

IUPAP C17: Commission on Laser Physics and Photonics

**Report to IUPAP Council and Commission Chairs Meeting, Sao Paulo, Brazil, 9-10 Oct. 2017
and**

Report to IUPAP General Assembly, Sao Paulo, Brazil, 11-13 October 2017

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1. International Year of Light (and Light Based Technologies) 2015

The International Year of Light (and Light Based Technologies) in 2015 [1] has been a clear highlight of the triennium for the Laser Physics and Photonics community that C17 represents within IUPAP. C17 congratulates Professor John Dudley (Chair of the IYL Steering Committee and Associate member of C17), with colleagues and partners, for leading these developments.

Stepping back through IYL's development, IUPAP endorsed IYL2015 at its 2011 General Assembly in London which was an important step prior to approaching the UNESCO General Conference and the UN General Assembly in 2013. IUPAP was in fact the first International Union to lend its support to IYL2015 and stimulated support from a wider base of partners including ICSU and ISSC. Members of the IUPAP leadership and C17 subsequently played a major role in the political progress of IYL2015 through the United Nations: specifically, Francis Allotey, IUPAP Vice President at Large, and, Victor Zadkov, the previous Chair of Commission C17, were instrumental in obtaining support at the Ministerial level from Ghana and the Russian Federation, respectively, to introduce the IYL2015 resolution to the United Nations General Assembly. The practical organization of IYL2015 was via a Secretariat located at the Abdus Salam International Centre of Theoretical Physics (ICTP). The choice of ICTP was motivated by its experience in promoting physics education and outreach to developing countries and its formal links with UNESCO. Amongst scientific societies and networks, the Founding Partners of IYL2015 were: the American Institute of Physics the American Physical Society, the Deutsche Physikalische Gesellschaft, the European Physical Society, the Abdus Salam International Centre of Theoretical Physics, the IEEE Photonics Society, the Institute of Physics, Light: Science and Applications, the lightsources.org International Network, 1001 Inventions, The Optical Society, and SPIE the International Society for Optics and Photonics. Additionally, many sponsors supported and participated in the year's activities [2].

The Executive Summary of the IYL2015, as reported to the UN General Assembly, and at the front of the final report [3], highlights the global success of the IYL2015, with a total of 13,168 activities of various types reaching 147 countries on all continents, including Antarctica. Specific events, such as outreach and conferences, were carried out in 129 countries and a further 18 countries issued commemorative stamps or coins or provided support in other ways, such as at UNESCO or the United Nations. Overall the audience reached by IYL2015 is estimated to be in the 100's of millions [3].

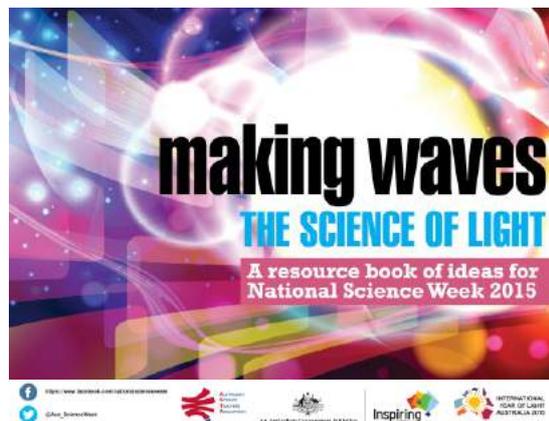
C17 supported the International Year of Light by strongly encouraging its officers and members to organise events and to activate the broader community with which they interact to do the same. Current members of the C17 (Appendix A) have worn many hats – those relating to their national societies and committees in addition to their C17 hat – in making this contribution. We mention a few of members' professional highlights of IYL as examples of the many thousands of activities.



Source: sydneynewyarseve.com; inset: smh.com.au

The current Chair of C17 was able to link with the City of Sydney at the beginning of 2014 to lead to one of the very first events for IYL being the repeated showing of a sequence of IYL themed slides, displayed on the Sydney Harbour Bridge Pylons, as part of the City of Sydney 2014 New Years Eve Festival [4]. The icon displayed on the Sydney Harbour Bridge at midnight, of a light bulb, was covered in the Sydney Morning Herald newspaper: "Sydney became the first place on the planet to embrace the International Year of Light and Light-based Technologies as more than 1.5 million people lining the foreshores welcomed in the new year watching a big lightbulb burst into life on the Sydney Harbour Bridge." The LED display panel for the icon required

less than a quarter of the power used by the previous technology. A fitting link to the IYL theme of energy saving through more efficient lighting. A second highlight was being able to facilitate the Australian National Science Week learning theme for schools to be light-based. The Australian Science Teachers Association prepare an e-book with science learning activities on a specific theme each year for science week. In 2015 it was “Making waves: the science of light - A resource book of ideas for National Science Week 2015” [5].



As the Director of the Institute of Applied Physics (IFAC) of the Italian National Research Council (CNR), Professor Roberto Pini supported various initiatives in collaboration with his colleague Francesco Baldini, who was serving in 2015 as the President of the Italian Society for Optics and Photonics (SIOF). IFAC edited the publication of a volume entitled “The Year of Light”, including many contributions on research related to light, carried out by scientists from various Florentine Institutes of the CNR. Moreover, the CNR together with SIOF and SIF (Italian Society of Physics) organized a one-day workshop entitled “L’Anno Internazionale della Luce a Firenze” in Palazzo Vecchio (the town hall of Florence), focused on the importance of light in Arts, including speeches from art historians, conservators and scientists. Celebrations of IYL 2015 during the 2015 Annual Meeting of the European Platform Photonics21, Photonics West 2015, and Fotonica 2015.



Art historian Giorgio Bonsanti speaking during the workshop entitled “L’Anno Internazionale della Luce a Firenze”, held on 17 October 2015 at Palazzo Vecchio in Florence, Italy

Prof Richter noted, that as the chairperson of the Condensed Matter Section of the German Physical Society in 2015, he chaired the DPG’s spring meeting. A large number of talks and symposia at this large meeting (with 5,500 participants) were dedicated to topics with thematic links to IYL. In a well attended central cross-disciplinary Symposium on “Frontiers of Light” (see image below) the prominent role of "light" (in a broader sense also beyond visible frequencies) was featured at the forefront of fundamental research in the context of condensed matter. Among several eminent speakers, Nobelist Stefan Hell gave a talk on “Nanoscopy with focused light”.



Prof. D. Narayana Rao gives many talks to college students on applications of lasers and emerging areas of photonics every year but these talks were particularly enjoyable when given under the IYL banner in 2015. His most satisfying talk was an annual one to elementary school children. He advocates strongly for more senior faculty to address these kids periodically. He notes that India lacks the experimental facilities to facilitate the best education for young minds using experiment.

Prof Tsuneyuki (John) Ozaki began the organization of the 7th Conference of the International Committee on Ultrahigh Intensity Lasers (ICUIL 2016) in May 2015 and this occupied his community service and outreach in IYL. ICUIL 2016 was organized in close collaboration with Working Group 7 (ICUIL), and was held in Sep. 2016 at Montebello, Canada. Prof Qihuang Gong and colleagues contributed a piece to the IYL Blog on “Optics in Ancient China” [7]. The IYL Blog had a new post every day during IYL.

The official launch for IYL was held at the UNESCO Headquarters in Paris 19-20 January 2015 [5]. Prof Cristina Masoller attended as a representative of C17. Previous Chair of C17, Prof Alan Shore (2008-2011) also attended as a representative for Wales. He provided comment on the prospectus in the summer of 2011 [8]. The IYL 2015 Closing Ceremony took place from 4-6 February 2016 in the city of Mérida, Mexico.

Overall the year has been judged to have been a resounding success with future benefits to continue to be derived as evidenced by the IYL steering committee having led establishment of an International Day of Light to be held on the 16th of May every year (the date Theodore (Ted) Maiman operated the first laser, a ruby laser, in 1960). The first IDL will be in 2018.

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2. Overview report on Laser Physics and Photonics from 2015-2017 (August) from C17

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Laser physics and photonics spans the pure and applied physics spectrum fully and continuously. This spectrum extends beyond physics to broad application in science, technology, medicine, culture and our everyday lives. It is this completeness and continuity of profile that has underpinned the success of the International Year of Light (IYL) in 2015, and the enthusiasm for continuance of the IYL aims and contributions through the, soon to be UNESCO proclaimed, International Day of Light (IDL). IDL will be held on the 16th May each year, starting in 2018.

The reporting triennium for the 29th IUPAP General Assembly is effectively from the second half of 2014 to mid 2017. Highlights in this period include the Nobel Prize in Physics 2014 awarded jointly to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura "*for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources*" [1], and, the Nobel Prize in Chemistry 2014 awarded jointly to Eric Betzig, Stefan W. Hell and William E. Moerner "*for the development of super-resolved fluorescence microscopy*" [2]. All of the Chemistry 2014 Nobelists are physics educated and the scientific achievements of their award were in large part optical physics-based.

We anticipate a Nobel Prize in Physics will be awarded for the detection of gravitational waves. This was a highlight of the triennium as chosen by all C17 contributors. The announcement caused significant excitement around the world including the public. The achievement of gravitational wave detection comes from a large scale international collaboration and the physics is shared across many commissions of IUPAP. The detection was made in 2015 at LIGO (Advanced Laser Interferometer Gravitational-Wave Observatory) in the USA, and was published in PRL (B. P. Abbott, et al., Physical Review Letters **116**, 061102 (2016)). This, first-ever measurement required state-of-the-art implementation of a high-power but extremely low noise laser source, enabling an optical interferometer capable of measuring length differences smaller than an atomic nucleus. Future improvements in LIGO's sensitivity, including innovations from quantum and nonlinear optics, are expected to continue to show how the many worldwide advances in laser physics enable mankind to observe phenomena it could not observe any other way. The key to achieving the required sensitivity of the detectors are underpinned by laser and interferometry research across more than five decades.

