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NEWSLETTER

COMMISSION INTERNATIONALE D'OPTIQUE · INTERNATIONAL COMMISSION FOR OPTICS

ICO Prize to Coherent X-Ray Imaging

Manuel Guizar-Sicairos, was awarded the 2019 ICO Prize "for his seminal contributions to method and algorithm development, and application of coherent lensless imaging, ptychography, x-ray nanotomography, and scanning small-angle x-ray scattering"

Dr. Guizar-Sicairos is currently beamline scientist at the cSAXS beamline in the Swiss Light Source (SLS).

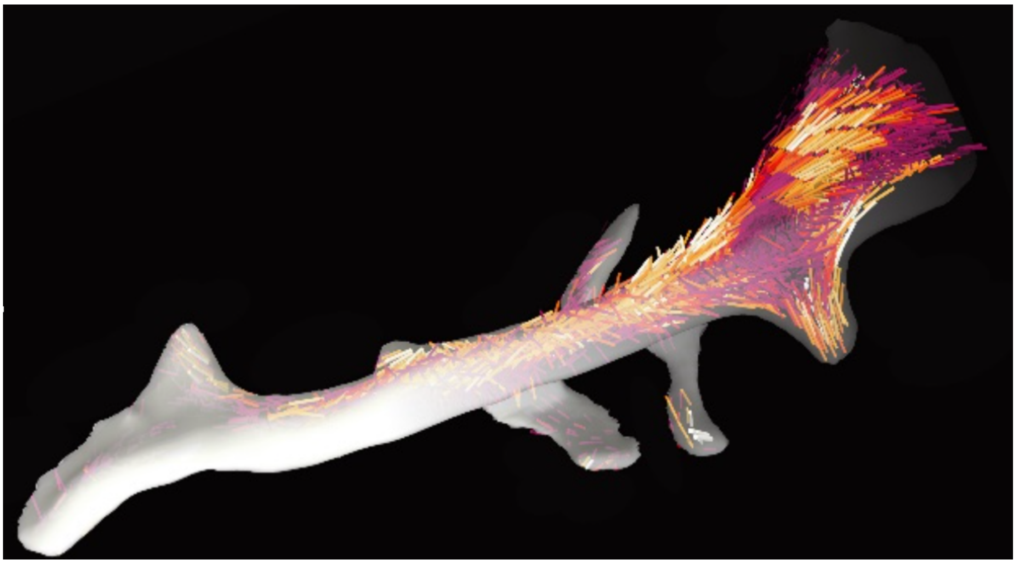
Manuel Guizar-Sicairos received his B.Sc. and M.Sc. from the Tecnológico de Monterrey, Mexico, and his Ph.D. from the University of Rochester in 2010. His research has focused on the development, advancement, and application of coherent X-ray imaging techniques, in particular on innovations in novel imaging methods and image reconstruction algorithms. He co-developed the basic principles and experimental demonstration for a generalization to off-axis holography termed HERALDO (see Opt. Express 15, 17592, 2007 and Phys. Rev. Lett. 105, 043901, 2010) an approach based on differential holographic encoding that allows a much larger class of extended references to be used for high-resolution X-ray lensless imaging. The added flexibility in holographic-reference design enables superior resolution over X-ray Fourier transform holography, eases sample fabrication, and allows for 3D imaging, all while maintaining the signal-to-noise ratio and algorithmic simplicity.

Dr. Guizar-Sicairos has carried out seminal algorithm developments in ptychographic nano-tomography, combining scanning microscopy with lensless imaging to reconstruct the sample transmissivity with a resolution that is neither bounded by the size of the beam, nor by defects in the illumination lens, nor by the scanning step size. In this manner, it enables very high-resolution 3D imaging with quantitative contrast, and is increasingly used or planned in synchrotron X-ray sources around the world.

