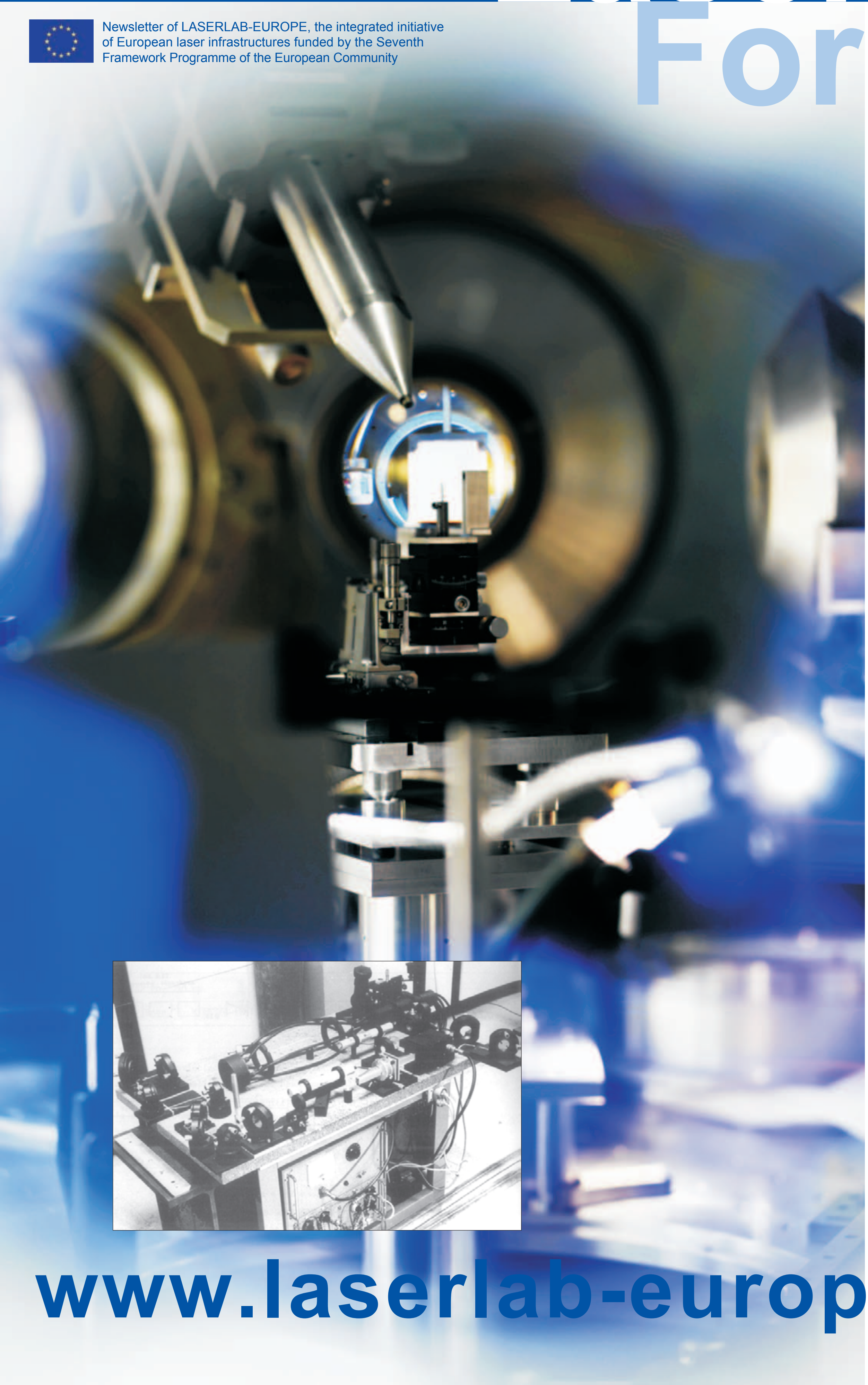
Issue 9 June 2010

Laserlab Forum

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



IN THIS ISSUE

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Editorial

This year, the laser community celebrates the fiftieth anniversary of the laser, a device that brought about so many scientific and technological wonders. A large part of this issue of Laserlab Forum is therefore dedicated to various retrospectives. You will find a short history on the contribution of three American men locked in battle for recognition for the invention of the laser, this alongside a nice collection of laser pictures some of which date from a long time ago. In addition, an interview with Sune Svanberg, one of the European nestors of laser science, looking back on his long and diverse career. But we also look ahead in a contribution about the fresh collaboration between the international laser and accelerator communities: ICUIL and ICFA. Finally, this issue's Access Highlight, about the analysis of old paintings with lasers, is a striking example of the diversity of applications for which the laser has been found useful in the course of half a century. Enjoy.

Tom Jeltes

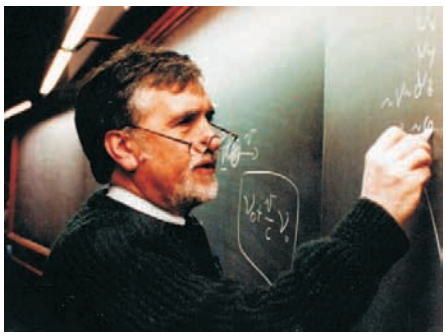
News

Advanced Grants for Laserlab researchers

The European Research Council (ERC) has awarded several high-profile researchers within LASERLAB-EUROPE an 'Advanced Grant'. ERC Advanced Grants allow exceptional established research leaders to pursue frontier research of their choice.

Prof. **Marcus Aldén** from the Combustion Physics Group of Lund Laser Centre in Sweden got 2.5 million euros for studying combustion processes in gas turbines and engines with lasers. Due to turbulence, the conditions in the combustion flame vary rapidly in time and from one place to another. To study the combustion process, a spatial resolution of the order of micrometers and timescales of microseconds is required. Aldén will use 'high rep-rate' lasers and several types of infrared spectroscopy to investigate the combustion flames in a non-intrusive way, thereby generating the knowledge needed to enhance the efficiency and reduce the amount of pollution resulting from burning fuels.

Prof. **Massimo Inguscio** from the European Laboratory for Nonlinear Spectroscopy (LENS) in Florence will use his Advanced Grant to study disorder in ultracold quantum gases. Disorder is ubiquitous in nature and has a strong impact on the behaviour of many physical systems. However, due to unavoidable interactions, the effect is hard to study in real condensed-matter systems. Inguscio will use ultracold atomic quantum gases, both bosonic and fermionic, as model systems to understand the physics of disorder. These quantum gases are easily manipulated and a variety of diagnostic techniques is available to gain detailed information on the system.