The C17 community is well served by large scale international conferences organised under the auspices of the large professional societies and their cognate continental and national level societies (which are typically cognate societies of IUPAP as well). Historically C17 had the International Quantum Electronics Conference (IQEC) as its main commission supported conference. C17 had not sponsored a Type A conference for some time before the start of this triennium. The reasons for this were reviewed and discussed within the commission. The change reflects that the Optical Society (OSA), and SPIE (the International Society for Optics and Photonics) provide long term scheduling and stability for the large scale meetings such as Conference on Lasers and Electro-optics (CLEO), CLEO-Europe/EQEC, CLEO PacRim, SPIE Photonics West and the IEEE Photonics Conference. These scientific meetings are also well integrated with major technology exhibitions and conferences that support engineering, technology and applications. The World of Photonics Congress (CLEO-Europe/EQEC and five other conferences) combined with the Laser World of Photonics Trade Fair, all held biannually, in parallel, in Munich, is an example of the integration of conferences with a major trade show for the benefit of all. In 2017 there were more than 32,000 visitors to the Trade Show from 90 countries, 1,293 exhibitors from 42 countries, 3,500 congress delegates and around 3,000 Congress lectures and presentations [3]. Sister shows of World of Photonics China [4] and World of Photonics India [5] are growing apace as the scale of photonics research and activity grows rapidly in both these

populous nations, with China further along in its growth than India. Such developments are embodiments of the continuous spectrum across science, engineering and industry uptake in laser physics and photonics. In this circumstance the need for C17 to support Type A conferences is essentially zero. However, the opportunity to encourage OSA and SPIE etc. to have IUPAP endorsement for key meetings, and, for the reports of these meetings to be captured in the overall conference reporting and statistics of IUPAP, are set for further consideration in the next triennium. Focus on the special features of laser physics and photonics within physics, that has led to these large and successful societies, may be of benefit to other commissions if and when considering ways to work towards broader engagement between science, engineering and end users/adopters.

Before giving some further highlights of Laser Physics and Photonics for the triennium we reinforce to readers that any such choices are to some extent subjective and necessarily inadequate in capturing an overview of fields as a whole. To give some sense of the scale of research activity and how it is distributed around the world we present some publishing metrics analysed by country in figs. 1-3. The graphs were generated from the Web of Science accessed on the 7th May 2017. The search was done on topic, fig. 1 “Lasers”, fig. 2 “Laser Physics” and fig. 3 “Photonics”. The finds were analysed by the country of the authors. With the top 30 nations retained in each triennium for inclusion in the graphs. These graphs should be regarded as containing indicative data rather than robust data as papers commonly have authors from more than one nation and such papers will have been doubly or multiply counted.

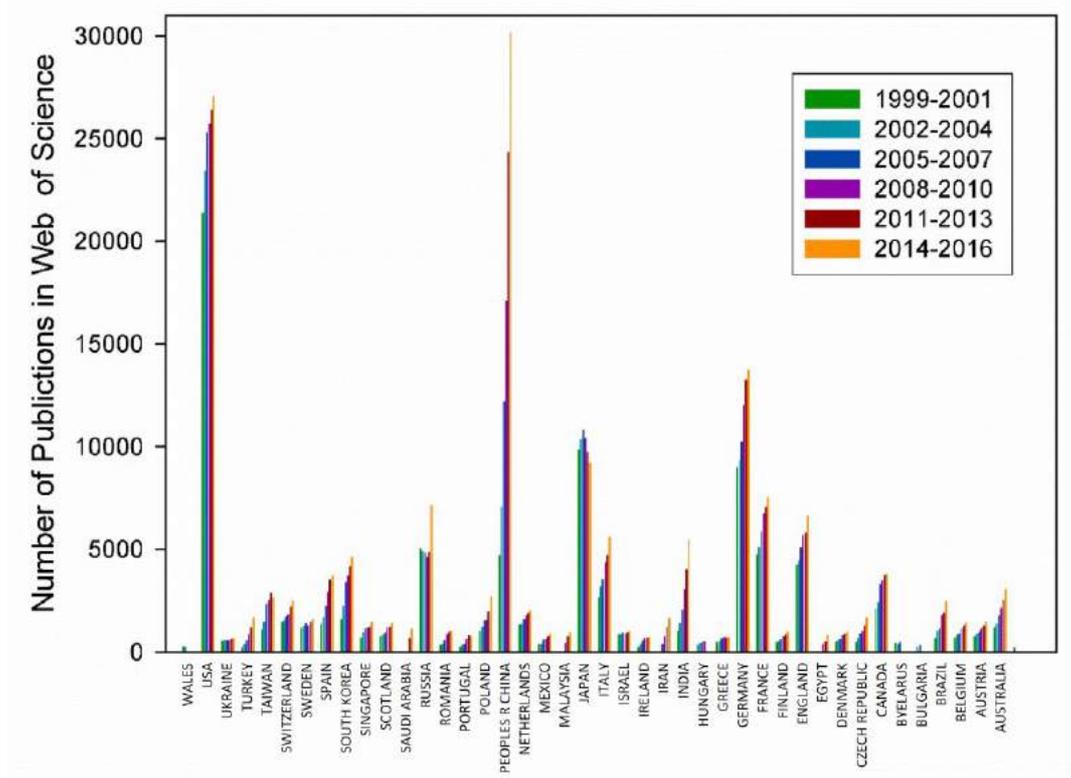


Fig. 1 Total number of publications, Web of Science topic search “Laser” plotted for the six triennia, 1999-2001 through to 2014-2016 for the countries named, in reverse alphabetical order, along the horizontal axis.

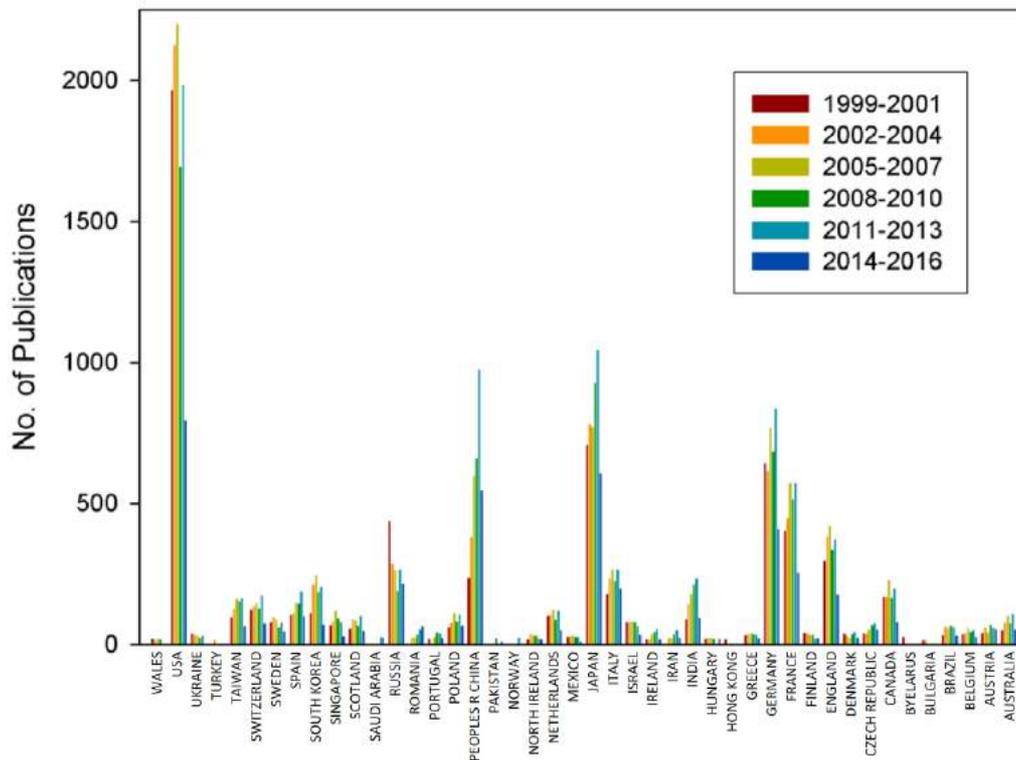


Fig. 2 Total number of publications, Web of Science topic search “Laser Physics”, plotted for the six triennia, 1999-2001 through to 2014-2016, for the countries named, in reverse alphabetical order, along the horizontal axis. Data accessed 7 May 2017.

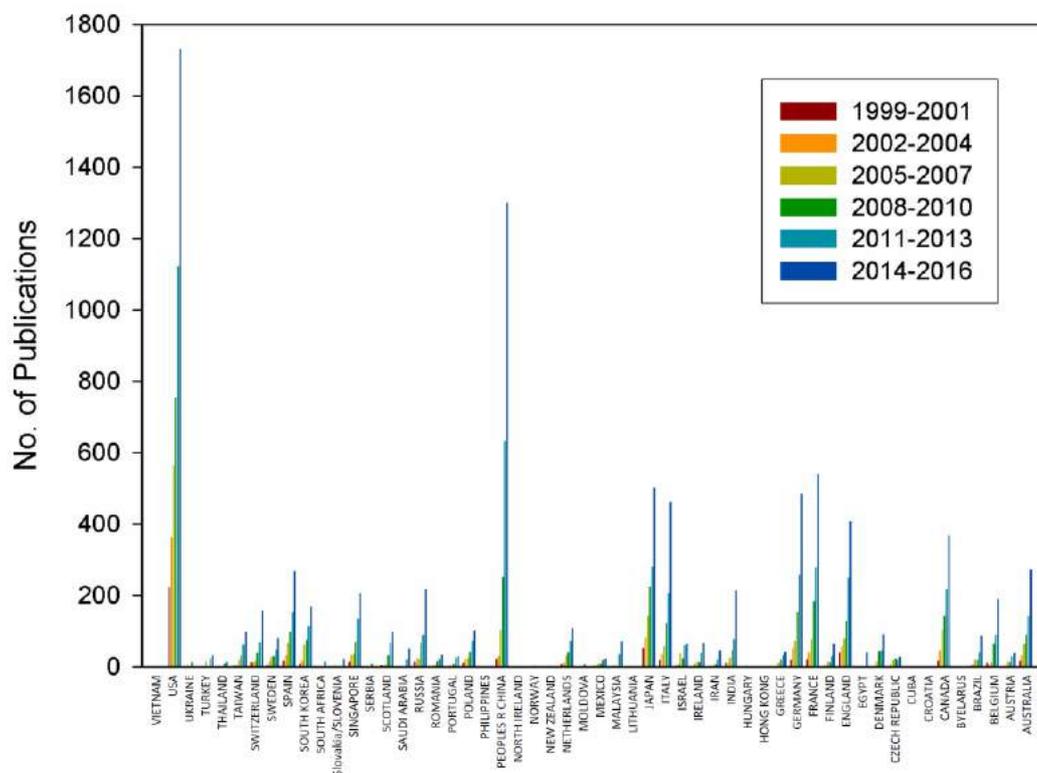


Fig. 3 Total number of publications, Web of Science topic search “Photonics”, plotted for the six triennia, 1999-2001 through to 2014-2016, for the countries named, in reverse alphabetical order, along the horizontal axis. Data accessed 7 May 2017.

