OPTICS CENTENARY EVENT

(A Chronicle)

IMPERIAL COLLEGE
LONDON

8TH SEPTEMBER 2017

RECOLLECTIONS

Queens Tower, Imperial College
1.0 PROLOGUE

On 8 September 2017, a centennial celebration was held by the Photonics Group, Department of Physics, Imperial College London. Imperial College’s Department of Technical Optics was established in 1917 during World War I, when the UK lacked both advanced optical design capability and advanced optical instrumentation. As a result, the UK government established the first dedicated Department of Optics in a higher education institution (1917) to meet industry’s training needs for optical designers. Appointed as first director of the department was Professor Frederick Cheshire, a former official of the Patent Office who had carried out wartime service as Scientific and Technical Director of the Optical Department of the Ministry of Munitions. Alexander Conrady was subsequently appointed to the principal teaching post in the Department of Technical Optics, recognizing Conrady’s significant contributions to the design of military optical equipment, particularly submarine periscopes, during World War I.

This centenary celebration was held to commemorate the 100 years of significant achievements of Imperial College’s Department of Technical Optics and its subsequent organizations, down to today’s Photonics Group within the Department of Physics. Although no formal record of this event was commissioned by the college to provide an event record for posterity, the centenary celebration was considered by some to be of such significance within the optical community, especially in view of IC’s highly recognized contributions to optical science and technology, that this informal report has been prepared. This Chronicle has been prepared by Tina Kidger, Senior Member of OSA and SPIE, and spouse of the late IC optical design lecturer Michael Kidger. Tina wishes to express sincere appreciation to several of the sponsors who, responding to her specific support request, significantly helped to make this event possible. Michael Damzen, Head of the Photonics Group, provided his consent and expert review of this chronicle and its recollections of the centenary event highlights.
It is with great pleasure that Imperial College London celebrates the 100\textsuperscript{th} anniversary of the establishment of the Department of Technical Optics which has evolved into today’s Photonics Group within the Department of Physics. As you will see during the events of today, our group of expert scientists and engineers has made very significant contributions during the last century to the development of optical science and technology allowing what was then unforeseeable advances in technology. Today we have in our everyday lives the achievements of optical lithography, medical instrumentation, optical communication... and basic science unachievable without the contributions of optics people. Optics is pervasive in everything we do and that with which we come into contact, indeed it is part of our complete conscious life. Please enjoy this look back at our optics history and then let’s all go forward to carry on our great optical tradition.
I would like to extend my thanks to all who attended this special 100th Anniversary event, to our distinguished speakers and to all who helped with its organisation. My special thanks go to Judith Baylis who sorted out the registration, bookings, and catering for the reception and to Tina Kidger for helpful advice throughout my organising of this event. Thanks to all our very generous sponsors who made the event possible.

The 100th Anniversary was a very special, once in a lifetime, occasion. The Physics Department where we have celebrated previous anniversaries of Optics was not large enough to accommodate such a large event so the prestigious Great Hall at Imperial was chosen as the venue for the presentations and the Queens Tower Rooms for the evening reception. I am so pleased that we had a large turn-out of about 400 attendees and so many staff and alumni from many years past meeting again over drinks during the evening reception, along with dignitaries, senior representatives from societies, councils and industry.

We have celebrated the distinctive heritage of Optics at Imperial over previous decades and details of these can be found in the following links:


80th Optics Section Anniversary: [https://www.imperial.ac.uk/college.asp?P=1843](https://www.imperial.ac.uk/college.asp?P=1843)

60th Optics Section Anniversary: [http://www.tandfonline.com/doi/pdf/10.1080/713819828](http://www.tandfonline.com/doi/pdf/10.1080/713819828)
4.0 COMPENDIUM OF OPTICAL ACHIEVEMENTS

100 Years of Optics at Imperial College (1917-2017)

"addressing training and research needs from applied Industry through to Fundamental Science for 100 Years"

