Tomas Cizmar

Uncovering secrets hidden in the startling and unimaginable complexity of the universe, nature and life represents for me the most magnificent commitment one can undertake. Photonics is one of the most rapidly progressing disciplines, studying and harnessing the interactions between light and matter. I envisage this branch as one of the most powerful and rewarding disciplines with huge implications for science, health-care and industry of this century.

- **EDUCATION**

2006	**PhD – Physics (Wave and Particle Optics),** Faculty of Sciences, Masaryk University, Brno, Czechia
2003	**Master – Physics (Plasma Physics) Faculty of Sciences,** Faculty of Sciences, Masaryk University, Brno, Czechia

- **CURRENT FACULTY POSITIONS**

2017 onwards	**Leader of Complex Photonics laboratory** Institute of Scientific Instruments of the CAS, v. v. i., Brno, Czechia
2017 onwards	**Head of department, Fibre Optics** Leibniz-Institute of Photonic Technology Jena, Germany
2017 onwards	**Professor of Waveguide Optics / Fibre Optics** Friedrich-Schiller-University Jena, Germany

- **PREVIOUS FACULTY POSITIONS**

2013 – 2017	**Reader in Physics & Life Sciences (first permanent position)** School of Science & Engineering, University of Dundee (SSE UoD), UK

- **FELLOWSHIPS**

2010 – 2013	**Academic Research Fellow (5 years contract),** School of Medicine, University of St Andrews, UK
2007 – 2010	**Post-doctoral Research Fellow (3 years contract)** School of Physics & Astronomy, University of St Andrews, UK
2006 – 2007	**Post-doctoral Research Fellow (5 years contract)** Institute of Scientific Instruments, Czech Republic

- **TEACHING ACTIVITIES**

2004 – 2006	**Tutorials in physics**, 1st year mechanical engineering, BUT Brno, CZ
2007 – 2010	**Tutorials in physics**, 1st year Physics & Astronomy, St Andrews, UK
2013 –	**Optics,** 2nd year undergraduate, SSE UoD, UK
2013 –	**Experimental & professional physics**, 3rd year undergraduate, SSE UoD, UK

- **RESEARCH SUPPORT**

2017 – 2022	**EC H2020 ERC Consolidator Grant**, "LIFEGATE", 2 m€
2017 – 2022	**European Regional Development Fund**, Project "Holographic endoscopy for in vivo applications" (No. CZ.02.1.01/0.0/0.0/15_003/0000476), 179m CZK (6.9 m€)
2013 – 2017	**Scottish Universities Physics Aliance** (SUPA) via Physics and Life Sciences (PaLS) initiative, 300k GBP.
2010 – 2013	Academic fellowship in Medical Photonics awarded by the University of St Andrews.

- **HIGHLIGHTED PUBLICATIONS:**

[1] I Leite, S Turtaev, X Jiang, M Siler, A Cuschieri, P St J Russell & T Cizmar *Three-dimensional holographic optical manipulation through a high-numerical-aperture soft-glass multimode fibre.* Nature Photonics 11(8) (2017)

[2] M Ploeschner, T Tyc & T Cizmar *Seeing through chaos in multimode fibres.* Nature Photonics 9(8) 529-535 (2015)

[3] T Vettenburg, H Dalgarno, J Nylk, C Coll-Llado, D Ferrier, T Cizmar, F Gunn-Moore & K Dholakia *Light-sheet microscopy using an Airy beam.* Nature Methods 11(5) 541-544 (2014)

[4] Brzobohaty, V Karasek, M Siler, L Chvatal, T Cizmar & P Zemanek *Experimental demonstration of optical transport, sorting and self- arrangement using a 'tractor beam'.* Nature Photonics 7(2) 123-127 (2013)

[5] T Cizmar & K Dholakia *Exploiting multimode waveguides for pure fibre-based imaging.* Nature Communications 3 1027 (2012)
[6] K Dholakia & T Cizmar *Shaping the future of manipulation.* Nature Photonics 5(6) 335-342 (2011)
[7] T Cizmar, M Mazilu & K Dholakia *In situ wavefront correction and its application to micromanipulation.* Nature Photonics 4(6) 388-394 (2010)

- **PATENTS:**

Title	Application Number(s)	Abstract
Optical Trap*	CA2730597A1 EP2297600A2 US8618469 US20110174961 WO2010007371A3	A system for forming an optical trap comprising two or more photonic crystal fibers (PCFs) and at least one source of radiation for inputting radiation to the photonic crystal fibers, the fibres being operable to provide counter-propagating outputs for forming the optical trap.
Controlling light transmission through a medium	CA2847023A1 WO2013038193A2 WO2013038193A3	A method for use in controlling light transmission through a medium comprises transmitting light from a single spatial portion of an input optical field through the medium to create an output optical field.
Holographic head-mounted display	WO2014151877 A1	We provide a head-mounted display unit based on the principle of Fourier holography. It allows for high-efficiency, parallel delivery of information to the retina or to a photo-sensitive implant in the eye.
Predicting light transport processes in multimode fibres	GB 1509418.8	Patent application was filled 1 June 2015, the abstract will be available later this year.

