accelerator physics together with related state-of-the-art topics comprising lectures, daily problems, labs and an examination at the end of the course. Despite a packed programme there was an opportunity to see the city, parks, waterfall and the accelerator facility.

Strong relationships between participants were built and a deeper knowledge of accelerator physics was developed verified with excellent final exam results which also demonstrated the high calibre of the LA³NET fellows.

Scientists go Industry: Laser and Accelerator Physics

The LA³NET fellows' workshop set for 17th-18th November at the Helmholtz Centre in Berlin is starting to take shape. The aim of the event is to give an overview of possible future career steps in industry for scientists. By bringing together potential future employers in industry with early stage researchers from the laser and acceleration field, the event will help to identify and solidify interesting future prospects for both sides. The event will be open for external delegates and should be interesting for any early stage researcher who wants to explore future career possibilities.

Watch this space for more news.

Partner News

New FOTON Products

During the last few months FOTON have released two new scientific instruments:

NPA-DET24 is the 24-channel electronic detection system for neutral particle analyzers primarily used with Channeltron-based detectors for tokamak plasma research. This diagnostics arrangement equipped with a set of FOTON power supplies developed last year enables ion temperature investigation in hot plasma (measurement of average ion temperature, ion temperature profile etc). The temporal resolution of this diagnostics system is 50 microseconds to 1 second with a 1-1000 temporal window for each channel. The device is TTL-triggered and communicates via duplex optical fibers with the central control system.

PIEZODRIVER FPZ 13-02 is the expandable 64-channel piezodriver for adaptive optics. Besides other things, the adaptive optics is used for optical correction of high intensity optical beams in high-power laser systems. The output of each channel is 0 to 250V and each channel is independently controlled via USB communication. Several configurations of piezosystem (configuration of electrodes) can be powered from this device.

Vacancies in the Network

Negotiations are underway for the position at GANIL for an early stage researcher to work on the **'Study of resonant laser ionization in the REGLIS low energy branch of the S3 spectrometer at SPIRAL2-GANIL'**, howevr, the post is not yet filled.

To check the latest situation if you are interested in the post please visit the website:

www.liv.ac.uk/la3net/projects/ganil/

Upcoming LA³NET Events

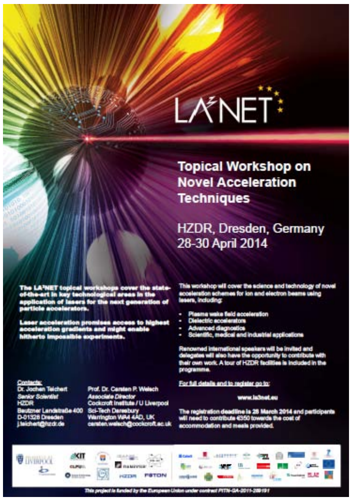
Last chance to register for Novel Acceleration Techniques Workshop

The deadline is fast approaching but there is still time left to book a place on the 3rd Topical Workshop on Novel Acceleration Techniques at HZDR in Dresden, Germany. Delegates can also submit abstracts about their own work for consideration to be included to complement the invited speakers' talks. To view the session topics and invited speakers go to the CERN Indico registration site .

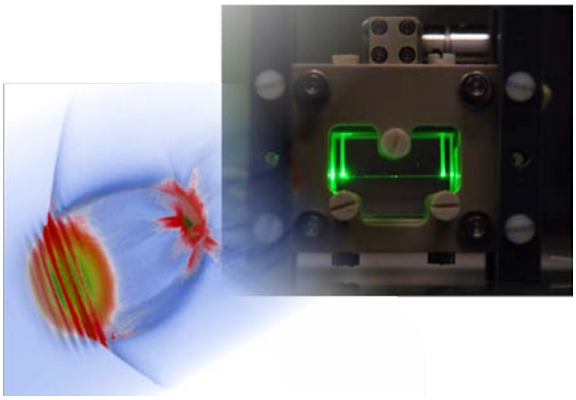
The workshop will include a discussion forum on future funding requirements in this field of novel acceleration schemes for ion and electron beams using lasers.

Topics include:

• Plasma wake field acceleration
• Dielectric accelerators
• Advanced diagnostics
• Scientific, medical and industrial applications



The workshop will take place between the 28th and 30th April 2014. For more information and to register go to www.la3net.eu .



Overlay of a capillary designed for electron laser wakefield acceleration (LWFA) and a simulation of LWFA' – Image courtesy of HZDR

School on Advanced Laser Applications

Registration is also open for the LA³NET School on Advanced Laser Applications from 29th September to 3rd October 2014 hosted by CLPU at the University of Salamanca.

For more information and to register go to: www.la3net.eu .

LA³NET Prize 2014

The Researcher Prize is an annual award by LA³NET of €1,000 for the researcher judged to have made the best contribution amongst all applicants to the field of laser application at accelerator facilities. The competition is open to all researchers in the first five years of their research careers from the time of achieving the qualification that would allow them to register for a PhD.

For consideration, applicants should submit their entries for the 2014 prize before the **30th June 2014 deadline**.

The competition is open to external applicants as well as researchers from within the network.
For more details go to the link: www.liv.ac.uk/la3net/la3net_prize/

Joke Box

What is the nuclear physicist's favourite food?

Fission chips.

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LA³NET Events

April 28th–30th 2014	Topical Workshop on Novel Acceleration Techniques, HZDR, Germany
Sept 29th-Oct 3rd 2014	School on Advanced Laser Applications at Accelerators, CLPU, Spain
Nov 17th–18th 2014	Scientists go Industry: Laser and Accelerator Physics, Berlin, Germany
June 26th 2015	Symposium on Accelerators for Science & Society, Liverpool, UK

Other Events

April 14th – 17th 2014	SPIE Photonics Europe, Brussels, Belgium
May 7th – 14th 2014	CAS & PSI: Power Converters, Baden, Switzerland
May 8th – 9th 2014	oPAC Workshop: Beam Diagnostics, Cividec, Vienna, Austria
May 19th – 22nd 2014	EuCARD-2 1st annual meeting, DESY Lab, Hamburg, Germany
June 15th - 20th 2014	IPAC14, Dresden, Germany
June 19th – 20th 2014	ESOF Marie Curie Conference, Copenhagen, Denmark
June 21st – 26th 2014	Euro Science Open Forum (ESOF), Copenhagen, Denmark
July 7th - 11th 2014	oPAC Accelerator School, Royal Holloway University of London, UK
Aug 25th – 29th 2014	FEL 2014, Basel, Switzerland

NOTICE BOARD

Host institutions and principal investigators must acknowledge the support received when any data or achievements resulting from research funded by the European Union are communicated such as in journals, patents, presentations, etc. As a minimum, the European flag emblem must be included along with a statement such as the following for LA³NET:

'The research leading to these results has received funding from the European Union's Seventh Framework Programme under Grant Agreement number 289191.'

DEADLINE FOR THE NEXT NEWSLETTER 30 May 2014

About LA³NET

The exploitation of Lasers for Applications at Accelerator facilities for ion beam generation, acceleration and diagnostics is the goal of this new Network within the FP7 Marie Curie Initial Training Network (ITN) scheme. In this frame, research centers, universities and industry partners from across Europe will develop beyond-state-of-the-art techniques and technologies through a joint inter-sectorial training program for early stage researchers within a unique European partnership.

LA³NET is funded by the European Commission under
Grant Agreement Number 289191