Prof. **Thomas Elsaesser** from the Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy in Berlin received a grant of 2.49 million euros for a project aiming at elucidating processes which determine the properties of hydrogen bonds in molecular systems. Elsaesser studies ultrafast processes in condensed matter. His project is devoted to unraveling changes of molecular structures on the length scale of a chemical bond and the ultrashort time scale of molecular motions. Within the project, novel methods of ultrafast optics in a wavelength range from the far-infrared to hard x-rays will be applied for investigating hydrogen bonds. A key goal consists in measuring molecular structures in real-time by initiating and reading out structure changes with ultrashort light pulses.

Symposium on 'Frontiers in Atomic Physics'

On April 9 and 10, a two-day symposium was held on the occasion of the 60th birthday of Prof. Massimo Inguscio, former director of LENS. The symposium took place at the Palazzo Vecchio in Florence and was given the title 'Frontiers in Atomic Physics'. The list of speakers included Nobel laureates such as Eric Cornell, Wolfgang Ketterle, William D. Phillips, John L. Hall and Theodor Haensch, who contributed to important developments in atomic physics. Recent advances in this field have led to the creation of new states of matter at the lowest temperatures in the universe, unprecedented accuracy in the measurement of fundamental constant, more accurate atomic clocks and position sensors, and model systems for quantum computing and cryptography.

News from the laboratories

Marc Vrakking, formerly AMOLF Amsterdam, has been appointed one of three Directors at the Max Born Institute and Professor at the Free University Berlin. He is one of the pioneers of time-resolved spectroscopy with attosecond pulses. At MBI, Vrakking takes over as successor of Ingolf Hertel.

Wolfgang Sandner, Director at the Max Born Institute in Berlin, has been appointed President of the German Physical Society (DPG) on April 13, 2010. The DPG is the largest physical society in the world with more than 57 000 members.

Cover photos: Images of LULI facilities: CO_2 lasers of 1974 and view inside a target chamber today.

Strategy meeting on high power laser technology for future accelerators

A first strategy meeting was held at GSI Darmstadt, April 8-10 on the laser technology needed to meet the challenge of future accelerators that use or rely on very high average power lasers. The event was opened by Hartmut Eickhoff, Technical Director of GSI and Wim Leemans from LBNL, chairman of the newly established *Joint Task Force on Future Applications of Laser Acceleration*.

The *Joint Task Force* operates under the umbrella of ICFA (International Committee for Future Accelerators) and ICUIL (International Committee on Ultra-High Intensity Lasers) and invited experts on high power laser technology as well as accelerator technology and their applications to this first meeting. The 47 participants came from China (1), France (4), Germany (18), Japan (4), Switzerland (2), the UK (4) and the US (14).

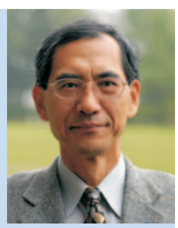
The main topics discussed at the workshop were the laser performance needed for accelerator technology to support the most challenging present and future accelerator needs, as well as questions of laser architecture, laser material and optical components. At the workshop, accelerator and light source representatives outlined the top level laser requirements for potential laser-based accelerator applications, i.e. colliders, light sources and medical applications.

The largest challenge for laser technology is a laser-plasma e-e collider up to the 10 TeV goal. The consensus in the world high energy physics community is that the next large collider after the LHC would be a TeV-scale lepton collider. Options currently under study include the International Linear Collider (ILC, 0.5-1 TeV), Compact Linear Collider (CLIC, up to 3 TeV) and the muon collider (up to 4 TeV), all using RF technology. The very high gradients (~10 GeV/m) possible with laser acceleration, on the other hand, open up new avenues to reach even higher energy and more compact machines. This workshop investigated the beam and laser parameters of a 1-10 TeV, 10^{36} $cm^{-2}s^{-1}$ e+e- collider based on two different technologies – laser plasma acceleration (LPA) and direct laser acceleration (DLA). The main challenges to the practical achievement of laser acceleration are: high average power (~100 MW), high repetition rate (kHz to MHz), high efficiency (~40-60%) at a cost that ideally would be an order of magnitude lower than using RF based technology. The workshop also studied the laser requirements for a 200 GeV $\gamma\gamma$ collider, proposed as the first stage of a full scale ILC or CLIC. The required laser systems for such a collider may be within reach of today's technology.

For light sources, lasers already play a significant role in existing facilities, and face new challenges with future light sources that aim at much higher repetition frequency. Ultrafast (femtosecond) lasers reaching 1-10 kW levels will be required for seeding and user driven experiments. The third area of application has been medical applications of laser acceleration of protons/ions and its potential to replace current technology used in tumor therapy. Such lasers are typically very high peak power (PW-class) and require special pulse shapes with very high temporal contrast. Again, multi-kW compact lasers will be needed.

Laser requirements for these applications are often many orders of magnitude beyond the capabilities of the lasers used in today's scientific demonstrations, i.e. MW's vs 10's of W's. Laser science representatives at the meeting discussed and outlined how, with appropriate R&D, emerging 100-kW-class industrial lasers, 10-MW-class laser fusion energy technologies and MW-class defense laser systems might be adapted to meet these challenging requirements.

Wim Leemans, LBNL and Ingo Hoffmann, GSI



Congratulations and Anticipation of a Second Wave

Lasers and the science supporting them have already contributed profoundly to many areas of today's society. However, it is our view that this is just a tip of an iceberg to come. In particular, intense lasers are coming of age, just entering their adolescent years. The community of intense lasers has created the International Committee for Ultra Intense Lasers (ICUIL) in 2004. The usage of intense lasers (sometimes we call them relativistic lasers, as electrons are shaken so strong to reach relativistic energies in a single optical cycle) has now begun to allow us to envision table top accelerators and brilliant X-ray sources, perhaps compact cancer therapy devices and diagnosis equipments, and other scientific and medical endeavors, opening a second wave of laser revolution. So, let me join in LASERLAB-EUROPE's congratulations for the half century greatness of lasers and for the anticipatory excitement for another half century as spectacularly impacting on science and society to come.

Toshi Tajima, Chair, ICUIL

Modern Trends in Basic and Applied Laser Spectroscopy

A symposium to honour Professor Sune Svanberg

About 150 scientists gathered in Lund for two days in April to discuss laser spectroscopy and related applications, with emphasis on research areas where Sune Svanberg has been most active. Talks were introduced and presented by a blend of previous students, now with leading positions in academic or industrial research, and prominent international collaborators from different parts of the world.