Figs 1-3 show that publication on “lasers” and “photonics” continues to grow while “laser physics” is steady but with quite large fluctuations from triennium to triennium for many nations. The meteoric growth of publication on “lasers” from the People’s Republic of China stands out, with total number of publications exceeding that from the United States for the first time for 2014-2016. We see that the use of “photonics” as a topic has emerged since 1999 and it is still comparatively little used in the publications context despite its strong use as an overall umbrella term. A similar trend was evident in analysis of “nanotechnology” publications undertaken in a different context some years back. But, overall the fields are growing which is a sign of good health.

Another publication metric is the representation of the fields in high impact journals. The showing of “Laser” and “Photonics” in Nature publications is given as an indicator for this. In the fig. 4 the percentage of publications in each triennium from 2002, that contains each of these keywords (from <https://www.nature.com/search>). We see significant increase in publications for both keywords, and especially a jump from the previous (2011~2013) to the current (2014~2016) triennium. The fields in which lasers and photonics are used have widened considerably, from physics and chemistry to material science, biology, medicine, and environmental science. Proposals of such applications have been made far before the current triennium. However, with scientific and technological advances in lasers and photonics, as well as the closer links between different disciplines, their actual implementation in various areas of science and technology have flourished. For example, researchers can now build lasers within a cell (M. Humar and S.-H. Yun, *Nat Photonics* 9, 572 (2015)), an achievement that sounds much like an episode from a science-fiction movie. This new technique could potentially lead to advanced therapeutic and imaging techniques that were difficult, if not impossible with conventional technology. Lasers are now also actively used in particle physics, for example, to experimentally prove the CPT theorem of matter and antimatter (M. Ahmadi et al., *Nature* 541, 506 (2017)).

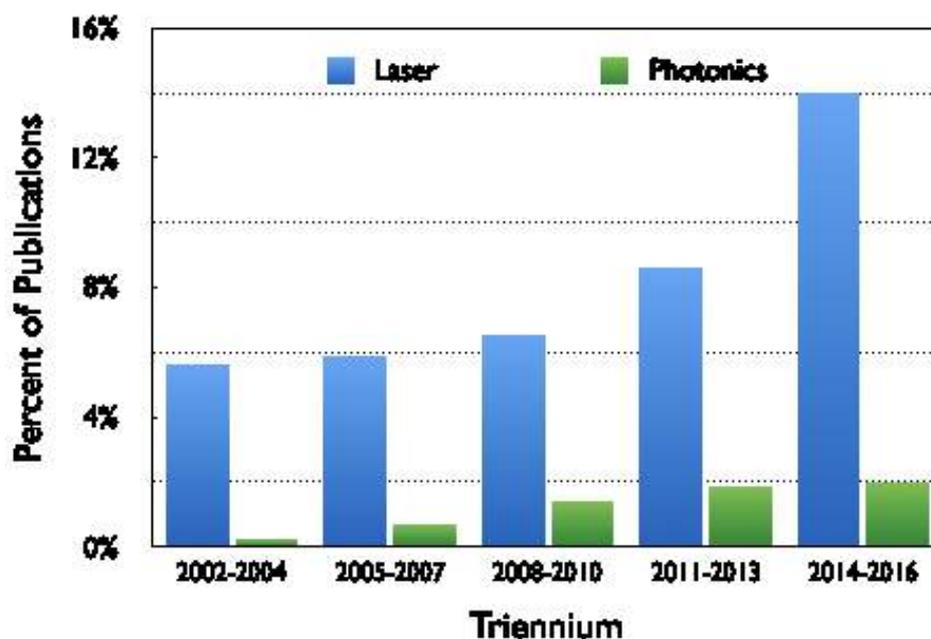


Fig. 4 Percent publications on “Laser” and “Photonics for the five triennia 2002-2004 through to 2014-2016 appearing in all Nature Publications.

To return to the selections of important research and developments as observed by members of C17, another area that has recently been attracting much attention is the opening of accelerator-based X-ray free-electron lasers (XFEL) around the world. This area is most related to Working Group 14 (Accelerator Science), and definitely belongs to large-scale science, but there have already been some interesting applications of such unique X-ray sources (in biology, material science and laser physics). For example, XFELs have been used to study the ultrafast dynamics of proteins (J. Tenboer *et al.*,

Science **346**, 1242 (2014)), unraveling the population of different intermediates of photoactive yellow protein, currently with nanosecond resolution. Researchers have also used XFELs to pump angstrom-wavelength narrow-linewidth lasers (H. Yoneda *et al.*, Nature **524**, 446 (2015)). They have shown that the angstrom wavelength laser has much better longitudinal coherence compared with the XFEL, with potentially significant impact in ultrafast X-ray spectroscopy and quantum optics.

A state-of-the-art nanophotonic component chosen from the Stanford University group of Jelena Vuckovic consists a small-footprint demultiplexing element, designed using computational inverse methods (A. Y. Piggott, *Nature Photonics* **9**, 374–377 (2015)). It has a seemingly random pattern of sub-wavelength etched holes designed to sort 1300nm from 1550 nm light, a task that typically requires interferometry, gratings, or prisms of multiwavelength scale. Such research indicates the degree of accuracy, understanding, and capability now present in manipulating light using current computational and fabrication methods.

In the area of nonlinear optics, research continues into the physics of optical frequency combs, and their applications in many areas of science. These include precision spectroscopy, measurement of fundamental constants, and in unexpected areas such as astrophotonics where they can be applied to calibrating high-resolution astrophysical spectrographs used, e.g., in exoplanet studies. Much of the recent work carried out in this area has been based on improving the original laser/photonic crystal fiber (PCF) comb technology for which the 2005 Nobel Physics Prize was awarded. There has also been much interest in miniaturized frequency comb technology through the use of optically pumped microresonators. Such microresonator-based combs are of applied interest for new applications in microwave photonics, time-frequency and telecommunications, but they are also of much fundamental interest in that their physics is based on the generation of dissipative cavity soliton pulse trains, and they are becoming an important platform for the wider study of nonlinear self-organisation.

Related work in nonlinear optics continues into expanding uses for the white light optical supercontinuum generated from nonlinear frequency conversion in optical fiber. Supercontinuum light is a high brightness light source that has already found important applications in imaging, spectroscopy and microscopy. The development of new optical fiber designs, as well as work establishing rigorous links with other areas of physics (e.g. extreme events, soliton theory) are leading to new approaches to achieve spectrally bright deep and vacuum UV sources based on gas-filled hollow core PCF and the generation of stable bright deep UV supercontinuum light in PCF drawn from the fluorozirconate glass. Also, practically useful supercontinua in the molecular fingerprint region in the mid infrared are the subject of emerging research activity.

In this context, it is essential to note the importance that mid-infrared photonics in general continues to be a major area of research. The mid-infrared spectral region (2-20 microns) finds many applications in fields such as chemical spectroscopy, sensing, and industry. The work into supercontinuum sources described above is part of a broader area of research considering other novel sources including fiber lasers and quantum cascade lasers. Quantum cascade lasers had their 20th anniversary in 2014.

Many school children get experience with the now ubiquitous laser 3D printing using polymers and plastics. Laser 3D printing of metallic components is an altogether more challenging technology which has seen recent technical breakthroughs in both laser melting deposition (LMD) and selective laser melting (SLM) for improved composition, microstructure and dimensional precision of printed components. This brings the promise of revolutionary progress in many industrial fields, like aeronautics and astronautics. Ground breaking research from Turkey has opened the prospect of a new and highly efficient regime of laser ablation using bursts of femtosecond laser pulses in an ablative cooling mechanism (C. Kerse *et al.*, Nature Vol. 537, 84-89 (2016)). This is now driving new research to create cost effective laser systems that can harness this regime for industrial use.

In the 25 years since the original publication on orbital angular momentum (OAM) [L. Allen et al., Phys. Rev. A 45, 8185 (1992)], researchers have come to realize the profoundness of this new degree of freedom of light photons. It has induced a fundamental change in the way in which we understand light, (C. T. Samlan, et al. Scientific Reports 6, 33141, (2016)). This area of research has brought together researchers from a wide range of backgrounds and a recent theme issue on “Optical orbital angular momentum” compiled and edited by S.M. Barnett, M. Babiker and M.J. Padgett (Phil. Trans. R. Soc. A, vol. 375, issue 2087 (2017)) is an excellent resource on OAM of light and how it is being harnessed.

Among the various tasks for which a quantum computer could outperform classical computers the problem of “*boson sampling*” has recently come up as a realistic possibility to achieve this in the near term. One way to experimentally achieve boson sampling is based on a quantum optical network built from beam-splitting integrated waveguides that, on the whole, form a complex quantum scattering system. Given an input arrangement of a given number of bosons distributed over a (larger) number of optical modes the calculation of an adequate sample of the possible output distribution turns out to be most probably a computationally hard problem. The related theoretical proposal of boson sampling put forward by Aaronson and Arkhipov for photons has, correspondingly, triggered large experimental activities in waveguide photonics aiming at an experimental realization for a network large enough such that a corresponding conventional computer simulation would be no longer feasible. This requires the creation of a larger number of correlated photons to be fed into such networks with low loss and high output fidelity, and hence poses strong future challenges to such measurements. This vivid subfield represents just one branch of the progressing field of quantum networks where photonics is playing a pivotal role.

As examples of national perspectives we include brief statements from Italy, Germany and India. The Italian Photonics Community includes traditionally two main groups, the first one composed of optical engineers developing telecom and ICT applications, the second composed of physicists, dedicated to research and applications in the fields of classical and quantum optics, lasers and optoelectronics. Three areas of note for the triennium are mentioned. (i) Advances in the development of Terahertz (THz) photonic devices and applications, including realization of THz quantum cascade laser sources based on quasi-crystal photonic structures, new detectors like the first room-temperature THz frequency nanodetector based on crystalline black phosphorus, and components like THz polarizers. Significant applications are in metrology, biomedical sensing/imaging and for the characterization of artworks and paintings. (ii) Multimodal spectroscopy, microscopy and imaging for biomedical applications, which exploit a combination of conventional (e.g. Raman, fluorescence, holography) and recently developed diagnostic techniques (e.g. light-sheet and multiphoton microscopy) to provide “in vivo” optical biopsy of cancer tissue and for the imaging of whole organs, like the brain and heart, with cellular resolution. (iii) Novel optical biochips based on biochemical or plasmonic platforms (e.g. Localized Surface Plasmonic Resonance, Surface Enhanced Raman Scattering) to realize miniaturized, high sensitivity and low cost sensors for industrial (e.g. gas) and medical use (like e.g. early detection of cancer and degenerative diseases, point-of-care diagnostics and analyses, fig. 5).