The team at SLS worked together on algorithms, side-by-side with important instrumental and methodological advances, and established ptychographic nanotomography as a routine measurement technique, with a broad range of applications in biological and materials science. For their achievements they received the prestigious Innovation Award on Synchrotron Radiation 2014 for "significant advances in high-resolution 3D hard X-ray microscopy" and for "establishing new standards for high-resolution 3D microscopy".

Later advances allowed measuring an integrated circuit at 3D isotropic resolution below 15 nm (Nature 543, 402, 2017) and 3D multiscale nanoimaging of regions of interest embedded in large extended areas (Nature Electronics 2, 464-470, 2019). With his collaborators, he developed a technique that allowed to image for the first time 3D magnetization textures, i.e. the direction of magnetization within magnetic materials, with nanoscale resolution in the bulk (Nature 547, 328, 2017). Alongside domain walls, vortices, and antivortices, the measurement revealed the first observation of a

Human trabecula bone sample, of 2.5 mm length, measured with SASTT (Nature 527, 349, 2015). The 3D rendered cylinders show the local main orientation of mineralized collagen fibrils. The length and color of the cylinders encode the fibril alignment within each voxel, i.e. their degree of orientation.



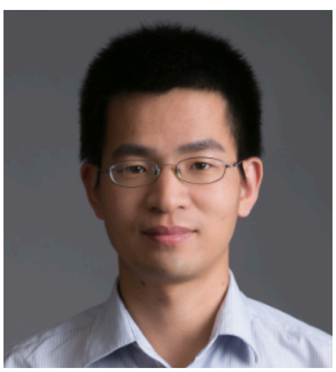
The techniques developed by Dr. Guizar-Sicairos are now in use at SLS and other synchrotron sources around the world.

Bloch point, a magnetization singularity that was first theoretically predicted over 60 years ago.
Small-angle X-ray scattering (SAXS) provides statistical information of nanostructure within the X-ray illuminated volume, yielding surveys of nanostructure, over large areas of the order of millimeters or centimeters, which probe local nanostructure down to a single nanometer. He co-developed a generalized tomography approach that allows fully extending SAXS to 3D imaging (see e.g. Nature 527, 349, 2015 and Nature 527, 353, 2015), a technique termed small-angle scattering tensor tomography (SASTT).
Measurements of SAXS patterns on a volumetric sample at all points and all orientations are fed to a novel tensor tomography reconstruction algorithm that allows reconstruction of a full 3D reciprocal-space map for each voxel. The reconstruction then provides localized statistical 3D information of the underlying nanostructure. The figure in the previous page shows a human trabecula bone sample of 2.5 mm in length, which was measured with this technique. The real-space spatial resolution of the measurement, i.e. voxel size, is 25 microns. However, with SASTT they recovered local information on the mineralized collagen fibrils, which have diameters between 50-200 nm. In particular, they obtained the 3D main orientation direction and degree of orientation, depicted by the orientation of the cylinders and their length, respectively. The technique is now in use at SLS and other synchrotron sources around the world.

