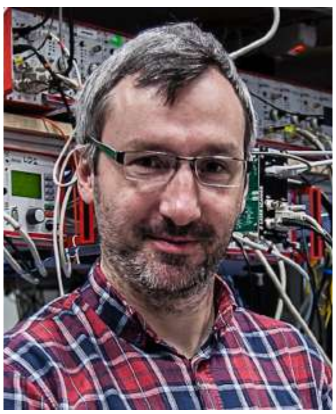
NEWSLETTER

COMMISSION INTERNATIONALE D'OPTIQUE · INTERNATIONAL COMMISSION FOR OPTICS

ICO Prize for Quantum Memories

"Quantum memories, show both outstanding storage capacity and remarkably extensive range of operations"



Prof. Wasilevski works on quantum memories at the University of Warsaw (Poland).

Wojciech Wasilewski, from the Center of New Technologies and the Faculty of Physics of the University of Warsaw (Poland) has been awarded the 2020 ICO Prize for "seminal contributions to experimental work in the field of multi-mode quantum memories, demonstrating systems with both outstanding storage capacity and remarkably extensive range of operations".

Prof. Wasilewski received his M.Sc. from University of Warsaw and Ph.D. from Nicolaus Copernicus University, Torun. His group theoretical and experimental research focuses on multimode aspects of quantum information processing, including quantum memories, single photon characterization and quantum enhanced measurements. The work for which this prize was awarded was the first realization of over five hundred mode quantum memory, which permits spontaneous generation of photons [1] and a broad range of operations on stored light [2, 3]. The research was carried out entirely by the group at the University of Warsaw. Results show that few spin wave states can be generated nearly deterministically and stored in the cold atomic quantum memory or processed via linear optical transformations. Wasilewski and his group continue to explore the protocols enabled by the novel memory. They recently made a 50kHz resolution spectrometer, a realization of a Fourier transform in an atomic ensemble that reversibly maps frequency onto time [4]. The results of Wasilewski group are primarily exploratory and unveil a range of potential further directions of research. The protocols demonstrated can be implemented in other types of quantum memories which may bring them closer to various applications. It is also envisaged that the methods worked out may find applications in quantum communications and may enable precise measurements.

[1] M. Parniak, M. Dąbrowski, M. Mazelanik, A. Leszczyński, M. Lipka and W. Wasilewski, *Wavevector multiplexed quantum memory as a universal platform for quantum state preparation*, Nature Communications 8, 2140 (2017).

[2] M. Mazelanik, M. Parniak, A. Leszczyński, M. Lipka, W. Wasilewski, *Coherent spin-wave processor of stored optical pulses*, npj Quantum Information 5, 22 (2019).

[3] M. Parniak, M. Mazelanik, A. Leszczyński, M. Lipka, M. Dąbrowski, W. Wasilewski, *Multidimensional quantum optics of spin waves through AC-Stark modulation*, Physical Review Letters 122, 063604 (2019).

[4] M. Mazelanik, A. Leszczyński, M. Lipka, M. Parniak, W. Wasilewski, *Temporal imaging for ultra-narrowband few-photon states of light*. Optica Vol. 7, Issue 3, pp. 203-208 (2020).