The delegates were welcomed by Per Eriksson, the Vice Chancellor of Lund University, while the scientific stage was set by Orazio Svelto, Milan. He gave a fascinating talk about the history of the laser, which highlighted the fact that the retirement of Sune Svanberg coincides with the 50th anniversary of the laser. This talk was followed by presentations by Theodor Hänsch, Garching, and Emile Biémont, Liège, discussing high-resolution and time-resolved laser spectroscopy, respectively. More applied activities were introduced as Marcus Aldén, Lund, and Jürgen Wolfrum, Heidelberg, turned to laser diagnostics in combustion research – a field that Sune Svanberg pioneered in Sweden some 30 years ago. Another field of research pursued by Svanberg for a long time is LIDAR remote sensing of the environment. This topic was covered primarily in a talk by one of his many collaborators and friends in the field – Giovanna Cecchi from Florence.

Laser spectroscopy in medicine is another research area pursued by Sune Svanberg with great commitment over the past decades. Highlights from this field were presented by Irving J. Bigio, Boston, USA and Hubert van den Bergh, Lausanne. In the same session, Jonas Johansson, Mölndal, talked about a related topic – scattering spectroscopy with pharmaceutical applications.

In the early 1990s, Svanberg started a new research field in Sweden by establishing the Lund high-power laser facility, presented in a talk by Anne L'Huillier, Lund. As an example of recent highlights in this area Wolfgang Sandner, Berlin, discussed acceleration of neutral atoms by high intensity lasers. Hans Hertz, Stockholm, focussed on laser-produced x-rays and x-ray optics.

A long-term mission of Sune Svanberg is the hands-on spreading of knowledge and scientific activities in optics and spectroscopy to developing countries. Many participants at the symposium witnessed about his importance in these contexts. For example, Ahmadou Wague, Senegal, supported by Paul Buah-Bassuah, Cape Coast and Ernst van Groningen, ISP, Uppsala, spoke about laser spectroscopy in Africa, while Jiang Zhankui brought greetings from China.

As the symposium progressed, it became very clear that the impact made by Sune Svanberg in the various fields was not only through his purely scientific contributions, but equally much by his ability to spread enthusiasm and to stimulate engagements among collaborators and students. Most speakers therefore, while presenting scientific highlights, reflected also upon their special friendship with Sune Svanberg, which in many cases included the whole Svanberg family.

The symposium included a banquet, where Sune Svanberg was further celebrated through songs, music and many talks. In particular, Ingvar Lindgren, Göteborg, once Sune Svanbergs PhD supervisor, gave the symposium a historical perspective by an after dinner speech about atomic spectroscopy before the days of the laser.

Special greetings from Laserlab-Europe were communicated via its co-ordinator, Wolfgang Sandner and, on behalf of the Lithuanian Academy of Science, Algis Piskarskas, Vilnius, presented the Academy's gold medal to Sune Svanberg for his contributions to science.

The symposium ended with a closing contribution by Sune Svanberg himself, which he concluded by sharing his visions for a very bright future for the field of laser spectroscopy.

Claes-Göran Wahlström and
Marcus Aldén
Lund Laser Centre

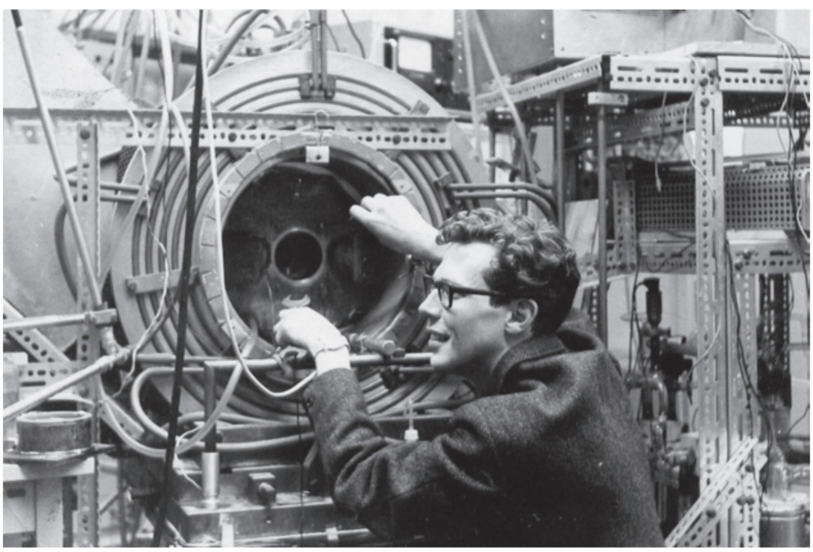
The concept of "Europe" really works

Interview Sune Svanberg

Prof. Sune Svanberg has been one of the most important figures in the European laser community for the past 40 years. After leading the Atomic Physics Division of Lund University for 30 years, time has come for Svanberg to retire. This does not mean he will stop working, though. He will, for example, stay on as the LLC director for some time. In addition to the report on his retirement symposium (see opposite page), Laserlab Forum decided to ask the grand old man a few questions about his long and rich career.

Do you remember the first time you saw a laser?
"On a winter evening, as a student in Göteborg, when walking to the Physics Department, I saw on the snow in front of me a bright red moving spot. This was in 1964; I had read about the laser and realized that this must be it. Looking up to see where the source was located I saw a faint red spot in a window of the Electrical Engineering Department 100 meters away! However, starting with research in physics, lasers did not first become my occupation, but rather optical resonance spectroscopy employing powerful discharge lamps. I learned the techniques at the Technische Universität Berlin, and then built up a lab in Göteborg pursuing optical pumping, optical double resonance and level crossing spectroscopy."

So when did you start working with lasers?
"Actually, in 1972 as a postdoc at Columbia University I got the opportunity to acquire the first commercial CW dye laser from Spectra Physics. It operated on Rhodamine 6G and by using it together with a discharge lamp we were able to reach high Rydberg states in alkali atoms by stepwise excitation, much extending the knowledge of hyperfine structures etc."



Sune Svanberg (1967, Berlin)

You have been involved in many projects over the years. Could you discuss briefly one or two that are for you personally the most important ones?
"Basic science is always very important. Among the applications of lasers probably the early detection and treatment of cancer is important to me, since such research can potentially mean a great difference to people. A recent speciality in Lund became the Gas in Scattering Media Absorption Spectroscopy (GASMAS) technique, with medical applications, e.g. sinusitis diagnostics, but also opening new possibilities in monitoring of food, pharmaceuticals, ceramics, etc."