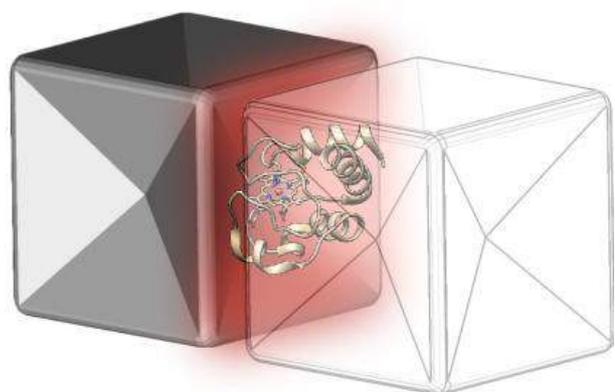


Fig 5 Plasmonic gold nanocubes for SERS detection of bioproteins (Source: Paolo Matteini, Institute of Applied Physics, CNR, Florence, Italy).

In Germany the field of ultra-short laser pulses has been rapidly developing over the last two decades or so, mainly under the general driving force of shortening the light pulses more and more. However, recently another challenge has been emerging, namely exploring matter simultaneously at ultra-short time scales and ultra-small lengths scales. This can be achieved, at least in principle, by combining scanning probe experiments (e.g. a scanning tunnelling microscope) with ultra-fast laser pulses. One very recent breakthrough experiment along these lines is based on such a “*light-field STM*”, where a THz laser carrier field provides an ultrafast AC bias voltage in an STM junction, representing a prime example of the emerging field of “*light-field electronics*”. The AC bias enables to chop the tunnelling current used for imaging nano-objects such as molecules on surfaces. This enables time-resolved STM measurements. Extending this to a quantum pump-probe setting allows one, for instance, to observe single-molecule vibrations in space and time with picometer and picosecond resolution (see e.g. Cocker et al., Nature 539, 263 (2016)). This novel experimental setting opens the door to a large variety of systems and phenomena that require simultaneous resolution of nanoscales in space and time.

In India active research is ongoing in optogenetics where ultrashort laser pulses are used to activate or inhibit signalling between neurons, and in some cases to map the neural network to know the behavioural and sensory functions of the whole animal. High harmonic generation and multidimensional spectroscopy continue to be important activities. Ultrafast lasers are widely used in India for spectroscopic studies such as transient absorption spectroscopy, laser induced breakdown spectroscopy (LIBS), Raman spectroscopy and two/multiphoton imaging. There is also a major focus on nonlinear optics (NLO), materials for NLO, theoretical understanding of NLO, metamaterials, intense laser field studies, and SERS. This is being carried out at different institutions in India (Ex. TIFR, Mumbai, IITs at Chennai, Delhi, Kanpur, Kharagpur, and Mumbai, JNCASR, Bangalore, University of Hyderabad, Raja Ramanna Centre for Advanced Technology, Indore, Physical Research Laboratory, Ahmedabad, IISERs at Kolkata, Pune, Bhopal, Trivandrum, and Mohali among many others). Work related to classical optics such as improved technology to make lenses, mirrors and telescopes have been undertaken at Indian Institute of Astrophysics, Bangalore, Indian Institute of Science Bangalore and ISRO. RCI, Hyderabad have developed optical gyroscopes – fiber based gyroscopes as well as Ring Laser Gyroscopes – fully fledged Inertial Guidance Systems. Atomic Physics area has been augmented by Precision Spectroscopy (IISc Bangalore, BHU, BARC etc.), Laser cooling (IISER Pune, TIFR, IISER Mohali, IITK, NISER Bhubaneswar, RRI, UoH etc.). Projects have started with goals of Quantum Cryptography and Quantum Computing (UoH, IITK, IISER Kolkota, ISI Kolkota). ISRO Trivandrum and NPL Delhi have built laser cooling systems for atomic – fountain clocks.

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3. IUPAP Young Scientist Prizes – Laser Physics and Photonics

The IUPAP Commission on Laser Physics and Photonics runs its Young Scientist Prizes every two years, awarding two prizes in each round. These two prizes recognize the very highest level of achievements in fundamental and applied research. The call for nominations in 2017 and 2015 are included in Appendix C. Historically the International Quantum Electronics Conference (IQEC) was the principle conference supported by C17 and would have been the natural venue for the YSP awards ceremonies. It is now held irregularly and as and when it is organized it is co-conference with other major meetings. Due to the sheer scale of activity in the areas of laser physics and photonics in the world, and the very large and strong professional societies that have grown to support the area, the major international conferences, such as the CLEO conferences (Conference on Lasers and Electro-Optics) have registration fees that make them ineligible for IUPAP conference support. This triennium the Commission instigated holding the C17 YSP Award Ceremonies at one of the CLEOs on a rotational basis. The 2015 awards were held at CLEO-Europe/EQEC in Munich in June 2015. The 2107 awards were held at CLEO PacRim, Singapore in August 2017. Forward planning for an Awards ceremony at CLEO-Europe/EQEC in June 2019 is in train.

3.1 2017 – Fundamental Aspects - Winner

Dr Mohsen Rahmani was awarded the 2017 IUPAP YSP with the citation: “For his outstanding contributions to light-matter interactions at nanoscale, particularly nonlinear nanophotonics via metallic, dielectric and semiconductor nanostructures and metasurfaces, which have paved the road for extending nonlinear optics to the nanoscale”. Dr Rahmani is currently an Australian Research Council Discovery Early Career Research Award holder at the Australian National University, Canberra Australia. Until recently he was a research associate at the Blakett Laboratory, Imperial College London, United Kingdom; following a PhD from the National University of Singapore, Singapore finished in 2013.



Dr Mohsen Rahmani being awarded his IUPAP Young Scientist Prize, C17—Laser Physics and Photonics, Fundamental Aspects at CLEO PacRim, Singapore on 1st August 2017, by Deb Kane

3.2 2017 – Applied Aspects - Winner

A/Prof. Igor Aharanovich was awarded the 2017 IUPAP YSP with the citation: “For his outstanding contributions to research on quantum emitters in wide band-gap semiconductors”. He is currently an academic at the University of Technology (UTS) Sydney, Australia where he leads the Nanophotonics research group. Previously he was a postdoctoral fellow at Harvard University, Boston, United States; following a PhD (2010) at University of Melbourne, Melbourne, Australia; and a BSc (2005) & MSc (2007) from Technion – Israel, Institute of Technology, Israel.



A/Prof Igor Aharonovich being awarded his IUPAP Young Scientist Prize, C17—Laser Physics and Photonics, Applied Aspects at CLEO PacRim, Singapore on 1st August 2017, by Deb Kane.



From left: A/Prof Igor Aharonovich, Prof Deb Kane, Prof John Dudley, Prof Yoon Soon Fatt (Chair, School of Electronic and Electrical Engineering, National Technological University, Singapore) and Dr Mohsen Rahmani at the 2017 awards ceremony CLEO PacRim, Singapore on 1st August 2017.

Acknowledgement

IUPAP C17 gratefully acknowledges the organisers of CLEO PacRim for organizing and hosting the IUPAP C17 Young Scientist Prize Awards ceremony at the opening ceremony of Photonics@SG 2017. Co-Chair of CLEO-PR 2017, Professor Perry Shum, Director, Centre for Optical Fibre Technology, Nanyang Technological University, Singapore is thanked for leading this.

3.3 2015 – Fundamental Aspects - Winner

The 2015 IUPAP Young Scientist Prize in Laser Physics and Photonics (Fundamental Aspects) was won by Dr Robert Fickler, Institute for Quantum Optics and Quantum Information, University of Vienna, Austria. Dr Fickler moved very recently to a postdoctoral fellowship in the Centre for Quantum Photonics, University of Ottawa, Canada. Robert Fickler was awarded “for his groundbreaking contributions to the entanglement of complex structures of photons, which have opened up new avenues for quantum communication”. He completed his Bachelor and Masters degrees (in Physics) at the University of Ulm, Germany, finishing in 2009. He completed his PhD in 2014 at the University of Vienna in the Institute for Quantum Optics and Quantum Information. His thesis, entitled “*Entanglement of Complex Structures of Photons*”, received a Doc.Award. Until recently he

has been working as a postdoctoral fellow, continuing in the group of Professor Anton Zeilinger in Vienna. The transcript of an interview with Dr Fickler appears in Appendix D



Dr Robert Fickler being awarded his IUPAP Young Scientist Prize, C17—Laser Physics and Photonics, Fundamental Aspects. At CLEO– Europe/EQEC on 24th June 2015. Also pictured, Professor Luc Berge, Chair of the Quantum Electronics and Optics Division of the European Physical Society and Professor Deb Kane, Chair of IUPAP Commission 17.

3.4 2015 – Applied Aspects - Winner

The 2015 IUPAP Young Scientist Prize in Laser Physics and Photonics (Applied Aspects) has been won by Dr Mark Thompson, Centre for Quantum Photonics, University of Bristol, United Kingdom. Dr Mark Thompson was awarded the prize “for his contributions to the new and emerging field of quantum photonics, and particularly for his pioneering work in integrated quantum photonic circuits.” He did his Master of Physics at the University of Sheffield, United Kingdom, finishing in 2000. He completed his PhD in 2007 at the University of Cambridge, UK, in the Department of Electrical Engineering. Subsequently he has held postdoctoral fellow positions at the University of Cambridge, University of Bristol, UK; and Toshiba, Japan. He was appointed as a lecturer in the School of Physics, University of Bristol, UK, in 2010 and is now a Reader in Quantum Photonics and Director of the Quantum Engineering Centre for Doctoral Training. The transcript of an interview with Dr Thompson appears in Appendix D



Dr Mark Thompson being awarded his IUPAP Young Scientist Prize, C17—Laser Physics and Photonics, Applied Aspects at CLEO– Europe/EQEC on 24th June 2015. Also pictured, Professor Luc Berge, Chair of the Quantum Electronics and Optics Division of the European Physical Society and Professor Deb Kane, Chair of IUPAP Commission 17.

Acknowledgement

IUPAP C17 gratefully acknowledges the Quantum Electronics and Optics Division of the EPS and the European Physical Society for hosting the IUPAP C17 Young Scientist Prize Awards ceremony at CLEO-Europe/EQEC 2015. The 2015 Chair of QEOD, Prof Luc Berge is thanked for leading this.