100 Years of Training in Optics

- First dedicated Department of Optics in a higher education institution (1917), established by the UK Government to meet the training needs of optical designers for the optics industry.
- Technical Optics courses delivered (1917) and full undergraduate and postgraduate Optics degree courses by 1919, the first in the world. 100 Years of advanced postgraduate training in Optics for Industry and Academia — still ongoing in IC’s existing MSc Optics and Photonics course, one of the few to still formally teach optical design using commercial software tools.
- Imperial College Optics Department played an influential role in meeting the national industrial training needs in optical design and instrumentation for its early period since World War 1. In latter decades training grew to meet expanding new optical and laser-based technologies.
- New recent (c. early 21st century) postgraduate Centre for Doctoral Training (CDT), training programmes in "Controlled Quantum Dynamics" and "Quantum System Engineering Skills" and MRes/PhD in Photonics (e.g. for biophotonics) addressing emergent new themes in Optics.

100 Years of Research in Optics

Optics activity at Imperial expanded into one of the world's largest and most diverse centres of optically-based fundamental science and applied technology by leading researchers in their field:

- **Optical Design and Optical Instrumentation**: e.g. Alexander Conrady; L C Martin; Harold H Hopkins; W D (David) Wright; Charles G Wynne; Walter T Welford
- **Diffractive, Holographic and Coherent Optics**: e.g. Robin Smith; J C (Chris) Dainty; Mark A A Neil
- **Laser and Nonlinear Optical Science and Technology**: e.g. Dan J Bradley; James R (Roy) Taylor; Geoff H C New; Henry Hutchinson; Wilson Sibbett; Paul M W French; Michael J Damzen
- **Spectroscopy**: e.g. William R S Garton; Lady Anne Thorne; Richard Learner; David Burgess; Richard Thompson; Keith Burnett
- **Biophotonics and advanced biological imaging**: e.g. Paul M W French; Christopher W Dunsby; James McGinty; Mark A A Neil; Peter Török
- **Fundamental Matter and Quantum Optics**: e.g. Peter Knight; Edward Hinds; Myungshik Kim
- **Attosecond and high-light-field science**: e.g. Jon Marangos; John Tisch; Peter Knight; Henry Hutchinson; Robin Smith
- More widely in Optics: John Pendry (Physics) pioneer of metamaterials and the concept of a perfect lens and invisibility cloak; Donal Bradley (Physics) revolutionised plastic electronics; and Dennis Gabor (Electrical Engineering) "father of Holography".
- And the vast number of past and present wonderfully gifted research students and researchers who have made amazing contributions, many who have gone on to stellar careers in optics and beyond.
5.0 THE CENTENARY EVENT

5.1 The Program

Optics Centenary Event

A celebration of 100 Years of Optics at Imperial

Venue: Great Hall, South Kensington Campus, Imperial College London
Date: 8th September 2017

https://www.imperial.ac.uk/photonics/events/optics-centenary-event/

Event Programme:

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
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| 13.50 | Welcome Address                                 | Prof Alice Gast
        |                                                | President of Imperial College London                                    |
| 14:00 | 100 Years of Optics at Imperial                 | Prof Chris Dainty                                                       |
| 14:30 | Heritage of Lasers at Imperial                  | Prof Roy Taylor, FRS                                                    |
| 15:00 | Applied Optics: Biophotonic Imaging             | Prof Paul French                                                        |
| 15:30 | COFFEE BREAK in QTR                            |                                                                        |
| 16:15 | Fundamental Optics: Quantum Science             | Prof Sir Peter Knight, FRS                                               |
| 16:45 | Industrial Optics: An industry perspective      | Dr Chris Dorman                                                         |
| 17:15 | The Future of Optics                            | Prof Ian Walmsley, FRS                                                   |
| 17:45 | Closing Address                                 | Dr Kenny Weir (Head of Physics)                                         |
| 17:50 | RECEPTION in QTR*                               |                                                                        |

* Additional Displays and Demonstrations supporting Centenary Event will be located in Queen's Tower Rooms (QTR)

Key-Note Event Speakers:

Prof Chris Dainty
(UCL)
Former Pilkington Head of Applied Optics and Postgraduate Alumnus, Past President of OSA