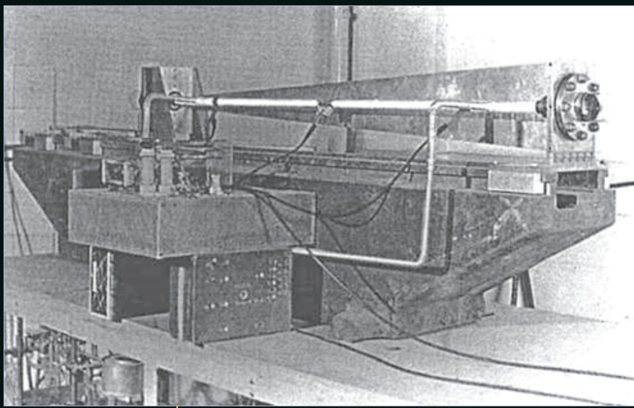
Sune Svanberg (2009, Lund)

What, according to you, has been the most surprising or spectacular progress within the field of laser physics in the past 40 years?
"Cooling and trapping of atoms, Bose-Einstein condensation in alkali vapours, and frequency comb techniques, as reflected by recent Nobel Prizes, certainly are astounding achievements."

Your retirement does not mean that you will stop working. What are the most important projects you will be involved in the coming years?
"I will mostly be involved in laser spectroscopy applied to the environmental and medical fields. These aspects are important in Western countries but also in the developing ones, e.g. in Africa, Asia and South America, where I have a lot of connections."

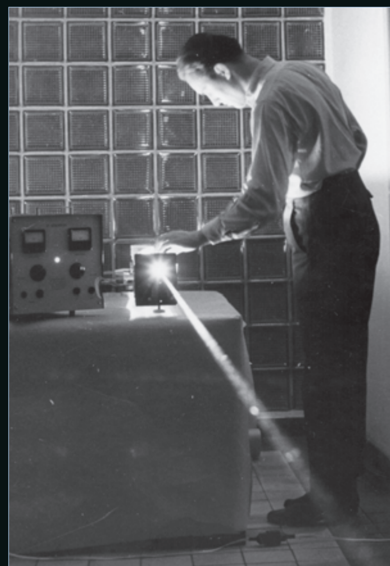
What is, according to you, the importance of LASERLAB-EUROPE ?
"The strong collaboration between the major laser laboratories in Europe is very encouraging and helps position Europe at the forefront of an important field of enabling technology. The community is really dynamically forged together in a very powerful way, while fostering genuine friendship. LASERLAB-EUROPE is a nice demonstration that the concept of "Europe" really works!"

First He-Ne laser built at the University of Jena (Germany)

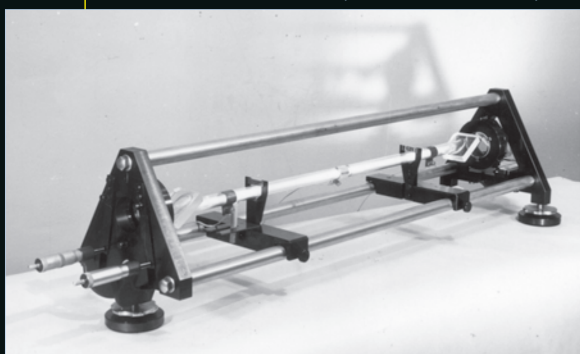


Components of the first civil laser in Portugal. (Photo credits: Gonçalo Figueira)

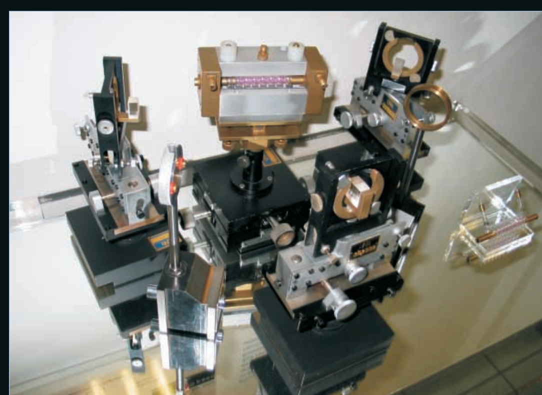
F. Petru testing the He-Ne laser (archive of ISI ASCR Brno)



First Czechoslovak He-Ne laser built in Brno (archive of ISI ASCR Brno)



5-ps pulses from a mode-locked ruby laser in 1969 (CUSBO)



He-Ne
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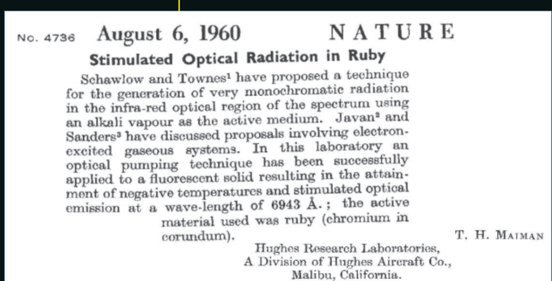