4. IUPAP C17 Sponsored conference

International Laser Physics Workshop 2016 (LPHYS'16), held in Yerevan Armenia, 11-15 July 2016. <http://www.lasphys.com/workshops/lasphys16/>

Report by Professor Koryun Oganesan, Chair, Local Organising Committee, edited by Deb Kane
LPHYS'16 paid tribute to three major anniversaries: (i) 100th Anniversary of Alexander M Prokhorov's Birth, (ii) 100th Anniversary of the Optical Society (OSA) and, (iii) 25th anniversary of the Laser Physics Workshop.

Alexander M Prokhorov, was one of scientists honoured for the invention of lasers as a Nobel Prize winner in physics of 1964. He also initiated the first International Laser Physics Workshop held in 1990. Over the following 10 years he was the esteemed leader and chairman of the conference. After his death in 2002, his disciples committed themselves to the ongoing organization of the conference. The conference is held annually, and almost every time in different countries of Europe, America and Asia. The conference website has a map on which you can trace the geography of its routes. This is Russia, Italy, Spain, France, Brazil, USA, Canada, Norway, Germany ... <http://www.lasphys.com/workshops/history>



The conference was held for the first time in Yerevan, Armenia, in 2016 (11-15 July) <http://www.lasphys.com/workshops/lasphys16>. It opened on the very day of the 100th anniversary of AM Prokhorov's birth. 2016 was also the first year LPHYS has been held in a Commonwealth of Independent States country. The choice of Armenia for 2016 was underpinned by several factors. The main one was that laser physics school in Armenia is still at operating at a high level, despite challenges. Secondly, the President of National Academy of Science of Armenia, Professor Radik Martirosyan, was a graduate student of AM Prokhorov. Living Prokhorov students can be counted on the fingers, so that it Radik Martirosyan was instructed to make a presentation about the famous scientist.

The conference was marked by yet another anniversary - the 100th anniversary of the Optical Society (OSA). Past president of the society - the famous American scientist Professor Joseph Eberle, also called for the conference to be held in Yerevan. For many years cooperation between the Yerevan Physics Institute (now the Alikhanyan National Science Laboratory) and the Moscow Prokhorov Institute of General Physics, Russian Academy of Sciences has continued. This close scientific relationship, and its international recognition, also supported the decision to hold a jubilee conference in Yerevan. Chairman of the local organizing committee of the conference, Prof. Koryun Oganesyanyan, a senior fellow at the Theoretical Department of the Alikhanyan National Science Laboratory (Yerevan Physics Institute) also has many articles co-authored with Prokhorov.

The 2016 the conference included 8 parallel Seminars covering topics from “Modern Trends in Laser Physics” to “Quantum Information Science”, and one Symposium on “Extreme Light Technologies, Science and Applications”. There were 361 participants from 35 countries. 17% of the participants were female. The conference, as noted by the participants, was successful. All aspects of laser physics were lit, new and interesting trends and results in the areas of laser physics, as coherent light sources, nonlinear and quantum optics, laser spectroscopy of atoms, modern trends in laser physics, the study of the optical properties of nanostructures and luminescent substances etc., in the program forum

reflected several scientific discoveries of 2015-16 and, of course, the most spectacular of them - heralding a new era in the history of science - the detection of gravity waves by LIGO. Gravitational waves are not relevant to laser physics, but they were able to be registered through the application of the highest achievements of the laser physics, laser engineering and technology.

The core contingent of participants are professors. These prominent scientists bring to the conference their graduate students early career researchers. Many of those who have participated in LPHYS as graduate students, have become renowned scientists in their own right. There is a backbone of some 60 people who have not missed a single conference in the series.

In addition to the high quality scientific program, Armenia, with its ancient architectural monuments and magnificent natural heritage left an indelible impression on all participants. The sponsorship from the International Union of Pure and Applied Physics supported participants from Ukraine, Kazakhstan, Bosnia & Herzegovina, and Russia (two female).



Professor Koryun Oganesan acknowledging sponsors during the opening ceremony of the conference.

5. International Day of Light 2018 (<https://www.lightday.org/>)

A general ambition is that young minds, particularly high school students, should be exposed to advancements in optics and photonics through open houses in all major institutions, to stimulate these young brains to start imagining innovations in science and technology. Supporting developing nations, and disadvantaged groups within developed nations, to achieve a similar exposure for high school students, via means that can be resourced and implemented where the children live, can be a positive approach. The connection of IDL aims to the United Nations Sustainable Development Goals should be kept front of mind. This connects directly with IUPAPs mission. The strong professional societies will once again play key roles, as will the many supporters and sponsors of IYL. But, C17 can play an important role in raising awareness of IDL, its programs and events through the international reach of our channels and networks. Members will also be strongly encouraged to support IDL by organising events as an additional responsibility specific to our commission.

The Commission would like to see an overarching IDL event that engages as much of the world as possible. Suggestions include that for May 16 2018, there should be an international collaboration to make a spectacular laser/light display worthy of the bygone era of World's Fairs. Imagine if a structure with the scale of the Eiffel Tower were created virtually from an array of high-power visible lasers and/ or LEDs projected onto water? Such a display would not be excessively expensive to build, and yet would capture the imagination of new generations of young scientists, showing the capabilities of the light sources of today. The company Laser Vision (<http://www.laservision.com.au/>), started in Australia, but now with an international presence, has shown what is possible with its award winning light extravaganzas increasing tourist income in Hong Kong, Singapore and Dubai.

More broadly the International Day of Light should have a wide impact involving Science, Culture, Arts and Society. Within this the Laser Physics and Photonics community should have the specific role of explaining and demonstrating how light can be generated, amplified, guided, manipulated, making it an indispensable instrument for the welfare and progress of humanity. To this aim, the plan to have a different theme every year is an important one. Suggested themes include "Light to communicate", "Light to heal", "Light to manufacture", and so on. Thus, each year when engaging with students from primary, middle and high schools the experience will always be a new one.

In considering international days we also recommend that IUPAP review which International Days it will promote for active observance by commissions. IDL should be such a day as it is relevant to several commissions and affiliated commission ICO. Also, the International Women's Day (8th March 2018) is an important opportunity to promote gender equity in Physics and Applied Physics. "The purpose of this day is to focus on various themes such as innovation, the portrayal of women in the media, or the importance of education and career opportunities." (<http://www.womensdaycelebration.com/international-womens-day.html>)

6. In Memoria, Tributes, Anniversaries, News, Selected Prizes

Jacques Beaulieu (Inventor of CO₂-TEA laser, Canadian; passed Aug. 2014)

Canadian physicist and researcher of very high caliber, he is the inventor of the CO₂-TEA laser. He received many prestigious prizes such as the Urgel-Archambeault and the Joseph-Armand-Bombardier awards from ACFAS, the Thomas W. Eadie medal from the Royal Society of Canada and the Denis-Gabor Award from SPIE, the international association of optics and photonics and he received a Honoris Causa Doctorat ès Science from Université Laval. He was member of the Royal Society of Canada, Great Officer of the Ordre national du Québec and Officer of the Order of Canada. (<http://photonscanada.ca/en/news/photonscanada-news/2014-news/obituary-dr-jacques-beaulieu/?m=10&y=2016>).

Charles Hard Townes (July 28, 1915 – January 27, 2015) was an American physicist and inventor of the maser and laser. Townes was known for his work concerning the theory and application of the maser, for which he obtained the fundamental patent, and other work in quantum electronics associated with both maser and laser devices. He shared the Nobel Prize in Physics 1964 with Nikolay Basov and Alexander Prokhorov.

George I. Stegeman, 1942-2015, OSA Fellow and 2003 recipient of OSA R.W. Wood Prize, passed away on 2 May 2015. George was an icon in the area of nonlinear optics and published more than 700 papers during his career. He co-authored the well-regarded text *Nonlinear Optics: Phenomena, Materials and Devices* (Wiley, 2012). He was Emeritus Professor of Optics, Physics & ECE at CREOL, College of Optics and Photonics, University of Central Florida (UCF).

Wolfgang Sandner (2 March 1949 – 5 Dec 2015) Fellow of the American Physical Society. Director, Max-Born Institute; former President, German Physical Society. A short CV of this esteemed scientist can be found under <http://staff.mbi-berlin.de/sandner/>

Ahmed Hassan Zewail (February 26, 1946 – August 2, 2016) was an Egyptian-American scientist, known as the "father of femtochemistry". He was awarded the 1999 Nobel Prize in Chemistry for his work on femtochemistry and became the first Egyptian to win a Nobel Prize in a scientific field. He was the Linus Pauling Chair Professor of Chemistry, Professor of Physics, and the director of the Physical Biology Center for Ultrafast Science and Technology at the California Institute of Technology. (https://en.wikipedia.org/wiki/Ahmed_Zewail)

Katharine Blodgett Gebbie (July 4, 1932 – August 17, 2016) was an American astrophysicist and civil servant. She was the founding Director of the Physical Measurement Laboratory of the National Institute of Standards and Technology (NIST), and of its two immediate predecessors, the Physics Laboratory and the Center for Atomic, Molecular and Optical Physics, both for which she was the only Director. During her 22 years of management of these institutions, four of its scientists were awarded the Nobel Prize in Physics. In 2015, the NIST Katharine Blodgett Gebbie Laboratory Building in Boulder, Colorado was named in her honor. Former chair and member of C15, IUPAP. (https://en.wikipedia.org/wiki/Katharine_Blodgett_Gebbie)

Mildred Dresselhaus (née Spiewak; November 11, 1930 – February 20, 2017) known as the "queen of carbon science", was the first female Institute Professor and professor emerita of physics and electrical engineering at the Massachusetts Institute of Technology. Dresselhaus won numerous awards including the Presidential Medal of Freedom, the National Medal of Science, the Enrico Fermi Award and the Vannevar Bush Award. (https://en.wikipedia.org/wiki/Mildred_Dresselhaus)

Adolf F. Fercher, 1939-2017, passed away on 10 March 2017 at the age of 77. Fercher, a noted pioneer in the field of ophthalmic laser interferometry, served as the Head of the Institute of Medical

Physics at the University of Vienna (and subsequently the Medical University of Vienna) from 1986 to 2007. Fercher was a brilliant visionary and internationally recognized expert in biophotonics and the medical application of lasers. He was considered the father of the first Low-Coherence Interferometry (LCI) devices and his groundbreaking research laid the foundation for the development of optical coherence tomography (OCT).