Prof Roy Taylor, FRS (ICL)
Head of Femtosecond Optics, Photonics Group

Prof Paul French (ICL)
Vice Dean of Research, FoNS, former Head of Photonics Group, and Optics Alumnus of Imperial

Prof Sir Peter Knight, FRS (ICL)
Former Head of Physics and Deputy Rector (Research), Past President of OSA

Dr Chris Dorman
(Vice President of Coherent Scotland, Imperial Postgraduate Alumnus from Optics Section

Prof Ian Walmsley, FRS (Oxford)
Imperial Physics Alumnus and current President-Elect of OSA

100 Imperial College

*I.C.I., is Imperial College London; OSA is the Optical Society of America*
5.2  Program Abstracts

As can be seen from the actual program given in section 5.1 above, the program was presented in two sessions of three papers each. Complete recordings are not available of each paper, however following are abstracts of the papers.

Session 1

Chair:  Tina E Kidger
Proprietor
(Kidger Optics Associates, UK)

5.2.1  Professor Chris Dainty

The Early Years and Classical Optics

Although there was talk of establishing a dedicated department of Optics in a university since the early 1900s, it was not until mid-1916 that the initiative was pushed hard by London County Council. They asked Imperial College to build a Department of Technical Optics, which would be overseen by a Technical Optics Committee, and, after some initial reticence, the College agreed in late 1916. The Technical Optics Committee consisted of representatives from Government (including defense) bodies, industry and the Royal Society. Their role was unusual, in that university departments were not usually run or monitored closely by outside bodies, and this Committee stayed in existence, albeit only in an advisory role since 1931, until 2006. This talk, traces the early history of Technical Optics from the appointment of the first staff in 1917. Through the eyes of the Technical Optics Committee: a full set of Minutes, 882 pages, exists in the Imperial College Archive.
which has now been digitised. The focus in these early days was in optical design and engineering, and the names associated with Imperial over the years in these fields are legendary: Conrady, Martin, Kingslake, Wright, Hopkins, Welford, Wynne and Kidger. Classical optics still has huge commercial importance worldwide: indeed the total market for passive optics is far greater than that for all other optical components (lasers, LED’s, etc) put together.

5.2.2 Professor Roy Taylor FRS

Heritage of Lasers Physics Department Imperial College

This presentation will deal primarily with the development and characterisation of lasers in the Physics Department from 1973 with the arrival of Dan Bradley and his group from Belfast. Prior to that although some basic laser development had been carried out most systems were commercially based. The talk covers, the early days in the development of flash-lamp pumped dye lasers, their mode-locking and the role of the saturable absorber, development of e-beam excited excimer lasers and mode-locked semiconductor lasers, leading on to cw femtosecond dye lasers, real time femtosecond diagnosties through the synchroscan streak camera and the first femtosecond vibronic laser based upon Ti:sapphire. Highly applicable, diode-pumped vibronic lasers. Diverse applications of high power fibre lasers and master oscillator power fibre amplifiers for nonlinear optics in fibre including, supercontinuum sources, Raman fibre lasers covering the complete visible and near infra-red and high average power mid infra-red sources using fibre laser pumps reprise the research programme coverage to the present day.
Bio-photonics in the Optics Section

This talk reviews the development of the bio-photonics research activity in the Optics Section, which was strongly influenced by our development and application of ultrafast lasers. I outline their impact on fluorescence imaging, particularly with respect to nonlinear (multiphoton) microscopy and fluorescence lifetime imaging (FLIM), which we translated to clinical trials for the diagnosis of skin cancer. Ultrafast lasers also supported our work in super-resolved microscopy, for which we developed new Stimulated Emission Depletion (STED) microscopes. More recently this has been complemented by the development of low-cost approaches to single molecule localisation microscopy. We have also translated FLIM to in vivo endoscopy and are exploring other nonlinear imaging modalities including the use of Brillouin scattering.
Session 2

Chair:  Professor Jon Marangos

Prof Jon Marangos
(Imperial College London)
Faculty of Natural Sciences
Department of Physics
Lockyer Chair in Physics

5.2.4  Professor Sir Peter Knight FRS

Professor Sir Peter Knight FRS
Blackett Laboratory,
Imperial College London
Kavli Royal Society International Centre,
Chicheley Hall, Chicheley, Buckinghamshire
Quantum Metrology Institute,
National Physical Laboratory

Fundamental Optics: Quantum Science at Imperial College

Imperial College has been at the forefront in the development of fundamental quantum optics for many years. I will describe in this talk some of the areas developed at Imperial and the people responsible for these.