No. 4736 August 6, 1960 NATURE

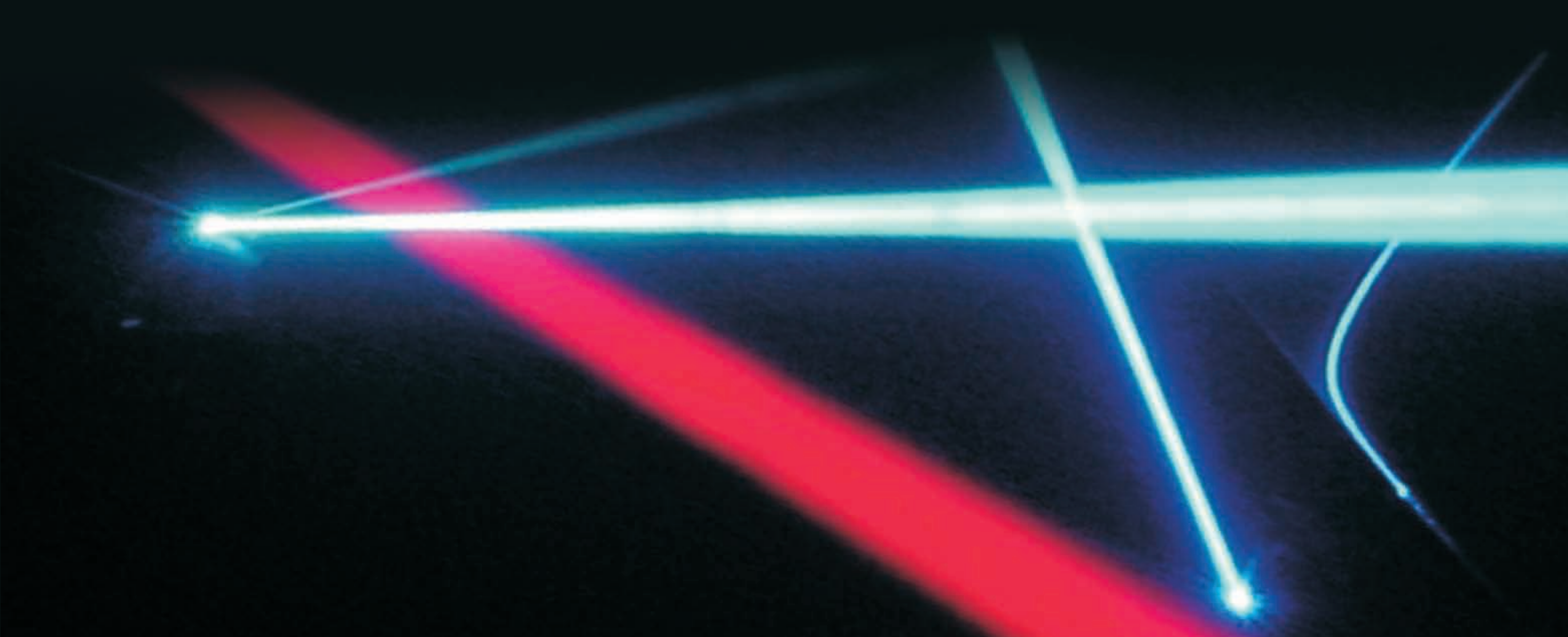
Stimulated Optical Radiation in Ruby

Schawlow and Townes[1] have proposed a technique for the generation of very monochromatic radiation in the infra-red optical region of the spectrum using an alkali vapour as the active medium. Javan[2] and Sanders[3] have discussed proposals involving electron-excited gaseous systems. In this laboratory an optical pumping technique has been successfully applied to a fluorescent solid resulting in the attainment of negative temperatures and stimulated optical emission at a wave-length of 6943 Å.; the active material used was ruby (chromium in corundum).

T. H. Maiman

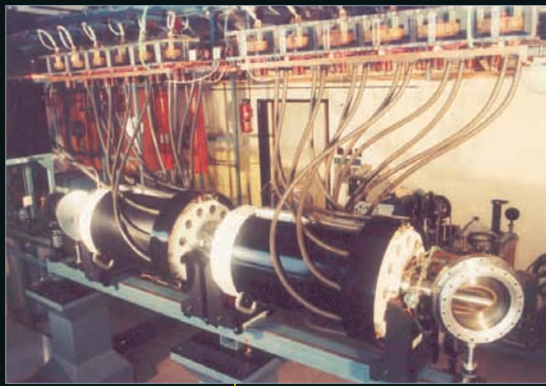
Hughes Research Laboratories,
A Division of Hughes Aircraft Co.,
Malibu, California.

1960 1962 1963 1964 1969 1969

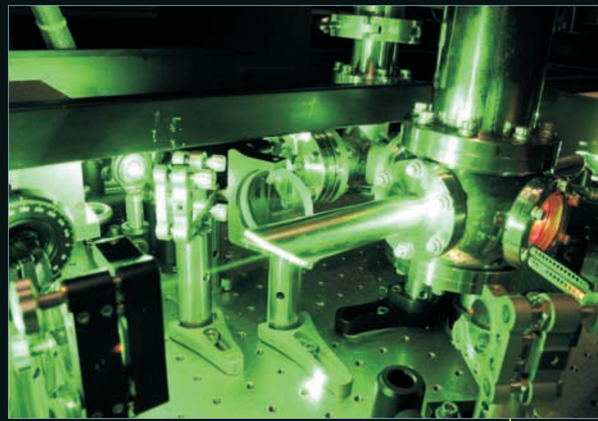


Courtesy of the University of Lisbon.

PERUN-1 100-GW iodine laser built at the Institute of Physics of the Czechoslovak Academy of Sciences (PALS photo archive)



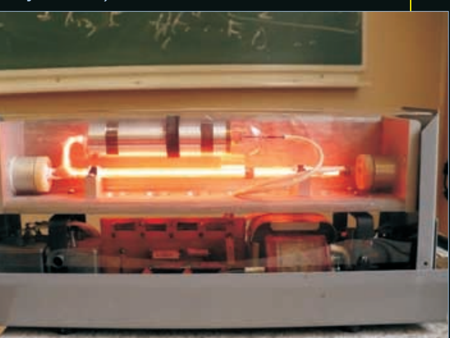
50W Ti:Sapphire system of the Attoscience and Ultrafast Optics group at ICFO



2F laser operating in the early 80's at LULI

6F laser operating from the mid 90's to 2002 at LULI

laser produced in the former Soviet Union
rsity of Latvia)



Beamline as1 where the first attosecond pulses worldwide were produced, constructed in Vienna, moved to MPQ

1972 1982 1986 1995 2001 2009

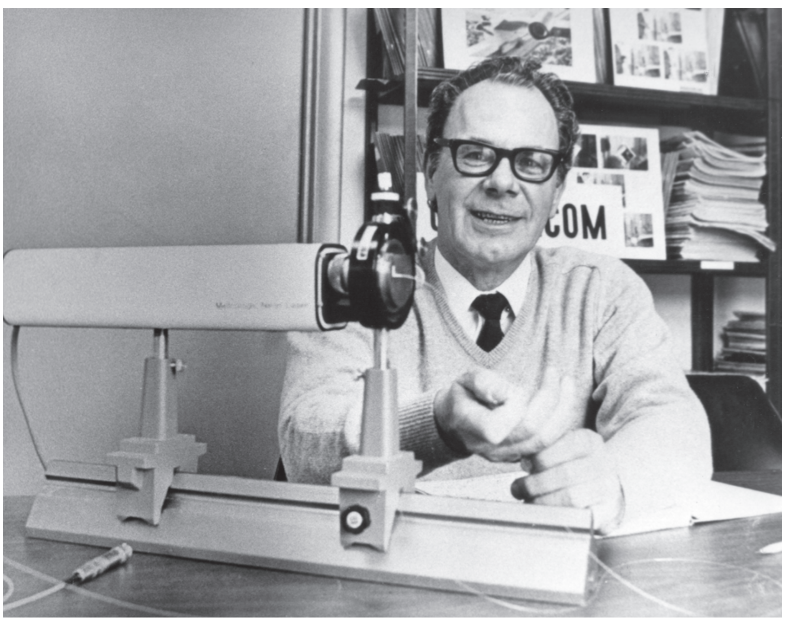
50 Years of Lasers

When lasers first saw the light of day

A short history of the invention of the laser, on the occasion of its 50th (?) birthday