Nicolaas "Nico" Bloembergen (March 11, 1920 – September 5, 2017) was a Dutch-American physicist and Nobel laureate, recognized for his work in developing the fundamental principles behind nonlinear optics for laser spectroscopy. During his career, he was a professor at both Harvard University and later at the University of Arizona. Bloembergen shared the 1981 Nobel Prize in Physics with Arthur Schawlow, along with Kai Siegbahn "for their contribution to the development of laser spectroscopy". (https://en.wikipedia.org/wiki/Nicolaas_Bloembergen, modified).



Giuliano Toraldo di Francia, 100th anniversary of his birth (Florence, 17 September, 1916 - Florence, 26 April, 2011) was an Italian physicist and philosopher. He has been involved in mathematics, optics, microwave, laser physics, quantum mechanics, and physics. Among the main contributions, in the field of optics, the formulation of the principle of inverse interference and the experimental demonstration of the existence of evanescent waves are to be remembered.

Prof AM Prokhorov The 100th Anniversary of his birth (Atherton Tablelands, Queensland, Australia, 11 July 1916). This anniversary was celebrated around the world, including in Australia, Prokhorov's birthplace. Russia issued a commemorative stamp.

<http://1015fm.com.au/2016/08/queenslander-alexander-prokhorov-meet-australias-forgotten-nobel-prize-winner/>

<http://www.abc.net.au/radionational/programs/breakfast/scientists-celebrate-the-laser/7585798>

<http://lpl.creol.ucf.edu/News.aspx?NewsID=659>

<http://www.diomedia.com/100-years-since-the-birth-of-alexander-prokhorov-russian-physicist-nobel-prize-laureate-d-2002-birth-anniversary-stock-images-62044-11072016.html>

<http://www.photonics-expo.ru/en/news/index.php?id4=7974>

<http://iopscience.iop.org/journal/1555-6611/page/Special-issue-dedicated-to-Alexander-M-Prokhorov>

<http://iopscience.iop.org/article/10.1070/QEL16172/meta>

<http://lpl.creol.ucf.edu/News.aspx?NewsID=659>

https://www.researchgate.net/publication/307558508_Prokhorovman_and_laser_on_the_100_th_anniversary_of_his_birth

https://www.facebook.com/TheTablelander/photos/?tab=album&album_id=1114400621955275

<http://postcardpress.ru/en/stamps/2109-100-years-since-the-birth-am-prokhorov-1916-2002-physicist-nobel-prize-laureate.html>

Anniversaries

20th anniversary of the Quantum Cascade Laser (QCL) (2014)

50th anniversary of Charles Kao developing optical fibre communications (2015)

55th anniversary of the birth of Lasers (2015)

150th anniversary of the formulation of Maxwell's equations (2015)

200th anniversary Fresnel and his theory of light as a wave (2015)

Laser Physicist/Research Leader Joins the Greek Government

Well known research leader in the European laser physics and photonics community, Professor Costas Fotakis, previously a Director of the Institute of Electronic Structure and Laser (IESL) at the Foundation for Research and Technology – Hellas (FORTH) in Crete, Greece and then elected as President of FORTH in 2011 started a new phase of his career as the Deputy Minister for Research and Innovation in the new Greek Government, January 2015.

<http://greece.greekreporter.com/2015/02/01/who-is-who-in-the-new-greek-government/>



Costas Fotakis is the new Deputy Minister for Research and innovation in Greece.

<http://www.nature.com/nmat/journal/v14/n9/full/nmat4403.html>

Selection of Prize Winners in Laser Physics and Photonics Prizes

The prizes awarded from three selected professional societies provide another window on the new knowledge that is prized within the field.

EPS Quantum Electronics Prizes

2017 Prize for Fundamental Aspects of Quantum Electronics and Optics: Niek F. van Hulst

The 2017 Prize for Fundamental Aspects of Quantum Electronics and Optics is awarded to Prof. Niek van Hulst, ICREA research professor at ICFO, The Institute of Photonic Sciences, Barcelona, Spain. The Prize is awarded to Professor van Hulst “For pioneering contributions to nano-optics and its applications to molecular spectroscopy and to ultrafast light-matter interactions.”

2017 Prize for Applied Aspects of Quantum Electronics and Optics: Victor Malka

The 2017 Prize for Applied Aspects of Quantum Electronics and Optics is awarded to Prof. Victor Malka, CNRS research director at the Laboratoire d’Optique Appliquée, Palaiseau, France and Professor at the Weizmann Institute for Science, Rehovot, Israel. The Prize is awarded to Professor Malka “For pioneering research using ultra-high intensity lasers for laser-plasma accelerators and their applications.”

2015 Prize for Fundamental Aspects of Quantum Electronics and Optics: Sir John Pendry,

Professor of theoretical solid-state physics at Imperial College London, United Kingdom. The Prize is awarded to Professor Pendry for helping formulate rules on how to incorporate different kinds of materials with nanoscale structures to form larger scale metamaterials with exciting new optical properties not seen in nature.

2015 Prize for Applied Aspects of Quantum Electronics and Optics: Professor Bahram Javidi,

Professor at the University of Connecticut, USA. The Prize is awarded to Professor Javidi for

pioneering contributions to information optics, including 3D imaging, 3D displays, and 3D imaging of photon starved scenes.

<http://qeod.epsdivisions.org/QEOD%20Prizes/eps-quantum-electronics-prize>

Optical Society (OSA) Prizes

Frederic Ives Medal / Jarus W. Quinn Prize

2017 - Margaret M. Murnane

For pioneering and sustained contributions to ultrafast science ranging from femtosecond lasers to soft x-ray high-harmonic generation to attosecond studies of atoms, molecules and surfaces

2016 - Gérard A. Mourou

For numerous pioneering contributions to the development of ultrafast and ultrahigh intensity laser science and for outstanding leadership of the international and commercial communities impacted by these technologies.

2015 - James G. Fujimoto

For pioneering the field of optical coherence tomography (OCT) and for leading the field to widespread medical application and major commercial impact

Charles Townes Award

2017 - Adolf Giesen

For pioneering breakthroughs in the field of solid-state lasers by the invention of and fundamental contributions to thin disk lasers.

2016 - Robert W. Boyd

For fundamental contributions to the field of nonlinear optics, including the development of methods for controlling the velocity of light, of quantum imaging methods, and of composite nonlinear optical materials.

2015 - Ursula Keller

For seminal contributions in the fields of octave-spanning lasers, frequency comb technology, and high application and major commercial impact.

http://www.osa.org/en-us/awards_and_grants/awards/award_categories/

SPIE Gold Medal of the Society

2017 - Katarina Svanberg, Professor of Oncology, Lund University Hospital, Division of Oncology, Lund, Sweden, and also active at South China Normal University, Guangzhou, is the 2017 recipient of the Gold Medal Award in recognition of her extraordinary contributions to Biophotonics, in particular her clinical work exploring and verifying the efficacy of phototherapy and in vivo diagnosis. This award also acknowledges her dedication to building scientific and medical infrastructure in Africa and inspiring young people across the world.

2016 - Paras N. Prasad

The SPIE Awards Committee has made this recommendation in recognition of his numerous, world renowned, pioneering contributions to nonlinear optics, nanophotonics and biophotonics, as well as over three decades of outstanding service to SPIE.

2015 - Nadar Engheta

The SPIE Awards Committee has made this recommendation in recognition of his transformative and groundbreaking contributions to optical engineering of metamaterials and nanoscale plasmonics, metamaterial-based optical nano circuits, and biologically-inspired optical imaging.

<https://spie.org/about-spie/awards-programs/current-award-winners/gold-medal-of-the-society>

IEEE Photonics Award

2018 - URSULA KELLER Professor, Physics Department, Institute for Quantum Electronics, Zurich, Switzerland “For seminal contributions to ultrafast laser technology enabling important industrial applications and novel scientific breakthroughs.”

2017 - JOHN BOWERS Kavli Professor of Nanotechnology, University of Santa Barbara, California, USA “For pioneering research in silicon photonics, including hybrid silicon lasers, photonic integrated circuits, and ultra-lowloss waveguides.”

2016 – MARK E. THOMPSON Professor, Department of Chemistry, University of Southern California, Los Angeles, CA, USA “For scientific and technical leadership in the conception, demonstration, and development of phosphorescent materials in organic light-emitting diode (OLED) displays.”

2015 - PHILIP ST. JOHN RUSSELL Professor, Max Planck Institute for the Science of Light, Erlangen, Germany "For pioneering contributions to the conception and realization of photonic crystal fibers."

https://www.ieee.org/documents/photonics_rl.pdf

7. Associate Members of C17

For the period 2016-2018 the approved Associate Members are as follows

1. A member to represent the Joint Council of Quantum Electronics

Prof Nicholas P. Bigelow

Department of Physics and Astronomy and
Institute of Optics
The University of Rochester

2. A member representing ICO

Prof John Harvey

Vice president, ICO
Physics Department
University of Auckland
New Zealand

3. A member representing IYL legacy

Professor John Dudley
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8. Items on which C17 seeks discussion at the C&CC Meeting, Sao Paulo, 2017

- The C17 Mandate
- Code of conduct for conferences
- Number of years post PhD for IUPAP YSP eligibility
- Contents of IUPAP Newsletter
- Supporting early career scientists

9. Contributions Made to IUPAP Business

- Consultation on ICO proposal to be a full Union of ICSU
- Authorship on role description for Commission officers and members
- Contributions to challenges for physics for IUPAP presentation to ICSU

10. Meetings and Communication within C17

The communications and meetings of the commission have been primarily electronic. A number of commission members were able to have a physical meeting on the 31st July 2017, in Singapore, in conjunction with CLEO PacRim. The Slate for C17 for 2018-2020 was a key item of discussion along with the proposed merger of ICSU and ISSC.

Appendix A. Commission Membership 2014-2017

Officers:

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Appendix B



International Union of Pure and Applied Physics (IUPAP) Commission 17: Laser Physics and Photonics Young Scientist Prizes

The IUPAP Commission 17 - Laser Physics and Photonics - is seeking nominations for its biennial Young Scientist Prizes. Two prizes are available for award. One prize is for outstanding contributions of a fundamental nature. The other is for outstanding contributions of an applied nature. Both prize winners will have demonstrated significant achievement, and exceptional promise for future achievement in the areas of laser physics and/or photonics. The recipients must be no more than eight years post PhD (excluding career interruptions) by the deadline for nominations.