Imperial College has pursued fundamental optical concepts and their applications for many years and I will describe some of these, through the personal lens of someone who has spent 40 years in the College working in this area.
Leading members of the Physics Department and in the wider college community have contributed massively to our understanding of light and its interaction with matter. Heroes such as G P Thomson, Denis Gabor, and Hanbury Brown were early pioneers of what became quantum optics. Experimental work on the nature of photons was pursued in the early days at Imperial by Leonard Mandel and Brian Morgan, amongst others. Tom Kibble contributed much to our understanding of laser light interactions with electrons (even while he was developing his much better-known work in field theory). In 1973, Geoff New was appointed to a faculty post and developed the theory group, with John Elgin and myself joining a little later. The group, originally the Laser Group within the optics section morphed into The Laser Optics and Spectroscopy Group and then into the Quantum Optics and Laser Science Group (QOLS).

Areas of focus within QOLS included Strong Field Physics (within the Laser Consortium), Ultra-fast phenomena, Cold atomic matter, Quantum Optics theory, and Quantum Information. My talk will describe some of the highlights achieved in each area over the past 40 years.

The 21st Century has seen the emergence of a networked world, connected by global fibre-optic communications and mobile phones, with geo-location provided through GPS, and all this has changed our lives more dramatically than at any time since the industrial revolution. Quantum-enabled technology is at the heart of this change. New developments in quantum technology, and in particular miniature atomic clocks that utilize concepts such as coherent population trapping have the potential for even more dramatic applications. Some of these include communication systems immune to GPS jamming (of importance for global security), as well as quantum sensors for medical applications, sensitive magnetometry, gyroscopes, and geophysical surveying. I will describe the basic quantum phenomena being exploited as well as prospects for exploitation in current research underway in QOLS.
Work Hours per Lumen of Light, A Historical Perspective

A review of the history of the creation of light by humans since the invention of fire from the perspective of work hours per lumen of light generated. Bringing this up to date with the invention of the laser, and industrial applications of laser light. A review of the significant impact the laser has on modern manufacturing, with a focus on the modern smartphone.
5.2.6 Professor Ian Walmsley

Professor Ian Walmsley FRS
(University of Oxford)
Hooke Professor of Experimental Physics
Pro-Vice-Chancellor
(Research and Innovation)

The Future of Optics

Optics has provided either the basic phenomenology or the enabling technology for many of the major advances in physics over the past 400 years, from telescopes and interferometers that enabled new measurements of gravitational models to tests of local hidden variables and the aether that provided insight into the nature of quantum mechanics and electromagnetism.

The close connection between discovery and application using light means that new tools enabling new science evolve rapidly. That’s as much the case now as it has been in the past: optics remains a vibrant enterprise, reaching across many different fields. Advances in our ability to use light to control, manipulate and measure objects will enable us to reach new frontiers in science, from the ultra-small, to the ultra-cold, to the ultra-complex, resulting in new applications from tests of fundamental constants to radically different means of communication and Information processing.
IC’s Centenary, Leading to the Future

Many thanks for the contributions of today’s speakers, sponsors and the people involved in organising and co-ordinating this centenary event. It is of tremendous value for everyone, including specialists and those even peripherally associated with the optical discipline, to pause and look back at the history of our chosen field of endeavour. It is only through such reflection that we can more fully absorb, appreciate and understand how optical science and technology has developed into what it is today. This past century’s work here at Imperial College, including the work of our predecessors in fundamental science, optics and associated applications, has laid the foundation supporting much of today’s research.