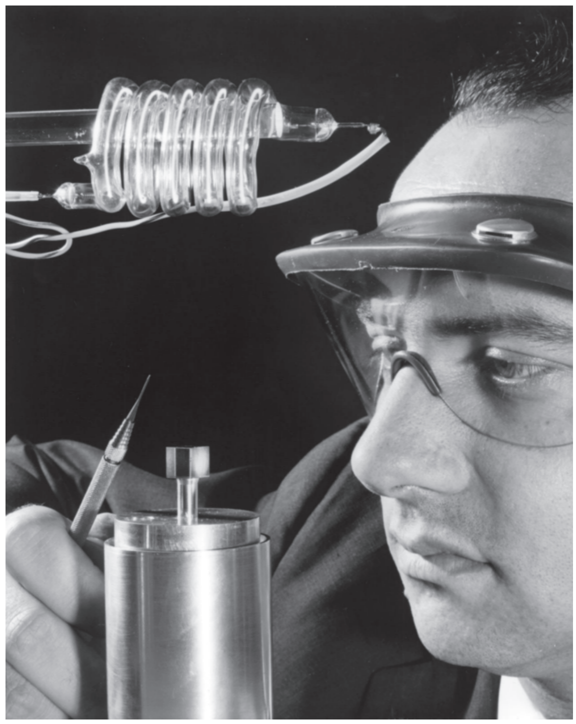
This year, we celebrate the 50th birthday of the laser. The question who invented the laser is not easily answered, though. Was it Charles Townes, who initially obtained the patent (with Bell Labs) and shared the Nobel Prize for his work on the 'maser-laser'-principle? Should we credit Gordon Gould, who – based on some pages in his 1957 laboratory notebook – got the main patents after a thirty year patent war? Or is Theodore Maiman, the physicist who actually built the first laser, the real father of the 'death ray'? Maiman, however, was never given recognition in the form of a patent or Nobel Prize.

In hindsight, the invention of the laser was an important event in the history of science and technology, but half a century ago Theodore Maiman (1927-2007), working with Hughes Aircraft in California, had difficulties getting the article published in which he described his invention: he got a ruby laser working on May 16, 1960. Samuel Goudsmit, a renowned nuclear physicist and then editor in chief of Physical Review, rejected Maiman's report on the construction of his ruby laser, judging it the umpteenth article related to a maser-type device and suggested to try a lower impact journal: "It would be more appropriate to submit your manuscript for possible publication to an applied physics journal, where it would receive a more appreciative audience", Goudsmit wrote back to Maiman.



Gordon Gould (photo: Union College)

A few months later, Nature decided that Maiman's article (less than 100 words, with hardly any details) *was* interesting enough for publication. But that was only after the general media were informed by Hughes Research Laboratories via a press conference on 7 July 1960. Hughes also issued a now-famous picture of Maiman with a ruby rod that was much bigger than the rod in which the first laser effects were obtained. According to reports, the photographer decided that the large rod looked much better on a picture. This resulted in competitors not being able to reproduce the results: they tried to make a big ruby rod laser, something which Maiman never succeeded in. The next day, the laser story made it to the front page of the New York Times and the 'death ray' was born.



Theodore Maiman (photo: Hughes Aircraft Company)

Meanwhile, researchers from Columbia University and Bell Telephone Laboratories were also trying to make an 'optical maser', as it was called at the time. They were inspired by a 1958 article in Physical Review, published by Charles Townes and his brother-in-law Arthur Schawlow. Townes (1915) had worked with Bell from 1933 until 1947, after which he moved to Columbia University, where he met Schawlow (1921-1999) who, in turn, moved to Bell Labs in 1951. Together, they described the various conditions required to generate coherent radiation in the optical part of the electromagnetic spectrum. The device would consist of an active medium, which was illuminated with radiation of the right wavelength (optical pumping) placed in a box-shaped cavity of about a centimetre in dimension.

Since Townes had been one of the inventors of the maser – in 1954, he built the first ammonia maser at Columbia University –, Schawlow and Townes saw the laser as a natural extension of the maser principle. Hence, their article was titled 'Infrared and Optical Masers'. The article was the basis for a patent filed by Bell Labs, even though the Bell patent office could hardly be called enthusiastic, as is clear from their first reaction: "Optical waves have never been of any importance to communications and hence the invention has little bearing on Bell System interests".

As mentioned above, Charles Townes shared the Nobel Prize with Russians Basov and Prokhorov for the maser-laser principle in 1964 and the Schawlow/Townes paper got Bell Labs a patent for the laser. Their description of the laser dated clearly from before Maiman's ruby laser, but there is a third party involved in this early laser history: Gordon Gould (1920-2005). He was a physicist who studied at Columbia University, became a PhD student there, but never obtained a doctorate. Besides his PhD research, Gould was pondering a way to aply the maser principle in the optical regime at around the same time as Townes. On Friday November 16, 1957, Gould went to the owner of a candy store who happened to be a friend of his wife's and let him put his seal on the first nine pages of in total over one hundred pages of his laboratory notebook, headed 'Some rough calculations on the feasibility of laser light amplification by stimulated emission of radiation'. Gould thereby coined the acronym 'laser' for the optical maser. Based on this notebook, Gould claimed to have been the first to propose optical pumping to excite a maser, an idea he had discussed with Charles Townes. Another idea he claimed was the application of an optical resonator using two mirrors in the form of a Fabry-Perot interferometer. Gould also envisaged optical pumping by collisions between two different atomic species.

Because Gould believed he needed to actually build a laser in order to get a patent, he abandoned his PhD research and joined the private company TRG in order to pursue this goal. Ironically, TRG got a million dollars from the U.S. government for their project, but since they envisaged military applications the project was declared classified. Gould, who had been a member of the Communist Political Association, was therefore not allowed to enter the lab where his colleagues were trying to build a laser based on his ideas. TRG subsequently lost the race to both Maiman and Bell/Columbia.

Since the notes in his laboratory notebook predated the article of Schawlow and Townes, Gould thought he should get a patent on his ideas. He spent the next three decades trying to get the U.S. patents originally obtained by Bell Labs in 1960, eventually with success. After receiving some British patents, Gould finally obtained the U.S. patent on optical pumping of lasers in 1977. By then, the Bell patent had expired (U.S. patents ran for 17 years at the time). Ironically, due to the growing volume of laser applications, Gould made a lot more money from his delayed patent than he ever could have, had he been given the patent when he filed it. In the nineties, Gould's patents were worth 7 million dollars a year, whereas Bell Labs made only about a million in total in 17 years.

Maiman, the man of the ruby laser, never got a patent nor the Nobel prize and felt he was left with empty hands, even though he received several prestigious awards in the 1980's. Still, he thought he was not given his due credits, as can be read in his 2000 autobiography 'The Laser Odyssey'. In this book, Maiman claims that both Gould's and Townes' proposals never led to the construction of a laser, at least not with the materials and methods his competitors described at the time.