Prof. Seung-Han Park

Chaired the ICO Prize Committee

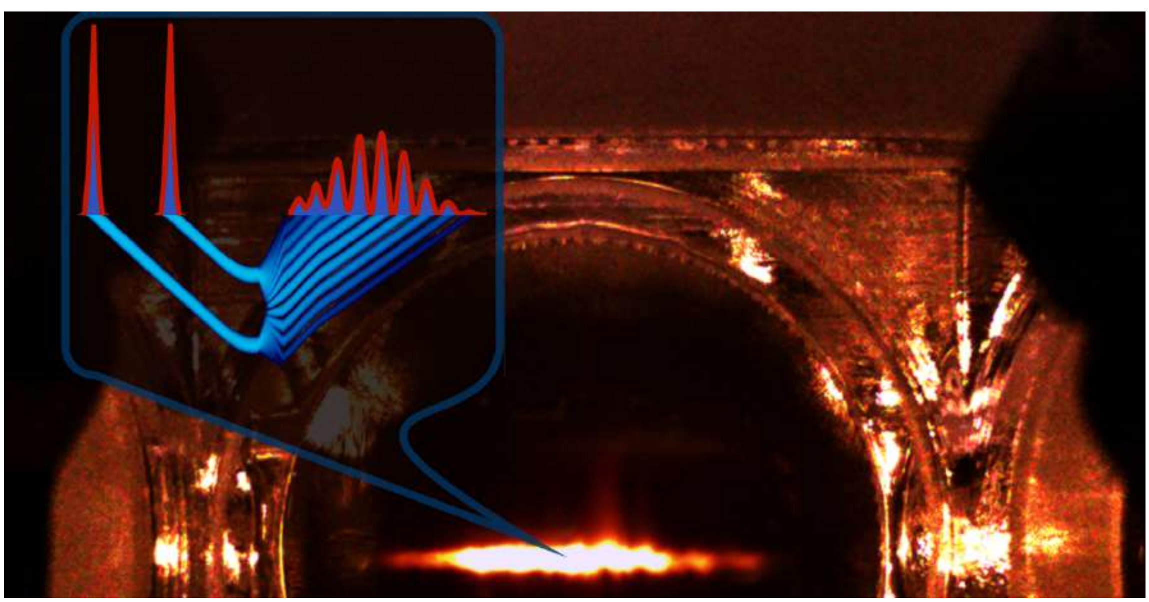


Photo of the cold atomic ensemble in which light is stored. Insert: plot of of the two light pulses (measured, red) used for storage as spin waves (simulated, blue) and readout of their spectrum (comb under Gaussian envelope in this case).

Galileo Galilei Medal for Jorge Ojeda-Castañeda

Prof. Ojeda-Castañeda works in diffractive optics at the University of Guanajuato (Mexico)

The ICO Galileo Galilei Medal is awarded for outstanding contributions to the field of optics which are achieved under comparatively unfavourable circumstances.

As a self-confessed declaration, most of Prof. Ojeda-Castañeda's research comes out-of-curiosity. Rather early, in his research, he wanted to identify the necessary and sufficient for rendering visible transparent structures. To this aim, he developed a symmetry-based treatment for identifying an effective transfer frequency function; which links thin phase variations, at an input, with irradiance distributions at the output [1].

The effective transfer function was applied for designing some nonconventional variations of the Schlieren techniques [2]. Also, out-of-curiosity, he analyzed the necessary and sufficient conditions for generating self-images. For this purpose, Prof. Ojeda-Castañeda developed a differential operator and working with Adolf Lohmann as a Humboldt Fellow, he proved, four years before the diffractionless term was coined, that the Bessel functions are the eigensolutions of the scalar wave equation [3].

The differential operator approach was usefully exploited for analyzing aberrated images; as well as for identifying refractive index profiles, alpha power GRIN, which can sustain either super-Gaussian beams [4], and Laguerre functions [5].

Also working with Adolph Lohmann and his students, Jorge proposed the use out-of-focus optical transfer functions for understanding the Lau effect. This simple treatment leads to related the impact of focus errors, on image quality, with the mathematical treatment of the ambiguity function [6]. In this manner an interesting link was stablished between space-frequency representations and the optical considerations for setting error tolerances on field depth [7]. At the left-hand side of Figure 2, we show some phase profiles. Next at the center. we display the modulus of their associate ambiguity functions and at the right-hand side, we plot the curves that are obtained by scanning the ambiguity functions along the depicted, white dotted lines.

Symmetric arguments were also employed for identifying optical masks that reduce the influence of focus errors on the modulation transfer function [8]. These optical masks are able, indeed, to reduce the impact of focus errors. However, the modulation is reduced "equally well" at several planes of a 3-D input.

For compensating the purposely induced "democratic distribution" of image quality, one needs a digital restoration technique. In this manner, he proposed a two-stage technique: (a) a pre-processing stage using an optical mask for reducing the impact of focus error; and (b) a post-processing stage employing digital restoration techniques; which work well provided that the values of the modulation transfer function are above certain recovering level [9]. This procedure helped to set the groundwork for computational imaging, before the term was even coined.