- **INVITED LECTURES:**

Invited talks at international symposia:

2005	**SPIE**, Optical Trapping and Optical Micromanipulation II, Sand Diego, USA
2008	**SPIE**, Laser Beam Shaping IX, Sand Diego, USA
2010	**Photonics 2010**, Indian Institute of Technology Guwahati, India
2011	**OSA**, Digital Holography and Three-Dimensional Imaging, Tokyo, Japan
2012	**COBRA**, European Conference on Optical Communication, Amsterdam, Netherlands
2013	**King's College London,** Complex nano-photonics science camp, Windsor, UK
2014	**OSA**, Computational Optical Sensing and Imaging, Hawaii, USA
	SPRC, Annual symposium, Stanford, USA
	SULSA, Optical imaging of Cells, Edinburgh, UK
	Rank Prize, Symposium on Structured Light and Orthogonality, Grasmere, UK
	Photon 14, Imperial college London, UK
2015	**SPIE**, Photonics West, San Francisco, USA
	SPIE, Optical Systems Design, Jena, Germany
	Photonex 15, Coventry, UK
	SPIE, Photonics West, San Francisco, USA
	Innsbruck Medical University, Trends in Optical Manipulation, Obergurgel, Austria
2016	**DFG**, Trends in Microscopy, Dresden, Germany
	SPIE, Photonics West, San Francisco, USA
	PALS, Plasmonics and Light Scattering, Exeter, UK

University seminars:

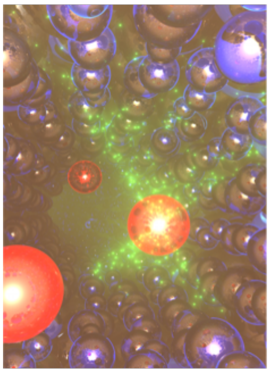
2007	Masaryk University, Czechia
2011	University of Southampton, UK
2012	University of Stanford, USA
	University of Dundee, UK
2013	University of Goteborg, Sweden
	Denmark Technical University, Denmark
	Bilkent University, Turkey
	University of St Andrews, UK
	Biological research centre, Szeged, Hungary
2014	Herriot-watt University, UK
	University of Oxford, UK
2015	University of Exeter, UK
	Okinawa Institute of Science and Technology, Japan
	MPL, Ringberg castle, Germany
2016	VU Amsteram, Netherlands
	University of Glasgow, UK

Guest lectures at summer schools:

2008	Summer school for Erasmus Mundus master students (ENS Cachan), Carcans, France
2010	Meeting & Training School (COST MP0605), Visegrad, Hungary
2013	Biophotonics summer school (INAOE), Puebla City, Mexico
2014	Lasers in Medicine and Life Sciences (University of Szeged), Szeged, Hungary
2014	Poly-Nano (COST 1205), Denmark Technical University, Copenhagen, Denmark
2015	Lasers in Medicine and Life Sciences II (University of Szeged), Szeged, Hungary
2015	Poly-Nano (COST 1205), Denmark Technical University, Copenhagen, Denmark
2016	Lasers in Medicine and Life Sciences II (University of Szeged), Szeged, Hungary