In a recent article in Physics Today, three (former) Bell researchers defend the way Bell Labs presented their first working laser on October 5, 1960. They stress that Maiman never described the laser oscillations characteristic for laser operation above threshold, whereas the Bell laser showed all characteristics of real coherent light: their 'pencil beam', which they transported over 25 miles, showed the classical interference patterns in Young's double slit experiment. On the other hand, it is ironic that the laser presented by Bell Labs was a ruby laser, while a year earlier, Schawlow had decided Maiman's type of laser could never work.

Charles Townes (photo: Clemson University)

In any case, the year 2010 has been chosen by the international laser community (and LASERLAB-EUROPE) to celebrate half a century of lasers, recognizing Maiman's first observations of the laser effect as the birth of a remarkable device. A device that has since become an indispensable tool for experimental scientists and an important element in many branches of technology.

Tom Jeltes

Further reading:
The History of the Laser, Mario Bertolotti (IOP Publishing Ltd, 2005)
The Laser Odyssey, Theodore Maiman (Laser Press, 2000)
Bell Labs and the ruby laser, Donald Nelson, Robert Collins and Wolfgang Kaiser (Physics Today, January 2010)

The picture behind the paint

UV-fluorescence spectroscopy for identification of varnishes in works of art

Darkening and yellowing of a varnish film due to aging is one of the main conservation problems in paintings and the varnish film may need to be periodically removed and replaced with a new one. Hence, the characterization of the varnish layer is essential in the planning of a restoration work, in order to choose the most suitable solvent or cleaning method for its removal. In this field, both the Italian research group at Physics Department of Politecnico di Milano, headed by prof. Rinaldo Cubeddu, and the French research group from the Institut des NanoSciences de Paris, headed by prof. Mady Elias, have extensive expertise in the analysis of works of art with optical spectroscopy techniques.Thanks to the LASERLAB-EUROPE facilities, the two research groups have been able to initiate a fruitful collaboration by employing their complementary fluorescence spectroscopy devices for the non-destructive analysis of a varnished painting.

Transparent varnished coatings have long been used on paintings for both protective and aesthetic purposes: a varnish layer, in fact, protects a paint film from dirt and mechanical damage, while at the same time saturating colours because of the refraction index matching.

A varnish layer is basically a film, of only microns in thickness, often made of a natural or a synthetic resin diluted in a suitable solvent. As an example, triterpenoid resins, such as *mastic* and *dammar*, used on their own or mixed with wax and oils, were the most popular varnishes because of their excellent adhesive properties, their good solubility in solvents, and because they yellow to a lesser extent than varnishes made with other resins. In most cases, the determination of the chemical composition of a varnish layer is carried out in laboratory using sensitive and highly specific chromatographic-mass spectroscopy techniques. However, the costs and extensive work-up associated with these analyses are significant; furthermore, sampling of varnish layers is not always straightforward. Therefore, alternative and complementary non-destructive techniques are particularly attractive.

With the advantage of not requiring any sample and being non-contact, UV-induced fluorescence is a useful phenomenon which can be used for the non-invasive examination of works of art, since many artists' materials, including binding media, modern pigments and colorants may be luminescent. Due to their chemical composition, even varnishes are naturally fluorescent materials or can develop fluorescence upon ageing. Hence, the visual examination of the fluorescence emitted from a varnished painting upon excitation with a simple UV lamp is widespread, providing immediate indications to conservators and curators regarding the presence of retouching, repainting and surface heterogeneity. Beside this simple approach, in recent years different laboratories have developed spectroscopic portable devices for the in situ analysis of works of art with features almost comparable to those of standard laboratory equipments.

The instrument developed in the French CNRS laboratories is a portable UV and visible spectrometer, capable of measuring both the fluorescence and the diffuse reflectance spectrum of a point of interest on a painted surface. A database of fluorescence spectra of known aged varnishes have been built up for varnish identification. Up to now, the database contains over 110 fluorescence spectra of different aged resins and varnishes, representative of the varnish layers most commonly found on easel paintings. The

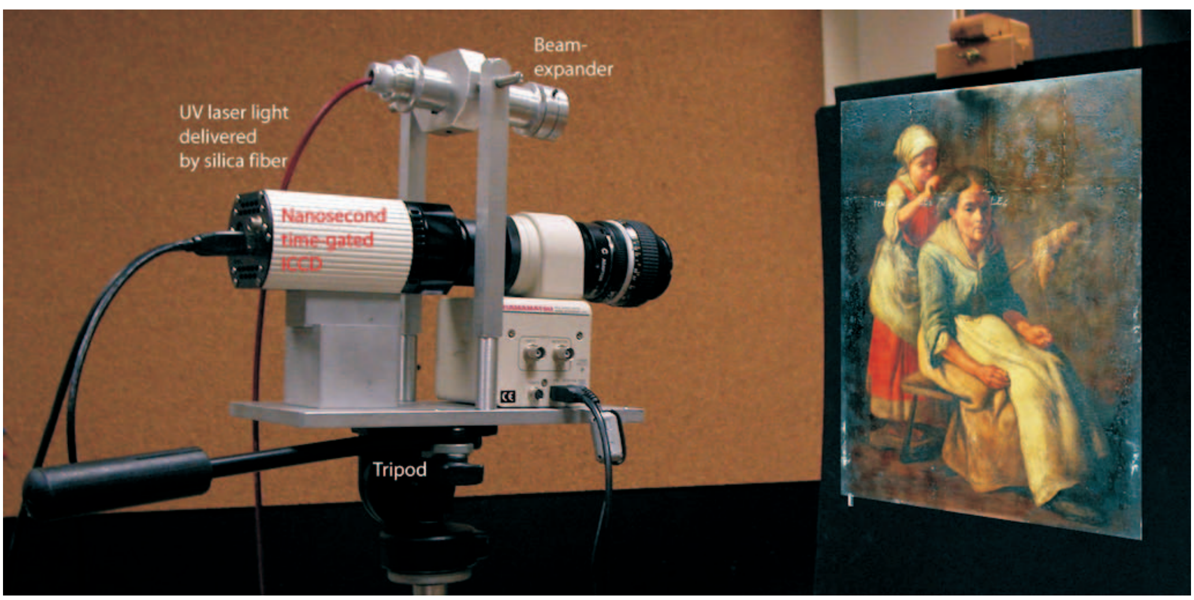


Fig. 1: The portable FLIM instrument developed at the Politecnico di Milano employed for the analysis of a varnished painting.

White light UV light

Fig. 2: Woman with a Child, Francesco Londonio (1723-1783), photographed under different lighting conditions.

fluorescence spectrum of the unknown varnish can be numerically compared with the spectral database using a least square method that prioritizes the wavelength range of the maxima of the reference spectra.