Nomination Requirements and Deadline for Submission:

Nomination for the Prize must be by a senior member of the research community, with one or two additional letters of endorsement by supporters. The deadline for submissions of nominations is 20 December 2016. A complete nomination packet submitted by a senior nominator will consist of:

- A cover letter by the nominator (please indicate clearly whether the nomination is for the prize for fundamental or applied aspects);
- A citation for the Prize (30 words or less referring to the nominee by gender);
- One or two additional letters of endorsement for the nomination, one of which must be from a senior scientist who was not a former supervisor of the nominee at either the graduate or postdoctoral level and who is not a close collaborator of the nominator;
- a one-page statement by the nominee explaining the achievements and the overall significance of the work;
- Up to three salient publications co-authored by the nominee;
- An up-to-date, one page CV of the nominee;
- A list of key publications, including citation statistics; patents, etc.

Nomination packages must be in the form of a single consolidated PDF file or a ZIP archive.

Please send all material via email to the IUPAP-C17-YS Prize Committee Chair, Professor Deb Kane, deb.kane@mq.edu.au, by the deadline of 20 December 2016.

The Prize: Each Prize will consist of 1,000 Euro, a Medal, and a Certificate.

Prize Selection: The prize selection committee will consist of C17 commission members. The Prize winners will be announced on the IUPAP website.

Prize Presentation: The IUPAP C17 Young Scientist Prizes will be awarded at the 12th Conf. on Lasers and Electro-Optics Pacific Rim (CLEO-PR 2017), to be held in Singapore, 31 July-4 August 2017, within Photonics@SG (<http://photonics2017.org/index.php>).

For information: the deadline for submission of abstracts to CLEO Pacific Rim (and OECC and PCG) is December 31, 2016. <http://photonics2017.org/orgcleo.php>



International Union of Pure and Applied Physics (IUPAP)

Commission 17: Laser Physics and Photonics

The IUPAP Commission 17 - Laser Physics and Photonics - is seeking nominations for its biennial Young Scientist Prizes. Two prizes are available for award. One prize is for outstanding contributions of a fundamental nature. The other is for outstanding contributions of an applied nature. Both prize winners will have demonstrated significant achievement, and exceptional promise for future achievement in the areas of laser physics and/or photonics. The recipients must be no more than eight years post PhD (excluding career interruptions) by the deadline of the competition.

Nomination Requirements and Deadline for Submission:

Nomination for the Prize must be by a senior member of the research community, with one or two additional letters of endorsement by supporters. The deadline for submissions of nominations is 31 January 2015. A complete nomination packet submitted by a senior nominator will consist of:

- A cover letter by the nominator (please indicate clearly whether the nomination is for the prize for fundamental or applied aspects);
- A citation for the Prize (30 words or less referring to the nominee by gender);
- One or two additional letters of endorsement for the nomination, one of which must be from a senior scientist who was not a former supervisor of the nominee at either the graduate or postdoctoral level and who is not a close collaborator of the nominator;
- a one-page statement by the nominee explaining the achievements and the overall significance of the work;
- Up to three salient publications co-authored by the nominee;
- An up-to-date, one page CV of the nominee;
- A list of key publications, including citation statistics; patents, etc.

Nomination packages must be in the form of a single consolidated PDF file or a ZIP archive.

Please send all material via email to the IUPAP-C17-YS Prize Committee Chair, Professor Deb Kane, deb.kane@mq.edu.au, by the deadline of 31 January 2015.

The Prize: Each Prize will consist of 1,000 Euro, a Medal, and a Certificate.

Prize Selection: The prize selection committee will consist of C17 commission members. The Prize winners will be announced on the IUPAP website.

Prize Presentation: The IUPAP C17 Young Scientist Prizes will be awarded at CLEO/Europe - EQEC 2015 (to be held in Munich, Germany, 21-25 June 2015).

For information: the deadline for submission of abstracts to CLEO/Europe – EQEC is January 19, 2015. <http://www.cleoeurope.org/>

IUPAP welcomes applications from outstanding women and other underrepresented groups.

Appendix D – Interview with 2015 IUPAP YSP Winners, C17

The transcript of these interviews also appeared in the IUPAP Newsletter December 2015, in an in an abridged form in the print version, and in full in the on-line version: <http://iupap.org/wp-content/uploads/2016/01/IUPAP-Dec2015-e-version.pdf>

Interview with Dr Mark Thompson*

DEB: Welcome Mark! I'm really pleased to be able to chat to you today about your winning of the IUPAP Laser Physics and Photonics Young Scientist's Prize for applied aspects for 2015. Congratulations!

MARK: Thank you very much.

DEB: And thank you very much for agreeing to answer the questions that we've got for you this afternoon. The citation for your prize says "for his contributions to the new and emerging field of quantum photonics, and particularly for his pioneering work in integrated quantum photonic circuits". Firstly, can you please tell us what the award-winning research is, for someone with a physics degree?

MARK: My research is about harnessing the quantum mechanical properties of light, and particularly to process, encode and transmit information. That really opens up the doors to a whole new range of different, and potentially ground breaking technologies in areas such as ultra-secure communication and new types of computation; for instance, complex quantum simulations and quantum chemistry calculations, or in machine learning. Controlling the quantum properties of photons is not a particularly simple matter. You have to be able to generate single photons, manipulate single photons and detect single photons. However, research into this has been going on since the early 1970s, when people first demonstrated that you could take single photons and put them in superpositions of being in many different places, or you could entangle single photons and control and manipulate the quantum mechanical properties of these photons. So that's well understood, but what we're doing now, and particularly what my research is focusing on, is developing more usable and practical technologies where we're taking the ideas and concepts from quantum physics, and using state of the art photonic engineering approaches and techniques to create what we call quantum microchip circuits. We're using the same sort of manufacture processes that would be used to fabricate a microprocessor in your computer, except we're using them to create quantum circuits where we can guide and manipulate single photons on the chip. That's allowing us to create new applications in quantum communications, and is enabling us to scale-up this technology so that ultimately, in the future, we may be able to make systems large enough to perform quantum computing calculations.

DEB: Best of luck with all of those challenges.

MARK: Thank you.

DEB: If I could ask you a follow up question. If you could translate that for somebody who was a bit earlier in their physics education, what would you say?

MARK: Oh, right, that's always a tricky question. In a sense, it's creating new technologies for information processing and communications, but instead of using, say for instance in conventional computing, electrons to do the computing, we're now using photons, single particles of light, to do the computing. By using single photons we can get access to a part of physics, known as quantum physics, that current computing machines don't use, and that gives us new ways of processing information and potentially incredibly powerful ways to perform computations that are completely beyond the capabilities of our current information processing machines.

DEB: Thank you. Do you have a feel for where your work fits into physics overall?

MARK: Right. It's grounded in quantum mechanics, which is one of the foundational theories of modern physics, and in a sense we're exploiting those ideas and concepts from quantum mechanics. So, I really see it as, potentially, a tool with which physics can explore an understanding in greater depth of the world as we know it. So we're creating machines that harness entanglement, super-

position and quantum states on a larger and larger scale. And so this will allow us to probe our understanding of quantum physics in an ever deeper and more meaningful way. It will also allow us to create machines that can perform computations far superior to the sorts of computations that we can do now. The particular areas where this will become significant is, for instance, when you want to fully simulate real physical systems and real quantum systems. We will be able to use these technologies as a tool to ask questions about like...well, where does high T super-conductivity arise from, how do we get to room temperature super-conductivity, can we perform advanced quantum simulations on molecular dynamics? To give you an example of the advantage that a quantum computing device can give you; if, for instance, you want to perform a simulation of an electron system, and say you've got 300 electrons in that system; this might be for instance a simulation of a super-conducting material. The size, or the amount of memory that you would need for your computer to fully simulate 300 electrons is greater than the number of atoms in the universe; so it's completely beyond what you can do with a conventional computer. However, a quantum computer could perform that sort of calculation with, of order, 300 qubits. So that gives you an idea of the potential power that a quantum computer could have. We would be able to use that machine as a tool to probe various aspects of physics that we would never be able to do otherwise.

DEB: Thank you. You've won the IUPAP YSP prize for applied aspects. Can you tell us about the applied nature of your research?

MARK: I guess the applied nature of my research is really about making things. I really enjoy making devices, and laboratory-based work. And so, the applied aspects of my work are really about using state-of-the-art photonic engineering approaches and principles, and bringing that technology to bear onto the area of quantum optics and quantum photonics. So, I work a lot with big semiconductor fabrication foundries; the sort that people like Intel would be using to make microprocessors. We use exactly the same capabilities and facilities to make our quantum photonic chips that are controlling and manipulating single particles of light rather than controlling and manipulating electrons – which is what microprocessors do. My applied aspects are really about developing these new types of quantum circuits. Having them fabricated in commercial fabrication facilities, and then back in the laboratories in Bristol where we do all the testing and characterisation, exploring how they work, and developing all of the capabilities that you would need on a single microchip to scale up this technology.

DEB: Can you tell the listeners a little bit about how you got to be doing what you do now. What was your journey in physics?

MARK: Well, I've always been interested in light, ever since a very early age; light and radio waves; I used to build my own radio-transmitters when I was a kid. I had some interesting moments with some pirate radio stations, but that probably shouldn't be on the record.

Laughter.

MARK: But yeah, I've always been interested in light. I did a degree in physics with engineering, and then straight after my degree I went to work in the telecommunications industry, designing and making devices for the world's first silicon-photonics companies. After working on various components for the telecommunications industry, I decided I wanted to go back and do something a bit more physics-based, so I did a PhD at the University of Cambridge working on quantum dot lasers. I had a fantastic time working with this new type of laser, and then towards the end of my time there, I decided I wanted to move into a new area that used both my interest in physics and my interest in engineering. This area of integrated quantum optics was the ideal place, there was a lot of interesting physics, but also some really hard engineering challenges to be overcome to have a significant impact. So that's why I've landed where I have, because I have this balance between physics and engineering. I have a passion for physics and a passion for making things.

DEB: I think you've answered my question which was what motivates you to do research at a high level, so we'll carry on.

Laughter.

DEB: What are you working on now, and how do you go about deciding what you should work on?

MARK: At the moment I'm continuing with the development of the waveguide integrated quantum circuits. Effectively, developing a technology platform that will allow us to propel this technology forward in terms of realising ultimately a quantum computer, and before that realising devices for quantum simulations and quantum communications. What this requires is development all of the basic components; so just like your classical computer has transistors, capacitors, resistors and ways of manipulating electrons, we need all of those sorts of components within a microchip circuit, but able to control and manipulate photons. We need photon sources, ways of switching and moving these photons around, we need quantum interference, and detection of these single photons. And so what I'm developing is the entire technology platform to get all of these components integrated onto a silicon chip. Then we'll start to scale up, but at the moment we have devices with about 100 components on them. Maybe next year we'll have devices with 1000 components on them, and then in a way we'll just keep scaling that up, while maintaining the quantum coherence of the system.