Prof. Dr. Sung-Han Park chaired the ICO Prize 2019 Committee

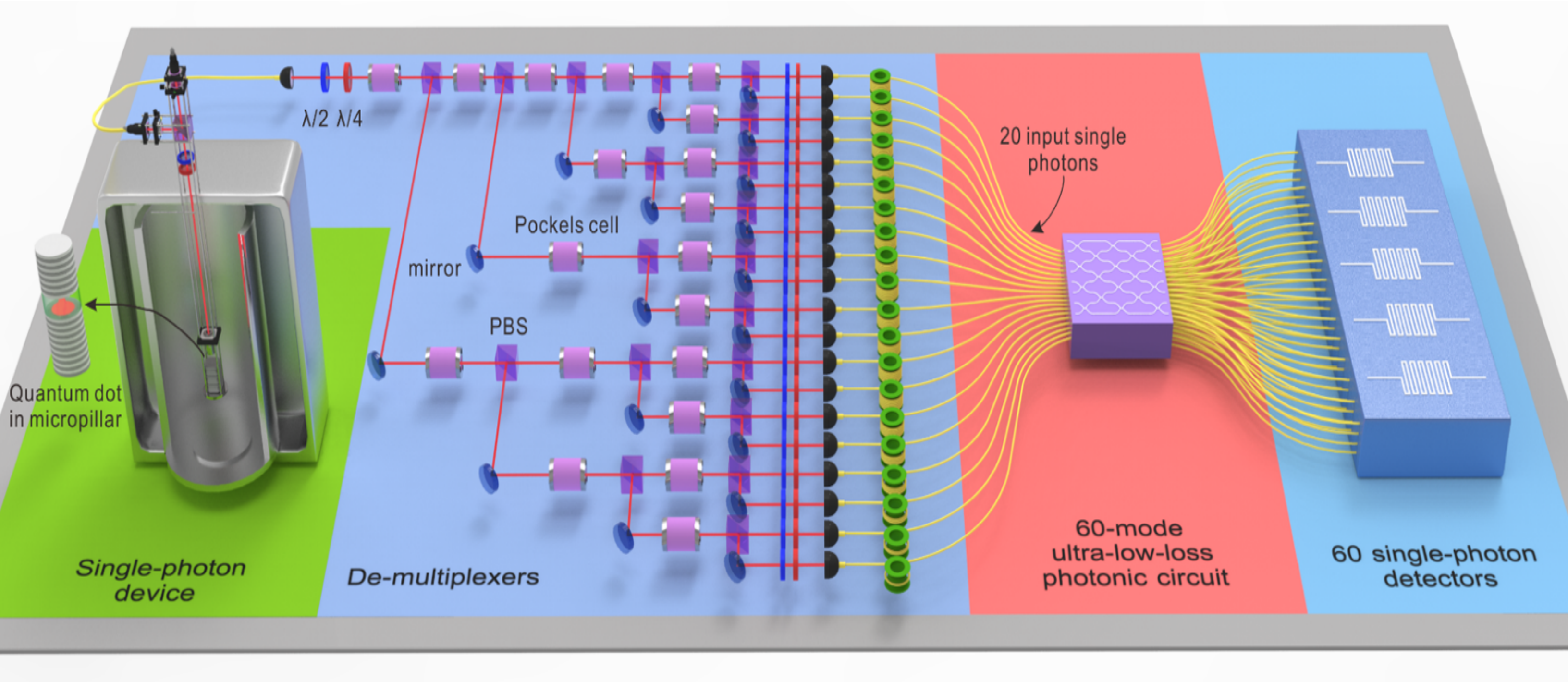
ICO-IUPAP Prize for Quantum Light Engineering

Prof. Chao-Yang Lu works in quantum light source engineering for quantum computing applications.



Dr. Chao-Yang Lu from University of Science and Technology of China received the ICO-IUPAP Young Scientist Prize in Optics 2019.