Researchers at Politecnico di Milano have developed a complementary fluorescence imaging device. The instrument is a Fluorescence Lifetime IMaging (FLIM) system, which allows the measurement of the nanosecond kinetic of the fluorescence emitted in each point of the surface of interest. The FLIM apparatus, already tested to study various Renaissance wall paintings and famous marble sculptures by Michelangelo, is used to reconstruct the spatial map of the fluorescence lifetime of a surface, revealing subareas characterized by the presence of different fluorescence materials.

The integration of the measurement of fluorescence lifetime and of the emission spectrum allows a better and more complete characterization of the surfaces of works of art: in fact, while the spectral features of fluorescence emissions can be crucial for the identification of different materials, the emission lifetime is particularly sensitive to the micro-environment of fluorophores, providing further means for differentiating complex fluorescent systems.

The painting studied during the research project funded by LASERLAB-EUROPE was painted by Francesco Londonio (1723-1783), an Italian painter who worked in Milano. It represents an Old Woman with a Child and belongs to the *Borromeo collection* located at Isola Bella, Stresa, Italia.

In Figure 2, three patches are present in the upper left part of the painting, corresponding to partially cleaned varnish; different solvents, with increasing polarities, were employed and different levels of varnish removal were achieved. The remaining part of the painting was not cleaned.

Both cleaned and un-cleaned areas of the painting have been studied with the two fluorescence devices. The fluorescence emission of the un-cleaned painting (varnish) appeared characterized by a heterogeneous intensity, mainly correlated with the colour of the underlying painting layer, whereas a uniform fluorescence lifetime, close to 3.60 ± 0.05 ns was measured, indicating the presence of a uniformly fluorescent varnish layer on the surface of the painting. Similar features have been recorded in different locations of the un-cleaned painting. The results suggest that varnishes with a similar fluorescence spectrum may also have a similar fluorescence lifetime and confirms that the historical upper varnish layer is the same on the whole un-cleaned painting. By numerical comparison with the spectral database, this upper varnish layer has been identified as an aged oil-mastic varnish.

The emission intensity measured in two test-patches appeared characterized by different fluorescence emission lifetimes, as shown in Figure 3. The highest variation in the emission decay kinetics can be observed in patch 3, cleaned with the most polar solvent (40% ethanol), where a mean lifetime near 4.00 ± 0.10 ns is measured, whereas in patch 2, cleaned with a less polar solvent (20% ethanol), a small-detectable variation of the emission kinetic (mean lifetime 3.70 ± 0.08 ns) is observed.

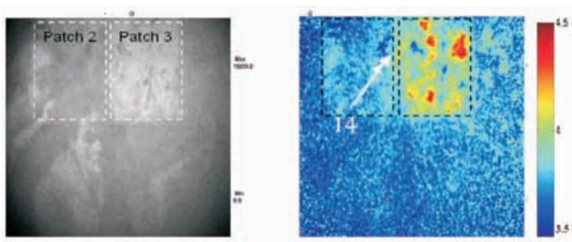


Fig. 3: Fluorescence intensity map (left panel) and fluorescence lifetime map (right panel) measured on the varnished painting in correspondence of two cleaned test patches.

The change in the emission lifetime can be explained with reference to the thickness of the varnish layer removed by the cleaning process. In fact, cleaning revealed materials with different photophysical properties, which are likely due to a gradient of the oxidative status with depth.

Fluorescence spectra recorded in these patches allow the identification of the varnish. The mathematical assessment of similarity applied to fluorescence spectra of the cleaned areas yields a good match for a varnish.

In conclusion, fluorescence spectra enabled us to establish that a homogeneous varnish layer made of oil-mastic was likely applied to the painting. Nevertheless, the fluorescence lifetime inspection, which is sensitive to even minor chemical changes, revealed different extent of oxidation within the layer.

Gianluca Valentini

M. Elias, C. V. Magnain, C. Barthou, D. Comelli, G. Valentini, A. Nevin, "UV-fluorescence spectroscopy for identification of varnishes in works of art: influence of the under layer on the emission spectrum", O3A: Optics for Arts, Architecture and Archaeology II (L. Pezzati, R. Salimbeni), 2009

HiPER Conferences in Prague and Abingdon

Prague

The 5th meeting of the strategic oversight body of the HiPER project, known as the Executive Board was held in Prague on 2nd March 2010. This meeting was followed by the HiPER Participants' Forum on 3rd March where the full project team gather to review and to discuss recent progress. The final day of the conference was set aside for the young researchers of the project, 'the HiPER fellows' to present the results of their work. Both the Participants and Fellow Forums were well attended, with close to 100 participants on each day.

Abingdon

On 15-16th March, a dedicated workshop to explore areas of technical overlap and collaboration between HiPER and several Russian institutes was held in Abingdon, close to the Rutherford Appleton Laboratory, UK. Members of the HiPER team met with a group of Russian researchers from a large number of institutes in the Russian Academy of Sciences, the Rosatom nuclear research centres, as well as representatives of Russian industry and universities.

Anne-Marie Clarke

Attendees of the HiPER Participants' Forum held on 3rd March 2010

Memorandum of Understanding signed for ELI

On April 16th, 2010, in Prague, a Memorandum of Understanding on the implementation of ELI was signed by the three future hosts of this infrastructure, namely the Czech Republic, Hungary and Romania. Resulting from more than five months of negotiation, this document sets a landmark by recognizing the achievements of the Preparatory Phase and setting a framework for the future.

The Memorandum enshrines the commitment of the three hosts to work in common on the implementation of ELI and on the establishment of a European Research Infrastructure Consortium (ERIC) that shall jointly operate three facilities with respective mission in the beamline, attosecond and photonuclear applications of ELI.

The intention of the MoU is to organise the transition between the ELI Preparatory Phase (scheduled to end in Oct. 2010) and this future ELI-ERIC. For this purpose, the MoU establishes a new organisation, the ELI Delivery Consortium, which is defined so as to connect efficiently political decision-makers to the main actors of the project's delivery. Over the coming months, the three countries will make all efforts to ensure the pan-European character of this transition and organise the involvement of other partners willing to contribute to the implementation of ELI.

Florian Gliksohn
executive manager of the ELI project
in the Czech Republic

Announcements

Forthcoming events

28-29 May, Laserlab Foresight Workshop "Future challenges for the European laser community: I3's, pan-European research infrastructures and human resources", ICFO, Barcelona

7-11 June, Endeavours of the Petawatt, Salamanca, Spain

21 June, General Assembly Meeting, Paris, France

22-23 June, Related event: 50 years of the Laser, Paris, France

How to apply for access

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

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

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

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