Since then, Prof. Ojeda-Castañeda and his students have identified large families of optical masks that are useful for optically engineering field depth, as a two-stage process [10]. In Figure 3, along its first line, we depict the interferograms of some 1-D phase masks, and 2-D helical masks, which reduce the influence of focus errors, on the MTF. Currently, the phase masks are used globally for improving the performance of optical microscopes.

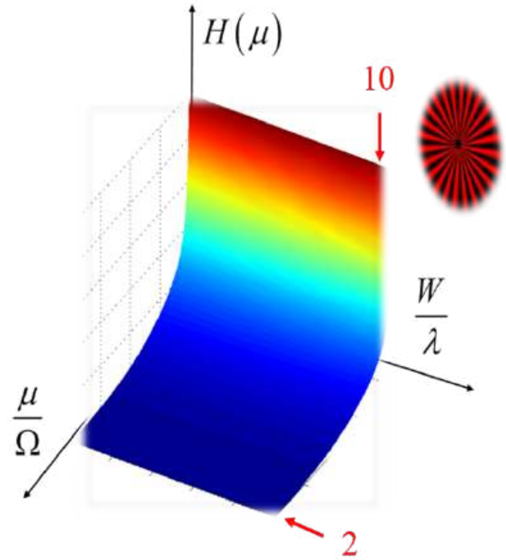


Figure 1: Modulation transfer function as a function of both the focus error, with coefficient W, in units of λ; and the spatial frequency μ. The cut-off spatial frequency is Ω).

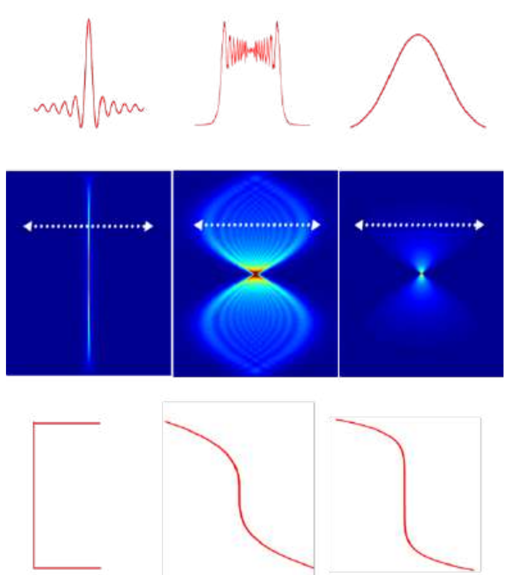


Figure 2: From left to right, phase profiles, the modulus of their associated ambiguity functions, and the variations of the modulation transfer function, for the spatial frequency located along the white dotted line.