Prof. Chao-Yang Lu from University of Science and Technology of China received the ICO-IUPAP Young Scientist Prize in Optics 2019 "for his significant contributions to optical quantum information sciences". After obtaining his PhD from the University of Cambridge in 2011, Dr. Lu and his team have been pioneering solid-state quantum light sources, multi-photon entanglement, quantum teleportation and quantum computing with photons.
A photonic quantum information processor usually consists of three parts: quantum light sources, linear optical network, and photon detection. Among these, the non-classical and non-linear quantum light sources, for example, single-photon sources and entangled-photon sources, represent the most challenging tasks. In the past two decades, extensive research efforts have been devoted into developing quantum light sources for scalable quantum technologies (Rev. Mod. Phys. 84, 777, 2012).
The key is how to compatibly combine all the check lists together into a single device, namely, high single-photon purity, indistinguishability, and efficiency. Dr. Lu and his team developed pulsed resonance fluorescence in semiconductor InGaAs quantum dots to deterministically generate single photons with near-unity indistinguishability (Nature Nanotech. 8. 213-217, 2013).
Further, by coupling the quantum dots to high-Purcell polarized micropillar, and using two-color coherent excitation, they produced pure and indistinguishable single photons with high extraction efficiency (Phys. Rev. Lett. 116, 020401, 2016), free from laser background (Nature Physics 15, 941-946, 2019), and with single polarization (Nature Photonics 13, 770-775, 2019) yielding a perfect single-photon source.
Meanwhile, based on a broadband microcavity, Dr. Lu and his team developed deterministic quantum-dot based entangled photon sources with high efficiency and indistinguishability Phys. Rev. Lett. 122, 113602, 2019).
In a parallel route: non-linear optics, Dr. Lu and his team pushed entangled photon sources based on spontaneous parametric down-conversion to its physical limit. They have demonstrated six-, eight-, ten-, and 12-photon entanglement (see, respectively, Nature Physics 3, 91-95, 2007; Nature Photonics 6, 225-228, 2012; Phys. Rev. Lett. 117, 210502, 2016 and Phys. Rev. Lett. 121, 250505, 2018) and, finally, 18-qubit hyper-entanglement (Phys. Rev. Lett. **120**, 260502, 2018), along this road. Now, the entangled-photon sources developed possess 97% efficiency and 96% indistinguishability, simultaneously.
Dr. Lu and his team have also systematically applied the novel quantum light sources in a series of fundamental quantum optics and quantum technology experiments. The single photons were used to perform astronomical-distance quantum interference with sunlight with 80% raw visibility, proving the quantum nature of thermal light (Phys. Rev. Lett. 123, 080401, 2019).
They developed non-demolition single-photon detection and demonstrated quantum teleportation of single photons with multiple degrees of freedom (Nature 518, 516-519, 2015) and high dimensions (Phys. Rev. Lett. **123**, 070505, 2019).



Experimental set-up of boson sampling with 20 single photons in 60 modes. A single InGaAs quantum dot coupled to a microcavity is used to create pulsed resonance fluorescence single photons. 19 pairs of Pockels cells (PCs) and polarized beam splitters (PBSs) are used to actively translate a stream of photon pulses into 20 spatial modes. The 20 input photons are injected into a 3D integrated, 60-mode ultra-low-loss photonic circuit consisting of 396 beam splitters and 108 mirrors. Finally, the output single photons are detected by 60 superconducting nanowire single-photon detectors.

In the near future, Dr. Lu aims to perform 30-50 photon quantum computing experiments, and build solid-state quantum entanglement-based networks.

By doubly dressing a single quantum dot, they conclusively demonstrated the interference-induced spectral line elimination (Phys. Rev. Lett. 114, 097402, 2015), a theory predicted by Zhu and Scully that waited for 19 years to be experimentally demonstrated.

Dr. Lu was also the first to observe non-classical single-photon emission from atomically thin semiconductor crystals (Nature Nanotechnology 10, 497-502, 2015), opening a new line of research on quantum optics with two-dimension materials.

In the field of optical quantum computing, Dr. Lu and his team performed seminal experiments exploring the potentials of linear optics quantum computing, including the first demonstration of Shor's algorithm (Phys. Rev. Lett. 99, 250504, 2007), loss-tolerant quantum coding (Proc. Natl. Acad. Sci. USA. 105 11050-11054, 2008), simulation of anyonic statistics in Kitaev model (Phys. Rev. Lett. 102, 030502, 2009), teleportation-based quantum CNOT gate (Proc. Natl. Acad. Sci. USA. 107 20869-20874, 2010), solving systems of linear equations (Phys. Rev. Lett. 110, 230501, 2013), entanglement-based machine learning (Phys. Rev. Lett. 114, 110504, 2015), cloud-based quantum computing (Phys. Rev. Lett. 119, 050503, 2017), and topological quantum walk (Phys. Rev. Lett. 121, 100502, 2018), pointing to future practical applications in code-breaking, big data, and quantum simulation.