- **MOST SIGNIFICANT RESULTS:**

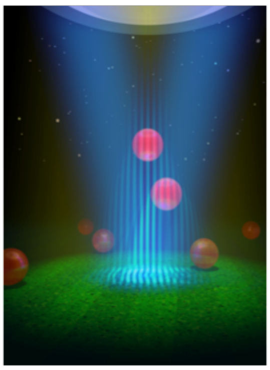
***In situ* wavefront correction:**



Aberrations in optical systems, which lead to blurring of an image, and their elimination using adaptive optics have been studied in astronomical research for quite a long time. Aberrations occur when light from one point of an object after transmission through the optical system does not converge into a single point. The complicated part in correcting this error usually lies in identifying the aberrations that need to be eliminated from the system. With the emergence of nanoscale applications, aberrations in modern microscopy have become a severe limitation on the optimal performance in imaging, nanosurgery, nanofabrication and micromanipulation, just to name a few.
This work has demonstrated a powerful method for aberration correction with a simple implementation that typically requires minimal changes in the particular geometry. At the same time it offers a way to compensate for a wide range of distortions from very weak ones seen in typical optical systems right up to those from an entirely random medium in a microscope sample. It is particularly suitable for bio-photonics optical systems where a perfect focusing of a laser light is crucial, but might be generally applicable whenever a focused light beam is required, e.g. in imaging.
The method restores the optimal focusing of laser light in situ, meaning that the light beam is optimally focused directly in the sample after propagating through sources of various optical aberrations, regardless of their distribution within the whole optical train. In one run we can eliminate aberrations of the output laser mode, imperfections of relay optics and alignment, aberrations caused by objective or even aberrations present in the sample chamber. This paper mentions the possibility to control light propagation in fibre optics for the first time.

T. Čižmár, M. Mazilu, & K. Dholakia, Nature Photonics, 4(6), 388-394 (2010)

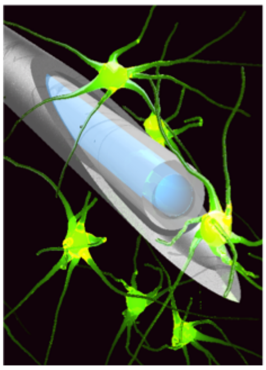
Passive tractor beam:



Following the Keplerian idea of optical forces, one would intuitively expect that an object illuminated by sunlight radiation or a laser beam will be accelerated along the direction of photon flow. Theoretical studies have however shown that small particles can be pulled by light beams against the photon stream, even in beams with uniform optical intensity along the propagation axis. The work introduced a geometry to generate such 'tractor beam', and experimentally demonstrated its functionality using spherical microparticles of various sizes, as well as its enhancement with optically self-arranged structures of microparticles. In addition to the pulling of the particles, it has been demonstrated that two-dimensional motion of micro-objects and one-dimensional size-dependent sorting may be controlled conveniently by manipulation of the polarization of the incident beam

O. Brzobohatý, V. Karásek,
M. Šiler, L. Chvátal, T. Čižmár & P. Zemánek, Nature Photonics 7, 123–127 (2013)

Imaging through multimode fibres:



This work has shown for the first time how to unscramble highly disordered images sent down single multimode fibers, making for the narrowest image-guiding system ever. The “order from disorder” approach means that single fibers could be fed down hypodermic needles, sending back deep-tissue images at a range of depths that more complex imaging approaches simply cannot reach.
The approach amounts to a characterization of the ways in which multimode fibers distort the phase, amplitude and polarization of light as it propagates along the fiber, and then the application of a transformation at the other end to undo the distortions. With fine holographic control of the light, the approach can also be used to select the location and size of the depth of focus leading to a new concept of a single-fiber, lensless imaging system. At the heart of the technique lies the idea that the classic microscopy imaging setup (with one lens performing a Fourier transform of the incident light and another performing the inverse transform to provide the reconstructed image of a sample plane) can be accomplished by any two optical elements that perform such orthogonal transformations. A single multimode fiber, with all of the depolarization, and apparent randomization of the light that it causes, can be viewed as the source of one such transformation, and computer-controlled spatial light modulator as the other one.
Importantly, this work has have shown that these advanced techniques are particularly promising for super-resolution imaging methods such as stimulated emission depletion (STED) microscopy, and the extraordinarily thin nature of single fibers makes the technique most promising of all for delicate procedures such as in vivo neuroimaging.

T. Čižmár & K. Dholakia, Nature Communications, 3 1027 (2012)

Predictability of multimode fibres:

How random and chaotic the light propagation in multimode fibres really is? Multimode fibres deliver light signals in the form of apparently random speckled patterns, in a very similar fashion to other random media. Although multimode fibres feature remarkably faithful cylindrical symmetry they are frequently classified as unpredictable optical systems. The work challenges this commonly held notion. We developed a powerful holographic geometry for complete and accurate analysis of light signals traveling in and out of the fibre and we compared the results with advanced numerical modeling. We have demonstrated that commercially available multimode fibres are capable of performing as extremely precise optical components and that light propagation within straight or even significantly deformed segments of multimode fibres may be predicted up to distances in excess of hundreds of millimetres. We believe that harnessing this newly discovered predictability in endoscopy will allow for high-resolution imaging deep inside motile organisms.

M. Plöschner, T. Tyc, T. Čižmár, Nature Photonics 9, 529–535 (2015)