Optics is an enabling and interdisciplinary subject that, at Imperial, has seen successful collaboration between groups within the Department of Physics, while simultaneously reaching out into other departments across the college, other research institutes and industry. By maintaining and strengthening our work in these activities, Imperial College Optics will continue to significantly impact science, technology and medicine for many years to come.
6.0 Attendee/Sponsor Remarks

6.1 Attendees:
6.1.1 Kelvin Hopkins, M.P. for Luton North

Kelvin Hopkins (son of H.H. Hopkins) with Tina Kidger (session chair)

“Many thanks for enabling me to attend the Imperial College event, which I thought went extremely well. Imperial has clearly been a world-renowned centre for optical science for a century and remains so today. The presentations by the distinguished scientists at the celebration were impressive and obviously at the cutting edge of modern science and most appropriate to the occasion.”
6.1.2 David E. L. Freeman

Imperial College's Optics Centenary Event was an extremely enjoyable occasion. The papers gave an interesting review of the Optics research work at IC past and present. As a classical optical designer, I particularly enjoyed Chris Dainty's paper and his evidence that classical optics is alive and well and still accounting for the lion's share of the optics market.

The Event was an opportunity to meet old friends and colleagues and share experiences of the IC Applied Optics Section. As students, we were so fortunate to have access to world-renowned academics who had a significant impact on our professional lives.

6.2 SPONSORS:

[Image of sponsors logos]
6.2.1 Sponsor:

Congratulations on celebrating 100 Years of Optics at Imperial College London from your friends and colleagues at OSA, The Optical Society.

The Optics Centenary Event on 8 September 2017 featured a programme of distinguished speakers, who embodied the outstanding legacy and impact of optics and lasers at Imperial College London.

OSA was proud to sponsor such an exceptional celebration that both honored the history of optics at Imperial and explored how advances in optical sciences will address global challenges in the future.

As the oldest institution of higher education and research in optics in the world, the Photon Science Section, formerly known as the Optics Section, has secured a distinguished position in the history of optics. Originally founded in 1917 to teach technical optics, the optics community at Imperial College London has grown to become a prestigious, world-renowned program in the field of optics and its industrial and scientific applications. The applied and fundamental research conducted by the Section and the novel technologies developed by current and future students will have a lasting impact on advances in optical science.

The optics community at the Imperial College London has been an invaluable and dedicated partner with OSA over the years. A number of faculty and graduates of the Imperial College of London have served in key leadership roles for OSA and have shaped the future of the Society and the community, most notably OSA 2004 President Prof Sir Peter Knight, OSA 2011 President Prof Chris Dainty, and OSA 2018 President Prof Ian Walmsley.

OSA recognizes the staff leadership and dedication of the Photon Science Section within the Imperial College London. The Imperial College London will continue to build on its history of developing exciting results in our field, long into the future. Congratulations once again on this milestone.

Eric Mazur, 2017 OSA President
Professor, Harvard University

Elizabeth Rogan, Chief Executive Officer
OSA, The Optical Society
SPIE leaders congratulate Imperial College London on optics centenary

SPIE Newsroom
08 September 2017

SPIE leaders on Friday joined in congratulating Imperial College London (ICL) on its 100th anniversary of optics research and education.

SPIE Past President Emery Moore, SPIE Fellow Chris Dainty, SPIE Senior Member Tina Kidger, and SPIE CEO Eugene Arthurs attended the optics centenary event, which included lectures, demonstrations, and displays of Imperial College's long history of vibrant optics-based research and its world impact on the science of light. SPIE was a cosponsor of the event.

Alice Gast (above, center), Imperial College London president, welcomed about 400 celebrants to a full day of lectures by distinguished optical scientists.
Imperial College's Photon Science Section is the largest university optics center in the UK, with research activities covering everything from applied optical systems to quantum optics.

ICL's optics program was established as the Department of Technical Optics in 1917 to address the shortage of optical engineers needed during the Industrial Revolution. A.E. Conrady, an eminent optical designer for whom an SPIE annual award is named, taught the first courses in optical design.