DEB: So that sounds like that's probably going to keep you going for most of your lifetime, so you're not really thinking about what else you need to do.

MARK: No, this is definitely a long-term career ambition.

DEB: Very good. What does winning the prize at this stage of your career mean for you?

MARK: It's really nice to be recognised; that's absolutely true, it's nice to be recognised for the work that you're doing. You get recognition within your own institute and you get recognised by your peers. And so, it helps my career in terms of my own visibility, which is important at this stage of my career.

DEB: IUPAP, the International Union for Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

MARK: I think, really, looking at how physics, physicists and the problem-solving abilities of physicists can be used to solve some of the major challenges facing society today, and I think looking at how physicists can be used to solve some of the major problems in climate, in energy, and communications.

DEB: Are there any questions I haven't asked you that you would have liked to have been asked? This is your opportunity to tell our listeners something you really want them to know about your work, physics, what matters to you.

MARK: Well the question that I most often get asked is "when will we have a quantum computer?" Or "how long would it take to make a quantum computer?" And that's always a really difficult question to answer. But I do generally think that within the next 10 years we'll have large scale computing machines doing advanced simulations of some sort or another. So I think it's actually a lot closer than a lot of people realise.

DEB: thank you very much Mark, and once again, congratulations on your Young Scientist prize from the Laser Physics and Photonics Commission and I wish you success in your future career.

MARK: Thank you very much.

*This transcript of the recorded interview has had minor editing for readability.

Interview with Dr Robert Fickler*

DEB: Thank you Robert! I am joined by Dr. Robert Fickler who has just been awarded the IUPAP Laser Physics and Photonics Young Scientist's prize for 2015 for Fundamental Aspects. The citation for Robert's prize was "for his ground-breaking contributions to the entanglement of complex structures of photons, which have opened up new avenues for quantum communications." Robert, Congratulations! Firstly, can you please explain your award-winning research to someone with a physics degree, where it sits in laser physics and photonics overall, and why it matters at this time.

ROBERT: Okay. Thanks, first of all, and yeah the research I did was as you mentioned the entanglement of structures of light. So first of all, it's about entanglement, it's about the foundations

of physics and entanglement is one key feature of quantum physics. We took advantage of the spatial structure of light, and we tried to increase its complexity and thereby gain new insights, or testing the limits, even, of quantum physics. So a few examples here are to certain spatial structures of light there's an orbital angular momentum degree, an orbital angular momentum connected, and there in principle it can be arbitrarily large, for a single photon, and even for an entangled photons. And this was one question we asked ourselves; "okay, what is...at least for the moment...the technical limit? How high can we go? And if there is a foundational limit, can we even reach that?" We are, I guess, far away from that if there is one at all, but this was one question. Another one was whether the spatial modes can be used as a laboratory realisation of high-dimensional Hilbert space. So, what does it mean for quantum information? Normally, everything is in qubits, but one could actually think of qutrits, ququarts, so not just 2 level systems but 3, 4 level systems; also infinitely high-dimensional systems. It's known that they have advantages when it comes to certain quantum particles. There, we try to find out how much information we can put in to one photon or in an entanglement. We did some research mainly trying to increase the complexity of either the theoretical state or even just the spatial structure. We tried to find out new properties; if there are new properties; if the theory is always right?, or just to see them actually in the lab we could try and get a better understanding of what was happening. This especially applies to quantum physics and quantum optics; the singular particles of light.

DEB: So that's quite a lot of physics. If you were to try to translate that to something that would resonate with someone a bit earlier in their physics education; have a go at doing that translation.

ROBERT: So I think I should first explain a little bit about entanglement. So, as I mentioned earlier, it is a key feature of quantum physics. So if you have two systems; two particles for example; at least two particles, they can be entangled. This means that they show strongly correlated features; they have some sort of connection, or it's like they know about each other. It's hard to explain. Correlations are known from classical physics as well, but quantum correlations are even stronger than classical physics can explain. So they can be separated by a big distance and still behave exactly the same; although, we can make sure that we they did not find an agreement before our measurements are done. Why we are interested in this is also a very foundational question as well. Well, with these experiments one can ask questions about how the world is, or how the properties are; if we can actually describe properties to these without measuring them or not; so it's a very philosophical discussion of course. This is what we investigate in the labs, and we try to push the limits. In the everyday world, we don't see these quantum correlations, so we ask ourselves why this is the case. Is it just happening for little systems or can we actually use some of these properties and extend them, or increase them so much, that we should be able to see them in the classical world and then see some correlations there? So this then applies to areas such as macroscopic entanglement and whether this is observable or not.

DEB: Well I was going to ask you what's fundamental about your research but I think that you've already answered that question and established that your research is fundamental in nature. So we might just move onto the next questions. May I ask what your physics story is? How did you come to be doing this award-winning research?

ROBERT: I guess I was always interested in physics so at one point I started to study physics. I was actually kind of lucky because at the university I was studying at, there was a small philosophy department as well and they promoted it because they wanted to have people study philosophy there as well. Because of this I heard about it and I went to some of the lectures in philosophy, and I became very attracted to philosophy as well. Especially then, because of my physics studies, the interplay between the two; or the overlap between these two fields was very compelling to me. There I found out that quantum physics especially has a big overlap and a big discussion although the theory, or the mathematical framework has been known since the 1930s or so, but the interpretation of this mathematical apparatus that we have is still highly debated. There is still a big discussion going on and this attracted my attention. This is why I went for this area in my PhD with Professor Zeilinger in Vienna, because he is interested as well in the foundational questions, the philosophical questions, and is still doing experiments. I am very interested in the philosophical questions, but I also love to do experiments. So I did a degree in physics, and then one in philosophy. This avenue was then one that

was very attractive to me and I followed this, and I was lucky to get an opportunity to work with the renowned Professor Zeilinger in this research. We sometimes do what we call metaphysical experiments, which is kind of a contradictory idea. However, this is what I think is the most interesting idea; at least for me it's one of the most interesting aspects of experimental physics; because it is so closely connected to philosophical questions.

DEB: I will follow up on that in that it's obviously quite competitive to become a PhD student in Professor Zeilinger's group. So was it a lucky outcome that a joint philosophy/physics background was advantageous in that regard?

ROBERT: I guess it helped. (*Laughter*). But you would also have to ask him about that. Apparently I didn't do that many things wrong because I was able to work there, but I'm not certain if that gave me a distinct advantage.

DEB: But it's certainly part of your motivation. So in terms of your motivation for doing what you do, you've given us a good sense of that already, is there anything you would like to add to that in terms of motivation?

ROBERT: I guess I think physics, or at least part of it, should not try to only follow avenues to produce new applications or to make existing technologies better; this is obviously very important, but blue sky research is also really important, and it's my field so this is definitely the most interesting thing for me. The other parts of physics research are important as well, but I think it is always nice if one does experiments where they are not directly working on applications. Some people challenge the relevance of foundational research; they believe it does not help society, they are sceptical about providing funding for this kind of research. However, in quantum optics, even though it started as a completely foundational field, one knows already that there's new technologies on the verge of becoming available to the public. And you can show the people of society that there are really useful things coming out of foundational research, even though it usually begins out of pure curiosity.

DEB: Research overall is a very small fraction of human activity, but within that we do want to see a very broad range of things explored, because we don't know what we're going to need in 10, 20, 30 years' time.

ROBERT: Exactly. I even realised in this conference that when you see how many people have their job because of the laser, even though at the start the laser was a solution with no problem. So, one could almost say it was useless, and yet now look at the significance it has.

DEB: Absolutely. So, you've just recently made a move from Vienna to Ottawa in Canada, so my next question which is about what you're working on now and how you go about deciding what you should work on; clearly you've just been putting quite a lot of thought into that step, so give us an insight into how you go about making those decisions.

ROBERT: So, I hope that whatever is interesting to me I will be able to follow in the research, without having to make big justifications the research will have applications coming out of it. So I hope I can follow that. Of course with Professor Bob Boyd I can do it as well. To be more precise, I will continue to work on complex structures, and use modern technology which has evolved so much that things are more complex, we'll add more complexity and control the quantum state perfectly. So, we're working on that. I haven't been involved so far because I've just moved there, but I hope I can work as well on extending similar methods to not just photons but to electrons. Some people have started exploring that already and I think it's highly interesting, because then you have mass particles and charge particles, which adds another complexity to the system. Another motivation for me was the group; the group in Ottawa is very diverse, and since my background so far is mainly quantum information and foundations. I think because they produce photonic crystals and do some plasmonics, so I can learn a lot there, and maybe even combine some other fields with my knowledge to develop new areas of research that are hopefully interesting and fun physics.

DEB: Well I wish you all the best in your new position. So, I'll ask you now: what does the prize mean to you at this stage in your career?

ROBERT: Well, first I will say that it's a big honour. Being awarded by such a huge, global organisation such as IUPAP is truly humbling, especially when you consider the long history of IUPAP. As well, I guess it helps you become recognised in your field, in your specific field, and even to a broader audience; the whole optics community, which helps for doing more interesting experiments because you can start collaborations. It also helps with the funding, as you have to get funding, and I hope this will help with that as well.

DEB: I hope so too. So regarding IUPAP, the International Union of Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

ROBERT: Well, I like the explanation you gave today, saying that it's kind of like the U.N. of physics. I think this is a nice way of phrasing it; I think it should bring the global community, and physics research in general is very global, together to share ideas, to collaborate, and thereby develop new areas of research that are hopefully interesting and fun physics.

DEB: I hope so too. So regarding IUPAP, the International Union of Pure and Applied Physics, what role do you think an overarching union of physics commissions should play for physics in the world?

ROBERT: Well, I like the explanation you gave today, saying that it's kind of like the U.N. of physics. I think this is a nice way of phrasing it; I think it should bring the global community, and physics research in general is very global, together to share ideas, to collaborate, and thereby develop new ideas; helping physics in general to tackle new problems develop new ideas; helping physics in general to tackle new problems of physics. I think because of technology, and this huge development in technologies over the last 20 years, I guess physics is developing incredibly; all different fields.

DEB: Absolutely. It's been very interesting and enjoyable to learn about insights into your research and why you do it. Thank you very much indeed for giving your time to this interview, and I wish you every success in your future career.

ROBERT: Thank you very much.

*This transcript of the recorded interview has had minor editing for readability.