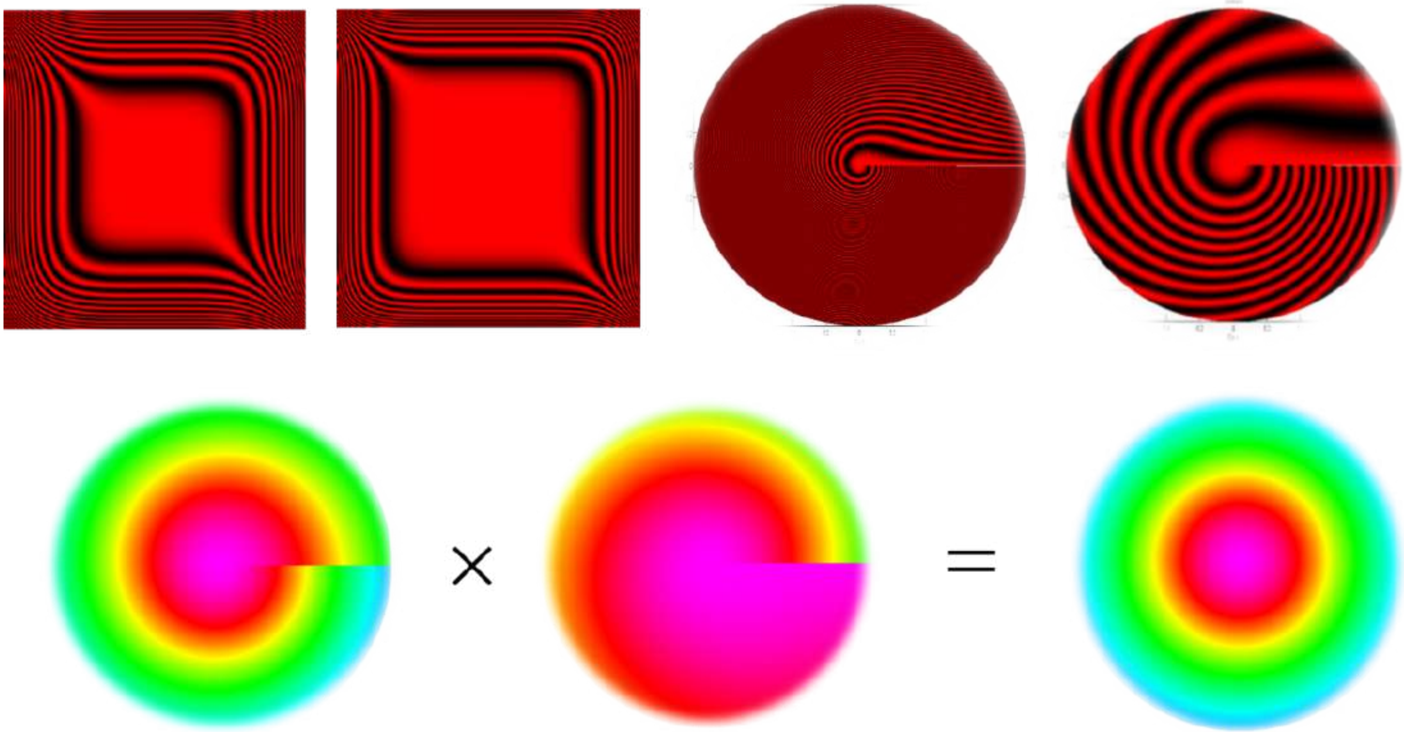


Figure 3: Along the first line, interferograms of optical masks useful for engineering either field depth, or for implementing varifocal lenses.

As a collateral effect, on the use of phase masks for reducing the impact of focus error, his research team noted that these masks generate spurious ripples; which can be attenuated by employing absorption masks, with moderate attenuation coefficients [11].

Along the second line of Figure 3, we show a pair of amplitude masks, which are used as pair for obtaining tunable absorption masks, with radial symmetry.

Here, it is also relevant to note that these approaches find also applications, for engineering temporally periodic pulse trains [12].

As an interesting extension, of the previous results, Prof. Ojeda-Castañeda and his group have also linked the autocorrelation operation, for evaluating the optical transfer function, with the use of pairs of phase conjugate masks. They have shown that helically modulated phase masks, used as conjugated pairs, are useful for setting large families of tunable optical focalizers.

Furthermore, by employing a suitable amplitude offset, pairs of helically distributed absorbing masks are useful for setting radially symmetric optical apodizers [13]; as depicted at the bottom of Figure 3. These novel devices can conveniently be incorporated for designing novel imaging devices [14-17].

References:

[1] Optica Acta, Vol. 27, 905-915 (1980).
[2] Applied Optics, Vol. 18, 3338-3341 (1979).
[3] Optica Acta, Vol. 30, 1259-1266 (1983).
[4] SPIE Proceedings, Vol. 402, 186-191 (1983).
[5] Optics Communications, Vol. 102, 21-24 (1993).
[6] Microwave and Optical Technology Letters, Vol. 3, 430-433 (1990).
[7] Optics Communications, Vol. 44, 323-326 (1983).
[8] Applied Optics, Vol. 27, 790-795 (1988).
[9] Applied Optics, Vol 27, 2583-2586 (1988).
[10]Advances in Optics and Photonics, Vol. 7, 814-880 (2015).
[11] Photonics Letters of Poland, Vol. 4, 115-117 (2012).
[12] Journal of the Optical Society of America A, Vol. 24, 2268-2273 (2007).
[13] Photonics Letters of Poland, Vol. 5 (1), 20-22 (2013).
[14] Photonics Letters of Poland, Vol. 7, 14-16 (2015).
[15] Applied Optics 59, D59-D63 (2020).
[16] Optics Communications 470, No. 126047 (2020).
[17] Applied Optics 59, 7099-7102 (2020).