In 1931, the department name was changed to the Technical Optics Section and the optics program continued to grow over the years, adding laser, photonics, applied optics, and other research groups over the years. It was recently renamed the Photon Science Section.

In addition to the A.E. Conrady Award, SPIE has two other annual awards named after individuals who worked and/or studied at Imperial, the Dennis Gabor Award and the Rudolf Kingslake Medal and Prize. Kingslake's wife, Hilda, was Conrady's daughter. Hilda Kingslake was, herself, another accomplished optical designer and graduate of Imperial College.

Tina Kidger, owner of Kidger Optics Associates and the author of a 2016 SPIE Proceedings paper, "The optical legacy of Imperial College London," introduced the first three speakers. Members of the SPIE Student Chapter at ICL distributed complimentary copies of Kidger's paper to attendees.

Michael Kidger, for whom an SPIE annual scholarship award is named, taught some the first courses in optical design at Imperial College.

In 1931, the department name was changed to the Technical Optics Section and the optics program continued to grow over the years, adding laser, photonics, applied optics, and other research groups over the years. It was recently renamed the Photon Science Section.
6.2.3  Sponsor:

Synopsys

George Bayz
Vice President
Synopsys' Optical Solutions Group, USA

It was an honor for Synopsys to participate in celebrating 100 years of optics education at Imperial College London. The College has a unique history as the world’s oldest institute of optics and it continues to be dedicated to excellence in optics education and research.
7.0 Appendices

7.1 Centenary Event Photos

Welcome – Alice Gast, President, Imperial College London

Reception: Tina Kidger and Mike Damzen (Event Organizer)
Hilda Conady was a member of the very first full-time degree class in the new Optics Department at Imperial College. After graduating in 1931, she continued at Imperial as a researcher publishing on topics including the Foucault knife-edge test and spherical aberrations. In 1938, she moved with her husband, Rudolf Klepslak, also an Optics Department graduate, to the Institute of Optics, Rochester, USA, making a lifelong career in optics. Hilda received major awards and commendations from many civic and professional societies, including the Fellowship of the Optical Society of America.

Hilda was elected daughter to Prof. Conady, the first Professor of Optical Design at Imperial in 1917. She died two days before her 101st birthday in 2003, followed by her husband, Rudolf Klepslak, just 13 days later aged 99.

Prudence Wormell was a Research Officer in the Optics Section from 1962 – 2000, and subsequently an Honorary Research Fellow. With a background as a mathematician who came from the budding computer industry, she joined the Optical Design Group led by Prof. Offiers Wyane. Her work provided computational programming and developed computational tools for the design of optical systems, freeing optical designers from the tedious hand calculations, these computer methods brought to design into the modern era.

Prudence was Honorary Secretary to the Optical Group at the Institute of Physics (UK). She played an important role in the organisation of the Optics Reading Room, a cherished and long-standing resource for the Optics Section.

Lady Anne Thorne was at Imperial College from 1953 – 1991 and subsequently Senior Research Fellowship in the Optics Section in Physics. Her research involved on the diffraction of atoms and subatomic molecules and experimental methods included Fourier Transform spectroscopy. Her seminal work, “Spectroscopy” was published in 1974 and subsequently reprinted as “Spectrophysics: Principles and Applications” in collaboration with U. Linné and S. Johansson in 1979. She was also active in playing a role in the College, serving 20 years as the first Senior Tutor for Women College Day Nursery.
Session 2: Professor Ian Walmsley

Reception: Facing are - Roy Taylor, Paul French and Eugene Arthurs
Reception: Jon Maxwell and Gareth Jones

Session 1: Professor Chris Dainty
Introducing Session 1: Tina Kidger

Session 1: Professor Paul French
Reception: MSc Optics and Photonics students

Reception: Professor Jon Marangos and Dr Emma Springate (STFC)
Reception: Professor Peter Torok (red shirt, at table) and Dr Gabrielle Thomas

Reception: Dr Vicente Aboites (CIO, Mexico) and Dr Robbie Murray
Reception: Dr Mark Richards and Professor Myungshik Kim

Reception: Professor Martin McCall (orange top)
7.2 End of a Perfect Day