An emphasize has been on building quantum machines that can outperform classical computers for some specific tasks, a milestone termed as "quantum supremacy", for which boson sampling is a strong candidate. In 2017, they have built a five-photon boson sampling machine, which is 4-5 orders of magnitudes faster than before (Nature Photonics 11, 361-365 , 2017).

Recently, Dr. Lu and his team reported boson sampling with 20 single photons injecting into 60-mode interferometer at a state space of 10^{14} (Phys. Rev. Lett. 123, 250503, 2019).

In the near future, Dr. Lu aims to perform 30-50 photon quantum computing experiments, and build solid-state quantum entanglement-based networks.

Prof. Dr. Adrian Podoleanu chaired the ICO-IUPAP Young Scientists Prize in Optics Committee

Malik Maaza, ICO Galileo Galilei Medal 2019

Prof. M. Maaza is the current incumbent of the UNESCO UNISA Africa Chair in Nanosciences & Nanotechnology in South Africa.

The committee for the Galileo Galilei Medal 2019, chaired by Prof. Nataliya Kundikova nominated Prof. Malik Maaza, as the recipient of the award "for extensive contributions to the frontiers of interdisciplinary research that involved both theoretical and experimental developments in the fundamental aspects of femtosecond laser-matter interactions under comparatively difficult circumstances". Prof. M. Maaza is with the UNESCO UNISA Africa Chair in Nanosciences & Naotechnology, a trilateral partnership between the UNESCO, IThemba LABS-National Research Foundation of South Africa & the University of South Africa (UNISA). He holds a in Ph.D. in Wave Matter neutron Quantum Optics from Paris VI & an MSC in Lasers & Photonics from Ecole Superieure d'Optique-Paris XI & Paris VI.

His research interest encompasses Nano-technology & advanced materials for solar energy, Photonics & Optical based technologies. He has mentored a large cohort of Postgraduates from the various corners of the African continent & the South with a significant female component in support of the gender equity. He has published about 450 ISI-SCI peer reviewed publications and is fellow of the National Academy of Sciences of India, the European Academy of Sciences, the American Association for Advancement of Science, the Royal Society of Chemistry, the Islamic Academy of Sciences, the African Academy of Sciences as well as the New York Academy of Sciences.

Prof. Nataliya Kundikova chaired the ICO Galileo Galilei Medal Committee

Contacts

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Forthcoming events with ICO participation

Below is a list of 2019/20 upcoming events with ICO participation. For further information, visit the ICO website http://e-ico.org

10-21 February 2020
Winter College on Optics: Quantum Photonics and Information
Trieste, Italy
Contact: Marco Zennaro
smr3424@ictp.it
http://indico.ictp.it/event/9021/

31 August–04 September 2020
ICO-25: 25th General Meeting of the International Commission for Optics
Dresden, Germany
Contact: Janet Hanel
ico-office@mailbox.tu-dresden.de
http://ico25.org

31 August–04 September 2020
16th Conference of the International Society on Optics within Life Sciences
Dresden, Germany
Contact: Janet Hanel
ico-office@mailbox.tu-dresden.de
http://ico25.org

07–11 September 2020
EOSAM-2020: Annual Meeting of the European Optical Society
Porto, Portugal
Contact: Elina Koistinen
elina@europeanoptics.org
http://eosam2020.org

25th Congress of the International Commission for Optics (ICO) • 16th International Conference on Optics Within Life Sciences (OWLS)

Responsibility for the correctness of the information on this page rests with the International Commission for Optics (ICO); http://www.e-ico.org/. *President:* Prof. Roberta Ramponi, Director IFN-CNR, Politecnico di Milano, Italy; roberta.ramponi@polimi.it. *Treasurer:* Prof. Joseph Niemela, International Center for Theoretical Physics, Italy; niemela@ictp.it. *Secretary:* Prof. Humberto Michinel, Universidade de Vigo, Spain; hmichinel@uvigo.es. *Associate Secretary:* Dr. Frank Höller, Carl Zeiss AG, Germany; frank.hoeller@zeiss.com