Prof. Nataliya Kundikova chaired the ICO Galileo Galilei Medal Committee 2020

Responsible Conduct of Research

My "Responsible Conduct of Research" MIT course presentation is available at *http://extras.springer.com/2020/978-3-030-21691-7*

Prof. Barry R. Masters is Elected fellow of AAAS

What is science? Science is a social process that generates knowledge about the physical universe and is built on trust and ethical conduct. Such generation of knowledge is always subject to experimental outcomes that can be objectively compared with predictions derived from theory. A lack of verification of theory typically results in either rejection or modification. Think of science as a set of algorithms that (if followed) can be used to generate knowledge about the physical universe. Furthermore, the process of science can be taught to others and passed on from generation to generation. As scientists, we strive to promote mentorship (critical to the teaching and training of a new generation of scientists) and cooperation, advance research, and work in a context of social responsibility.

What is pseudoscience? Pseudoscience is composed of spurious theories that are promulgated as science but are actually bogus (i.e., without objective validation). Today the boundaries between truth and falsehoods and lies, between science and pseudoscience, are becoming distorted and subsequently weakened. Facts and opinions are becoming less distinct.

In fact, science today is coming under increasingly severe attacks. We see this phenomenon in the public debates between political leaders and government officials with respect to climate change and the putative harmful effects of vaccines. Pseudoscience and nonsense can cause great harm when they affect public policy. Think of the human effects of climate change. Think of the global outbreaks of infectious diseases. The aims of scientists include the promotion of science, the protection of science, and the advancement of science. Mentoring, risk taking, and innovation all serve to promote science. A deep understanding of scientific misconduct is necessary to enhance the protection of science. Good practices in terms of research and scientific communication all serve to advance science.

What are the impacts of scientific misconduct on the progress of science? Impacts may include scientists being misled by false publications, funding being wasted, and the time and effort of editors and peer-reviewers being wasted too.

Another concern is loss of trust by the public in the process of science and the subsequent diminishing of government funding. The set of best practices for science falls under the rubric of Responsible Conduct of Research. These principles are taught as interactive courses at universities and research institutes worldwide. Topics typically include good research practices; fraud, fabrication, and falsification; authorship; plagiarism; peer review; research misconduct; the use of animals in research; research involving human subjects; manipulation of digital images; proper citation; and intellectual property. Another important topic is the dissemination and sharing of data.

B. R. Masters, "Superresolution Optical Microscopy", Springer Series in Optical Sciences 227, https://doi.org/10.1007/978- 3-030-21691-7

Contacts

International Commission for Optics (http://e-ico.org).

Forthcoming events with ICO participation

For further information, visit the ICO website http://e-ico.org

19-23 July 2021

AOP2021: International Conference on Applications of Optics and Photonics
Guimarães, Portugal
Contact: Manuel F. Costa
info@aop2021.org
http://aop2021.org

13–17 September 2021

ICO-25: 25th General Meeting of the International Commission for Optics
Dresden, Germany
Contact: Jürgen Czarske
ico-office@mailbox.tu-dresden.de
http://ico25.org

13–17 September 2021

16th Conference of the International Society on Optics within Life Sciences
Dresden, Germany
Contact: Jürgen Czarske
ico-office@mailbox.tu-dresden.de
http://ico25.org

06–10 September 2021

EOSAM-2021: Annual Meeting of the European Optical Society
Paris, France
Contact: Elina Koistinen
elina@europeanoptics.org
http://eosam2021.org

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